Data sheet

BNO055
Intelligent 9-axis absolute orientation sensor

Bosch Sensortec

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BNO055: data sheet

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BNO055

INTELLIGENT ABSOLUTE ORIENTATION SENSOR, 9-AXIS SENSOR FUSION ALL-IN-ONE WINDOWS 8.x COMPLIANT SENSOR HUB

Basic Description

Key features:

• Outputs fused sensor data	Quaternion, Euler angles, Rotation vector, Linear acceleration, Gravity, Heading
• 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
• Power Management	Intelligent Power Management: normal, low power and suspend mode available
• Common voltage supplies	V_{DD} voltage range: 2.4V to 3.6V
• Digital interface	HID-I2C (Windows 8 compatible), I²C, UART V_{DDIO} voltage range: 1.7V 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 BNO055 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 running Bosch Sensortec sensor fusion software, 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. For optimum system integration the BNO055 is equipped with digital bi-directional I^2C and UART interfaces. The I^2C interface can be programmed to run with the HID-I2C protocol turning the BNO055 into a plug-and-play sensor hub solution for devices running the Windows 8.0 or 8.1 operating system.

This datasheet release describes the BNO055 engineering samples programmed with version 0.3.0.4 of the BNO055 firmware. The firmware version can be identified by read SW_REV_ID_MSB and SW_REV_ID_LSB registers; firmware version 0.3.0.4 will return the value 0x03 for the MSB and 0x04 for the LSB.

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Specification

If not stated otherwise, the given values are over lifetime and full performance temperature and voltage ranges.

1.1 Electrical specification

Table 0-1: Electrical parameter specification

OPERATING CONDITIONS BNO055						
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	--	-40	--	+85	°C
Total supply current normal mode at T_A (9DOF @100Hz output data rate)	I_{DD} + I_{DDIO}	V_{DD} = 3V, V_{DDIO} = 2.5V	--	--	13.7	mA
Total supply current Low power mode; interrupt driven at T_A (80% suspend mode and 20% normal mode with 9DOF @100Hz output data rate)	I_{DD_LPM}	V_{DD} = 3V, V_{DDIO} = 2.5V	--	2.6	--	mA
Total supply current suspend mode at T_A	I_{DD_SuM}	V_{DD} = 3V, V_{DDIO} = 2.5V	--	--	0.12	mA

1.2 Electrical and physical characteristics, measurement performance

Table 0-2: Electrical characteristics BNO055

OPERATING CONDITIONS BNO055						
Parameter	**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Unit**
Start-Up time	T_{Sup}	From Off to configuration mode		400		ms
POR time	T_{POR}	From Reset to Normal mode		650		ms
Data Rate	DR	s. Par. 3.7.3.2				
Data rate tolerance 9DOF @100Hz output data rate (if internal oscillator is used)	DR_{tol}			±1		%
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 (ACCELEROMETER ONLY MODE)						
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, $V_{DD\_min} \leq V_{DD} \leq V_{DD\_max}$		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, $V_{DD\_min} \leq V_{DD} \leq V_{DD\_max}$		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

Parameter	Symbol	Condition	Min	Typ	Max	Units
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	TBD	%
Alignment Error	E_A	relative to package outline		±0.5	TBD	°

OPERATING CONDITIONS GYROSCOPE

Parameter	Symbol	Condition	Min	Typ	Max	Unit
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 (GYRO ONLY MODE)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
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} ≤ V_{DD} ≤ V_{DD_max}		TBD		%/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	OffΩ_{VDD}	T_A=25°C, V_{DD_min} ≤ V_{DD} ≤ V_{DD_max}		TBD		°/s /V
Output Noise	n_{rms}	rms, BW=47Hz (@ 0.014°/s/√Hz)		0.1	0.3	°/s

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 (MAGNETOMETER ONLY MODE)						
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[4]	$OFF_{m,cal}$	After calibration in fusion mode -40°C ≤ T_A ≤ +85°C		±2		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
[4] Magnetic zero-B offset assuming calibration in fusion mode. Typical value after applying calibration movements containing various device orientations (typical device usage).

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 (TBD)	+150 (TBD)	°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

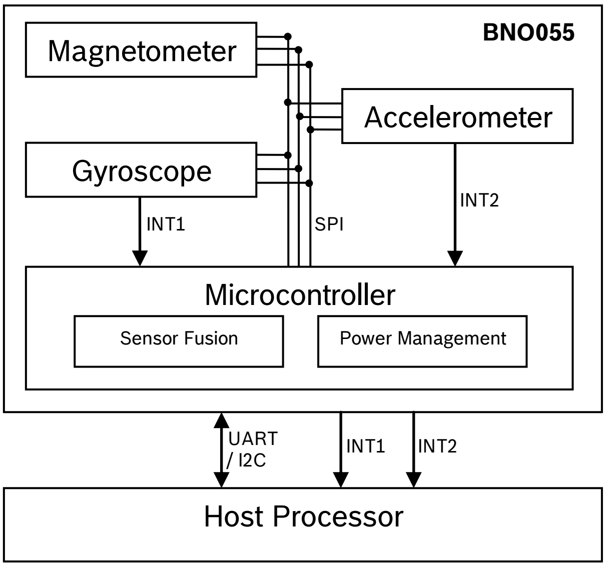
Note: Stress above these limits may cause damage to the device. Exceeding the specified electrical limits may affect the device reliability or cause malfunction.

3. **Functional Description**

3.1 Architecture

Fehler! Verweisquelle konnte nicht gefunden werden. shows the basic building blocks of the BNO055 device.

Figure 1: system architecture



3.2 Power management

The BNO055 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.

The BNO055 can be configured to run in one of the following power modes: normal mode, low power mode, and suspend mode. These power modes are described in more detail in section 3.4.

3.3 Operating Modes

The BNO055 can be operated in various operating modes depending on the output data required and for effective power usage. Table 3-1 below explains the outputs available in each of the various operation modes

Table 3-1: operating modes overview

Operating Mode	HW Sensor power			Sensor Signal			Fusion Data			
	Accel	Mag	Gyro	Accel	Mag	Gyro	Euler	Quaternion	Linear Accel	Gravity vector
CONFIGMODE	ON	ON	ON	NO	NO	NO	NO	NO	NO	NO
ACCONLY	ON	OFF	OFF	YES	NO	NO	NO	NO	NO	NO
MAGONLY	OFF	ON	OFF	NO	YES	NO	NO	NO	NO	NO
GYROONLY	OFF	OFF	ON	NO	NO	YES	NO	NO	NO	NO
ACCMAG	ON	ON	OFF	YES	YES	NO	NO	NO	NO	NO
ACCGYRO	ON	OFF	ON	YES	NO	YES	NO	NO	NO	NO
MAGGYRO	OFF	ON	ON	NO	YES	YES	NO	NO	NO	NO
AMG	ON	ON	ON	YES	YES	YES	NO	NO	NO	NO
IMU	ON	OFF	ON	YES	NO	YES	YES	YES	YES	YES
COMPASS	ON	ON	OFF	YES	YES	NO	YES	YES	YES	YES
M4G	ON	ON	OFF	YES	YES	YES[5]	YES	YES	YES	YES
NDOF_FMC_OFF[6]	ON	ON	ON	YES	YES	YES	YES	YES	YES	YES
NDOF[7]	ON	ON	ON	YES	YES	YES	YES	YES	YES	YES

[5] M4G – Magnet for Gyroscope; Gyroscope signal is emulated by the magnetometer.
[6] FMC – Fast magnetic calibration; when turned-off the magnetometer must be calibrated using a figure of eight motion.
[7] In NDOF mode FMC is active; magnetic calibration is perform in the background with small movement of the device.

The operating mode can be select by writing to the OPR_MODE register, possible register values and the corresponding operating modes are shown in Table 3-2. The default operation mode after power-on is Config mode.

Table 3-2: operating modes selection

Parameter	Value	[Reg Addr]: Reg Value
CONFIG MODE	CONFIGMODE	[OPR_MODE]: xxxx0000b
Sensor Mode	ACCONLY	[OPR_MODE]: xxxx0001b
	MAGONLY	[OPR_MODE]: xxxx0010b
	GYROONLY	[OPR_MODE]: xxxx0011b
	ACCMAG	[OPR_MODE]: xxxx0100b
	ACCGYRO	[OPR_MODE]: xxxx0101b
	MAGGYRO	[OPR_MODE]: xxxx0110b
	AMG	[OPR_MODE]: xxxx0111b
Fusion Mode	IMU	[OPR_MODE]: xxxx1000b
	COMPASS	[OPR_MODE]: xxxx1001b
	M4G	[OPR_MODE]: xxxx1010b
	NDOF_FMC_OFF	[OPR_MODE]: xxxx1011b
	NDOF	[OPR_MODE]: xxxx1100b

Config mode is used to configure the various settings of the BNO, in this mode all output data is reset to zero and sensor fusion is halted.
The following registers may be configured in all operation modes, all other registers can only be configured while in config mode:

- Sensor interrupts
  - ➔ Interrupt registers (INT and INT_MSK).
- System configurations
  - ➔ Operation mode register (OPR_MODE), only config mode is configurable

In the fusion modes, the calibrated sensor data are available in the data register based on the unit selected. The axis of the data is configured based on the axis-remap register configuration.

In this mode, BNO works according to fusion mode configuration and user can not configure the sensor power mode like deep suspend, suspend and sleep mode when sensor is ON and it is over written as normal mode while switching from config mode to any fusion mode. As similar, user can not configure the sensor power mode as normal mode when sensor is OFF and it is over written as deep suspend or suspend while switching from config mode to any fusion mode.

For example:
In IMU mode, the accelerometer, gyroscope should be ON and magnetometer should be OFF. If the user configures the accelerometer, gyroscope to deep suspend mode and magnetometer to forced mode, then the user configuration is over written with normal mode

of accelerometer and gyroscope in the register map. Whereas the magnetometer is overwritten with suspend mode.

Apart from the power mode, the fixed range and bandwidth is configured as mentioned below,

Sensor	Range	Bandwidth	Sensor Power mode if Sensor is ON	Sensor Power mode if Sensor is OFF
Accelerometer	4G	62.5 Hz	Normal	Deep suspend
Magnetometer	NA	10 Hz	Force	Suspend
Gyroscope	2000 dps	32 Hz	Normal	Deep suspend

User configuration is over written in the register map when switching from config mode to any fusion mode if the user configures something other than above.

In the sensor modes, the un-calibrated sensor data are available in the data register based on the unit selected. The axis of the data is configured based on the axis-remap register configuration.

In this mode, BNO works according to user configuration when a particular sensor is ON while switching from config mode to sensor mode. In the OFF condition BNO works according to sensor mode configuration. At any time later, user changes to fusion mode then the register map will get updated as fusion mode configuration and BNO will work according to fusion mode configuration later on. So user has to handle to do the proper configuration whenever he switches from one operation mode to another.

Table 3-3 below shows the time required to switch between CONFIGMODE and the other operating modes.

Table 3-3: Operating mode switching time

From	To	Switching time
CONFIGMODE	Any operation mode	7ms
Any operation mode	CONFIGMODE	19ms

3.4 Power Modes

The BNO055 support three different power modes: Normal mode, Low Power Mode, and Suspend mode.
The power mode can be selected by writing to the PWR_MODE register as defined in Table 3-4. As default at start-up the BNO055 will run in Normal mode.

Table 3-4: power modes selection

Parameter	Value	[Reg Addr]: Reg Value
Power Mode	Normal Mode	[PWR_MODE]: xxxxxx00b
	Low Power Mode	[PWR_MODE]: xxxxxx01b
	Suspend Mode	[PWR_MODE]: xxxxxx10b

3.4.1 **Normal Mode**

In normal mode all sensors required for the selected operating mode (see section 3.3) are always switched ON. The register map and the internal peripherals of the MCU are always operative in this mode.

3.4.2 **Low Power Mode**

If no activity (i.e. no motion) is detected for a configurable duration (default 5 seconds), the BNO055 enters the low power mode. In this mode only the accelerometer is active. Once motion is detected (i.e. the accelerometer signals an any motion interrupt), the system is woken up and normal mode is entered. The following settings are possible.

Entering to sleep: NO Motion Interrupt

Parameter	Value	Reg Value	Restriction
Detection Type	No Motion	[ACC_NM_SET] : xxxxxxx1b	
	Detection Axis	[ACC_INT_Settings] : bit4-bit2	Shares common bit with Any Motion interrupt axis selection
Params	Duration	[ACC_NM_SET] : bit6-bit1	
	Threshold	[ACC_NM_THRE] : bit7-bit0	

Waking up: Any Motion Interrupt

Parameter	Value	Reg Value
Detection Type	Detection Axis	[ACC_INT_Settings] : bit4-bit2
Params	Duration	[ACC_INT_Settings] : bit1-bit0
	Threshold	[ACC_AM_THRES] : bit7-bit0

Additionally, the interrupt pins can also be configured to provide HW interrupt to the host. For details, please refer to section 3.7.5.

The BNO055 is by default configured to have optimum values for entering into sleep and waking up. To restore these values, trigger system reset by setting RST_SYS bit in SYS_TRIGGER register.

There are some limitations to achieve the low power mode performance:

- Only No and Any motion interrupts are applicable and HG, Slow interrupts are not applicable in low power mode.
- Low power mode is not applicable in operation mode were accelerometer sensor is OFF.

3.4.3 **Suspend Mode**

In suspend mode the system is paused and all the sensors and the microcontroller are put into sleep mode. No values in the register map will be updated in this mode. To exit from suspend mode the mode should be changed by writing to the PWR_MODE register (see Table 3-4).

3.5 Axis remap

The device mounting position should not limit the data output of the BNO055 device. The axis of the device can be re-configured to the new reference axis.

Axis configuration byte: Register Address: **AXIS_MAP_CONFIG**

Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Reserved		Remapped Z axis value		Remapped Y axis value		Remapped X axis value	

There are two bits are used to configure the axis remap which will define in the following way,

Value	**Axis Representation**
00	X - Axis
01	Y - Axis
10	Z- Axis
11	Invalid

Also, when user try to configure the same axis to two or more then BNO055 will take this as invalid condition and previous configuration will be restored in the register map. The default value is: X Axis = X, Y Axis = Y and Z Axis = Z (AXIS_REMAP_CONFIG = 0x24).

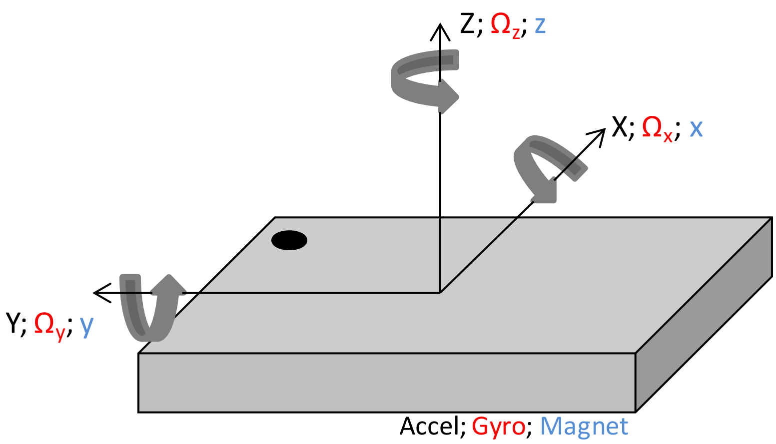
Axis sign configuration byte: Register Address: **AXIS_MAP_SIGN**

Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Reserved					Remapped X axis sign	Remapped Y axis sign	Remapped Z axis sign

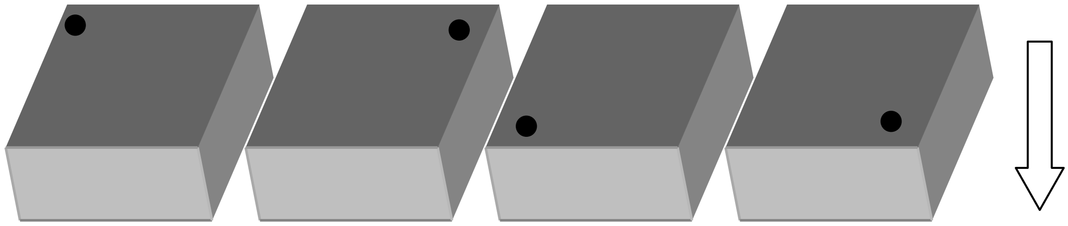
Value	**Sign**
0	Positive
1	Negative

The default value is 0x00.

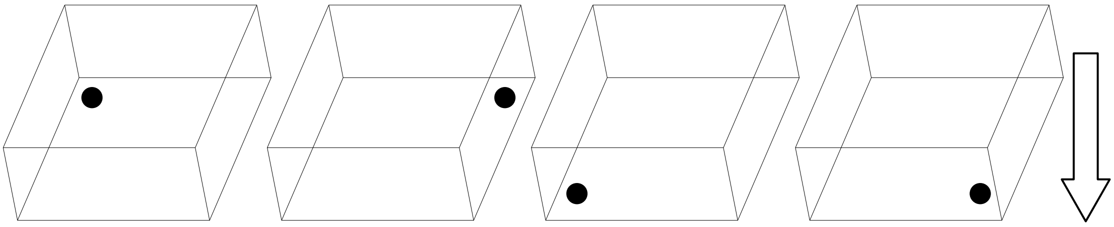
The default values correspond to the following coordinate system (see also chapter 6.2):



Some example placement for axis vs. register settings:



TOP VIEW

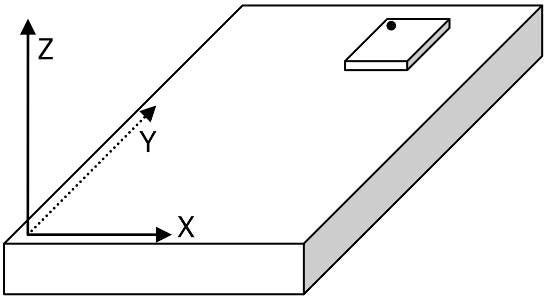


Bottom View

For the above described placements, following would be the axis configuration parameters.

Placement	AXIS_REMAP_CONFIG	AXIS_REMAP_SIGN
P0	0x21	0x04
P1 (default)	0x24	0x00
P2	0x24	0x06
P3	0x21	0x02
P4	0x24	0x03
P5	0x21	0x01
P6	0x21	0x07
P7	0x24	0x05

Example: For a device with a coordinate system as shown in the following figure the axis remapping of placement P0 (see table above) applies:



3.6 Sensor Configuration

The fusion outputs of the BNO055 are tightly linked with the sensor configuration settings. Due to this fact, the sensor configuration is limited when BNO055 is configured to run in any of the fusion operating mode (see Table 3-1). In any of the sensor modes the configuration setting can be updated by writing to the configuration registers as defined in the following sections.

3.6.1 **Accelerometer configuration (BMA25x)**

The fusion outputs of the BNO055 are tightly linked with the accelerometer sensor settings. Therefore the configuration possibilities are restricted when running in any of the fusion operating modes. The accelerometer configuration can be changed by writing to the ACC_Config register, Table 3-5 below detail the configurations which are allowed for the BMA25x sensor.

Table 3-5: BMA25x allowed configurations

Parameter	Values	[Reg Addr]: Reg Value	Restrictions
G Range	2G	[ACC_Config]: xxxxxx00b	
	4G	[ACC_Config]: xxxxxx01b	
	8G	[ACC_Config]: xxxxxx10b	
	16G	[ACC_Config]: xxxxxx11b	
Bandwidth	7.81Hz	[ACC_Config]: xxx000xxb	Auto controlled in fusion mode
	15.63Hz	[ACC_Config]: xxx001xxb	Auto controlled in fusion mode
	31.25Hz	[ACC_Config]: xxx010xxb	Auto controlled in fusion mode
	62.5Hz	[ACC_Config]: xxx011xxb	Auto controlled in fusion mode
	125Hz	[ACC_Config]: xxx100xxb	Auto controlled in fusion mode
	250Hz	[ACC_Config]: xxx101xxb	Auto controlled in fusion mode
	500Hz	[ACC_Config]: xxx110xxb	Auto controlled in fusion mode
	1000Hz	[ACC_Config]: xxx111xxb	Auto controlled in fusion mode
Operation Mode	Normal	[ACC_Config]: 000xxxxxb	Auto controlled in fusion mode
	Suspend	[ACC_Config]: 001xxxxxb	Auto controlled in fusion mode
	Low Power 1	[ACC_Config]: 010xxxxxb	Auto controlled in fusion mode
	Standby	[ACC_Config]: 011xxxxxb	Auto controlled in fusion mode
	Low Power 2	[ACC_Config]: 100xxxxxb	Auto controlled in fusion mode
	Deep Suspend	[ACC_Config]: 101xxxxxb	Auto controlled in fusion mode

The accelerometer sensor operation mode is not configurable by user when BNO power mode is configured as low power mode. BNO rewrites the user configured value to Normal mode when switching from config mode to any BNO operation mode. This used to achieve the BNO low power mode performance.

3.6.2 **Gyroscope configuration (BMG160)**

The fusion outputs of the BNO055 are tightly linked with the angular rate sensor settings. Therefore the configuration possibilities are restricted when running in any of the fusion operating modes. The gyroscope configuration can be changed by writing to the GYR_Config register, Table 3-6 below detail the configurations which are allowed for the BMG160 sensor.

Table 3-6: BMG160 allowed configurations

Parameter	Values	[Reg Addr]: Register value	Restrictions
Range	2000 dps	[GYR_Config_0]: xxxxx000b	Auto controlled in fusion mode
	1000 dps	[GYR_Config_0]: xxxxx001b	Auto controlled in fusion mode
	500dps	[GYR_Config_0]: xxxxx010b	Auto controlled in fusion mode
	250 dps	[GYR_Config_0]: xxxxx011b	Auto controlled in fusion mode
	125 dps	[GYR_Config_0]: xxxxx100b	Auto controlled in fusion mode
Bandwidth	523Hz	[GYR_Config_0]: xx000xxxb	Auto controlled in fusion mode
	230Hz	[GYR_Config_0]: xx001xxxb	Auto controlled in fusion mode
	116Hz	[GYR_Config_0]: xx010xxxb	Auto controlled in fusion mode
	47Hz	[GYR_Config_0]: xx011xxxb	Auto controlled in fusion mode
	23Hz	[GYR_Config_0]: xx100xxxb	Auto controlled in fusion mode
	12Hz	[GYR_Config_0]: xx101xxxb	Auto controlled in fusion mode
	64Hz	[GYR_Config_0]: xx110xxxb	Auto controlled in fusion mode
	32Hz	[GYR_Config_0]: xx111xxxb	Auto controlled in fusion mode
Operation Mode	Normal	[GYR_Config_1]: xxxxx000b	Auto controlled in fusion mode
	Fast Power up	[GYR_Config_1]: xxxxx001b	Auto controlled in fusion mode
	Deep Suspend	[GYR_Config_1]: xxxxx010b	Auto controlled in fusion mode
	Suspend	[GYR_Config_1]: xxxxx011b	Auto controlled in fusion mode
	Advanced Powersave	[GYR_Config_1]: xxxxx100b	Auto controlled in fusion mode

3.6.3 **Magnetometer configuration (BMM150)**

The fusion outputs of the BNO055 are tightly linked with the magnetometer sensor settings. Therefore the configuration possibilities are restricted when running in any of the fusion operating modes. The magnetometer configuration can be changed by writing to the MAG_Config register, Table 3-7 below detail the configurations which are allowed for the BMM150 sensor.

Table 3-7: BMM150 allowed configurations

Parameter	Values	[Reg Addr]: Register value	Restrictions
Data output rate	2Hz	[MAG_Config]: xxxxx000b	Auto controlled in fusion mode
	6Hz	[MAG_Config]: xxxxx001b	Auto controlled in fusion mode
	8Hz	[MAG_Config]: xxxxx010b	Auto controlled in fusion mode
	10Hz	[MAG_Config]: xxxxx011b	Auto controlled in fusion mode
	15Hz	[MAG_Config]: xxxxx100b	Auto controlled in fusion mode
	20Hz	[MAG_Config]: xxxxx101b	Auto controlled in fusion mode
	25Hz	[MAG_Config]: xxxxx110b	Auto controlled in fusion mode
	30Hz	[MAG_Config]: xxxxx111b	Auto controlled in fusion mode
Operation Mode	Low Power	[MAG_Config]: xxx00xxxb	Auto controlled in fusion mode
	Regular	[MAG_Config]: xxx01xxxb	Auto controlled in fusion mode
	Enhanced Regular	[MAG_Config]: xxx10xxxb	Auto controlled in fusion mode
	High Accuracy	[MAG_Config]: xxx11xxxb	Auto controlled in fusion mode
Power Mode	Normal	[MAG_Config]: x00xxxxxb	Auto controlled in fusion mode
	Sleep	[MAG_Config]: x01xxxxxb	Auto controlled in fusion mode
	Suspend	[MAG_Config]: x10xxxxxb	Auto controlled in fusion mode
	Force Mode	[MAG_Config]: x11xxxxxb	Auto controlled in fusion mode

3.6.4 **Default sensor configuration**

At power-on the sensors are configured with the default settings as defined in Table 3-8 below when switching BNO operation mode from config to NDOF.

Table 3-8: Default sensor configuration at power-on

Sensors	Parameters	Value
Accelerometer	Power Mode	NORMAL
	Range	+/- 4g
	Bandwidth	62.5Hz
	Resolution	14 bits
Gyroscope	Power Mode	NORMAL
	Range	2000 °/s
	Bandwidth	32Hz
	Resolution	16 bits
Magnetometer	Power Mode	FORCED
	ODR	20Hz
	XY Repetition	15
	Z Repetition	16
	Resolution x/y/z	13/13/15 bits

3.7 Output data

Depending on the selected operating mode the device will output either un-calibrated sensor data (in sensor mode) or calibrated / fused data (in fusion mode), this section describes the output data for each modes.

3.7.1 Unit selection

The measurement units for the various data outputs (regardless of operation mode) can be configured by writing to the UNIT_SEL register as described in Table 3-9.

Table 3-9: unit selection

Data	Units	[Reg Addr]: Register Value
Acceleration, Linear Acceleration, Gravity vector	m/s^2	[UNIT_SEL] : xxxxxxx0b
	mg	[UNIT_SEL] : xxxxxxx1b
Magnetic Field Strength	Micro Tesla	NA
Angular Rate	Dps	[UNIT_SEL] : xxxxxx0xb
	Rps	[UNIT_SEL] : xxxxxx1xb
Euler Angles	Degrees	[UNIT_SEL] : xxxxx0xxb
	Radians	[UNIT_SEL] : xxxxx1xxb
Quaternion	Quaternion units	NA
Temperature	°C	[UNIT_SEL] : xxx0xxxxb
	°F	[UNIT_SEL] : xxx1xxxxb

3.7.2 Sensor mode

When the BNO055 is running in one of the sensor operating modes (see Table 3-1) the device will output un-calibrated data from the activated sensors. The sensor configuration settings can be configured as described in section 3.6.

3.7.3 **Fusion mode**

When the BNO055 is running in one of the fusion operating modes (see Table 3-1) the device will calculate and output calibrated and fused data such as Euler angles, quaternion's, Linear acceleration and gravity vector. The core library allows for these outputs to be configured to the desired use-case.

3.7.3.1 Data output format

The data output format can be selected by writing to the UNIT_SEL register, this allows user to switch between the orientation definition described by Windows and Android operating systems.

Table 3-10: Fusion data output format

Parameter	**Values**	**[Reg Addr]: Register value**
Fusion data output format	Windows	[UNIT_SEL]: 0xxxxxxxb
	Android	[UNIT_SEL]: 1xxxxxxxb

For details on Windows orientation description, refer to "Integrating Motion and Orientation Sensors" from msdn.microsoft.com. (There is no such document yet describing the Android orientation.)

3.7.3.2 Fusion output data rates

The output data rates can be selected by writing to the OPR_MODE register as shown in Table 3-11, the actual output data rates depend on the fusion operation mode selected, the mapping between operating modes and output data rates are shown in Table 3-12 to Table 3-15.

Table 3-11: Data Rate Modes in Fusion Mode

Data Rates Modes	**[Reg Addr]: Register Value**
FASTEST_MODE	[OPR_MODE]: x001xxxxb
GAME_MODE	[OPR_MODE]: x010xxxxb
UI_MODE	[OPR_MODE]: x011xxxxb
NORMAL_MODE	[OPR_MODE]: x100xxxxb

3.7.3.2.1 FASTEST_MODE

Table 3-12: FASTEST_MODE

BNO055 Operating Mode	Data input rate			Algo calling rate	Data output rate			
	Accel	**Mag**	**Gyro**		**Accel**	**Mag**	**Gyro**	**Fusion data**
IMU	100Hz	NA	100Hz	100Hz	100Hz	NA	100Hz	100Hz
COMPASS	20Hz	20Hz	NA	20Hz	20Hz	20Hz	NA	20Hz
M4G	50Hz	50Hz	NA	50Hz	50Hz	50Hz	NA	50Hz
NDOF_FMC_OFF	100Hz	20Hz	100Hz	100Hz	100Hz	20Hz	100Hz	100Hz
NDOF	100Hz	20Hz	100Hz	100Hz	100Hz	20Hz	100Hz	100Hz

3.7.3.2.2 GAME_MODE

Table 3-13: GAME_MODE

BNO055 Operating Mode	Data input rate			Algo calling rate	Data output rate			
	Accel	**Mag**	**Gyro**		**Accel**	**Mag**	**Gyro**	**Fusion data**
IMU	100Hz	NA	100Hz	100Hz	100Hz	NA	100Hz	100Hz
COMPASS	20Hz	20Hz	NA	20Hz	20Hz	20Hz	NA	20Hz
M4G	50Hz	50Hz	NA	50Hz	50Hz	50Hz	NA	50Hz
NDOF_FMC_OFF	100Hz	20Hz	100Hz	100Hz	100Hz	20Hz	100Hz	100Hz
NDOF	100Hz	20Hz	100Hz	100Hz	100Hz	20Hz	100Hz	100Hz

3.7.3.2.3 UI_MODE

Table 3-14: UI_MODE

BNO055 Operating Mode	Data input rate			Algo calling rate	Data output rate			
	Accel	**Mag**	**Gyro**		**Accel**	**Mag**	**Gyro**	**Fusion data**
IMU	100Hz	NA	100Hz	100Hz	100Hz	NA	100Hz	100Hz
COMPASS	20Hz	20Hz	NA	20Hz	20Hz	20Hz	NA	20Hz
M4G	50Hz	50Hz	NA	50Hz	50Hz	50Hz	NA	50Hz
NDOF_FMC_OFF	100Hz	20Hz	100Hz	100Hz	100Hz	20Hz	100Hz	100Hz
NDOF	100Hz	20Hz	100Hz	100Hz	100Hz	20Hz	100Hz	100Hz

3.7.3.2.4 NORMAL_MODE

Table 3-15: NORMAL_MODE

BNO055 Operating Mode	Data input rate			Algo calling rate	Data output rate			
	Accel	**Mag**	**Gyro**		**Accel**	**Mag**	**Gyro**	**Fusion data**
IMU	100Hz	NA	100Hz	100Hz	100Hz	NA	100Hz	100Hz
COMPASS	20Hz	20Hz	NA	20Hz	20Hz	20Hz	NA	20Hz
M4G	50Hz	50Hz	NA	50Hz	50Hz	50Hz	NA	50Hz
NDOF_FMC_OFF	100Hz	20Hz	100Hz	100Hz	100Hz	20Hz	100Hz	100Hz
NDOF	100Hz	20Hz	100Hz	100Hz	100Hz	20Hz	100Hz	100Hz

3.7.3.3 Soft iron correction matrix (SIC)

The soft iron correction matrix feature should only be used if a distortion free magnetic environment is available to create the required matrix, for further details please refer to the appropriate application note.

3.7.3.4 Sensor offset

3.7.3.4.1 Accelerometer offset

The accelerometer offset can be configured in the following registers,

Reg Name	Default Reg Value (Bit 0 – Bit 7)
ACC_OFFSET_X_LSB	0x00
ACC_OFFSET_X_MSB	0x00
ACC_OFFSET_Y_LSB	0x00
ACC_OFFSET_Y_MSB	0x00
ACC_OFFSET_Z_LSB	0x00
ACC_OFFSET_Z_MSB	0x00

There are 6 bytes required to configure the accelerometer offset (2 bytes for each of the 3 axis X, Y and Z). Configuration will take place only when the user writes the last byte (i.e., ACC_OFFSET_Z_MSB). Therefore the last byte must be written whenever the user wants to changes the configuration. The range of the offsets varies based on the G-range of accelerometer sensor.

Accelerometer G-range	Maximum Offset range in mg
2G	+/- 2000
4G	+/- 4000
8G	+/- 8000
16G	+/- 16000

Unit	Representation
m/s^2	1 m/s^2 = 100 LSB
mg	1 mg = 1 LSB

3.7.3.4.2 Magnetometer offset

The magnetometer offset can be configured in the following registers,

Reg Name	Default Reg Value (Bit 0 – Bit 7)
MAG_OFFSET_X_LSB	0x00
MAG_OFFSET_X_MSB	0x00
MAG_OFFSET_Y_LSB	0x00
MAG_OFFSET_Y_MSB	0x00
MAG_OFFSET_Z_LSB	0x00
MAG_OFFSET_Z_MSB	0x00

There are 6 bytes required to configure the magnetometer offset (bytes (2 bytes for each of the 3 axis X, Y and Z). Configuration will take place only when the user writes the last byte (i.e., MAG_OFFSET_Z_MSB). Therefore the last byte must be written whenever the user wants to changes the configuration. The range of the magnetometer offset is +/-6400 in LSB.

Unit	Representation
µT	1 µT = 16 LSB

3.7.3.4.3 Gyroscope offset

The gyroscope offset can be configured in the following registers,

Reg Name	Default Reg Value (Bit 0 – Bit 7)
GYR_OFFSET_X_LSB	0x00
GYR_OFFSET_X_MSB	0x00
GYR_OFFSET_Y_LSB	0x00
GYR_OFFSET_Y_MSB	0x00
GYR_OFFSET_Z_LSB	0x00
GYR_OFFSET_Z_MSB	0x00

There are 6 bytes required to configure the gyroscope offset (bytes (2 bytes for each of the 3 axis X, Y and Z). Configuration will take place only when the user writes the last byte (i.e., GYR_OFFSET_Z_MSB). Therefore the last byte must be written whenever the user wants to changes the configuration. The range of the offset varies based on the dps-range of gyroscope sensor.

Gyroscope dps range	Maximum Offset range in LSB
2000	+/- 32000
1000	+/- 16000
500	+/- 8000
250	+/- 4000
125	+/- 2000

Unit	Representation
Dps	1 Dps = 16 LSB
Rps	1 Rps = 900 LSB

3.7.3.5 Radius

The radius of accelerometer, magnetometer and gyroscope can be configured in the following registers,

Reg Name	Default Reg Value (Bit 0 – Bit 7)
ACC_RADIUS_LSB	0x00
ACC_RADIUS_MSB	0x00
MAG_RADIUS_LSB	0x00
MAG_RADIUS_MSB	0x00

There are 4 bytes (2 bytes for each accelerometer and magnetometer) to configure the radius. Configuration will take place only when user writes to the last byte (i.e., ACC_RADIUS_MSB and MAG_RADIUS_MSB). Therefore the last byte must be written whenever the user wants to changes the configuration. The range of the radius for accelerometer is +/-1000, magnetometer is +/-960 and Gyroscope is NA.

Radius for sensor	Maximum Range
Accelerometer	+/- 1000 LSB
Magnetometer	+/- 960 LSB

Accelerometer Unit	Representation
m/s^2	1 m/s^2 = 100 LSB
mg	1 mg = 1 LSB

Magnetometer Unit	Representation
µT	1 µT = 16 LSB

3.7.4 **Output data registers**

3.7.4.1 Acceleration data

In sensor mode uncompensated acceleration data for each axis X/Y/Z, can be read from the appropriate ACC_DATA_<axis>_LSB and ACC_DATA_<axis>_MSB registers.

In fusion mode the fusion algorithm output offset compensated acceleration data for each axis X/Y/Z, the output data can be read from the appropriate ACC_DATA_<axis>_LSB and ACC_DATA_<axis>_MSB registers.

Table 3-16 and Table 3-17 describe the output data type and data representation (depending on selected unit, see Table 3-9)

Table 3-16: Acceleration data

Parameter	Data type	bytes
Accel_Data_X	signed	2
Accel_Data_Y	signed	2
Accel_Data_Z	signed	2

Table 3-17: Acceleration data representation

Unit	Representation
m/s^2	1 m/s^2 = 100 LSB
mg	1 mg = 1 LSB

3.7.4.2 Magnetic Field Strength

In sensor mode uncompensated field strength data for each axis X/Y/Z, can be read from the appropriate MAG_DATA_<axis>_LSB and MAG_DATA_<axis>_MSB registers.

In fusion mode the fusion algorithm output offset compensated magnetic field strength data for each axis X/Y/Z, the output data can be read from the appropriate MAG_DATA_<axis>_LSB and MAG_DATA_<axis>_MSB registers.

Table 3-18 and Table 3-19 describe the output data type and data representation (depending on selected unit, see Table 3-9)

Table 3-18: Magnetic field strength data

Parameter	Data type	bytes
Mag_Data_X	signed	2
Mag_Data_Y	signed	2
Mag_Data_Z	signed	2

Table 3-19: Magnetic field strength data representation

Unit	Representation
µT	1 µT = 16 LSB

3.7.4.3 Angular Velocity

In sensor mode uncompensated angular velocity (yaw rate) data for each axis X/Y/Z, can be read from the appropriate GYR_DATA_<axis>_LSB and GYR_DATA_<axis>_MSB registers.

In fusion mode the fusion algorithm output offset compensated angular velocity (yaw rate) data for each axis X/Y/Z, the output data can be read from the appropriate GYR_DATA_<axis>_LSB and GYR_DATA_<axis>_MSB registers.

Table 3-20 and Table 3-21 describe the output data type and data representation (depending on selected unit, see Table 3-9)

Table 3-20: Yaw rate data

Parameter	Data type	bytes
Gyr_Data_X	signed	2
Gyr_Data_Y	signed	2
Gyr_Data_Z	signed	2

Table 3-21: Angular rate data representation

Unit	Representation
Dps	1 Dps = 16 LSB
Rps	1 Rps = 900 LSB

3.7.4.4 Orientation (Euler angles)

Orientation output only available in fusion operation modes.

The fusion algorithm output offset and tilt compensated orientation data in Euler angles format for each DOF Heading/Roll/Pitch, the output data can be read from the appropriate EUL<dof>_LSB and EUL_<dof>_MSB registers.

Table 3-22 and Table 3-23 describe the output data type and data representation (depending on selected unit, see Table 3-9)

Table 3-22: Compensated orientation data in Euler angles format

Parameter	Data type	bytes
EUL_Heading	Signed	2
EUL_Roll	Signed	2
EUL_Pitch	Signed	2

Table 3-23: Euler angle data representation

Unit	Representation
Degrees	1 degree = 16 LSB
Radians	1 radian = 900 LSB

3.7.4.5 Orientation (Quaternion)

Orientation output only available in fusion operating modes.

The fusion algorithm output offset and tilt compensated orientation data in quaternion format for each DOF w/x/y/z, the output data can be read from the appropriate QUA_DATA_<dof>_LSB and QUA_DATA_<dof>_MSB registers.

Table 3-24 and Table 3-25 describe the output data type and data representation

Table 3-24: Compensated orientation data in quaternion format

Parameter	Data type	bytes
QUA_Data_w	Signed	2
QUA_Data_x	Signed	2
QUA_Data_y	Signed	2
QUA_Data_z	Signed	2

Table 3-25: Quaternion data representation

Unit	Representation
Quaternion (unit less)	1 Quaternion (unit less) = 2^14 LSB

3.7.4.6 Linear Acceleration

Linear acceleration output only available in fusion operating modes.

The fusion algorithm output linear acceleration data for each axis x/y/z, the output data can be read from the appropriate LIA_DATA_<axis>_LSB and LIA_DATA_<axis>_MSB registers.

Table 3-26 and Table 3-27 describe the output data type and data representation (depending on selected unit, see Table 3-9).

Table 3-26: Linear Acceleration Data

Parameter	Data type	bytes
LIA_Data_X	signed	2
LIA_Data_Y	signed	2
LIA_Data_Z	signed	2

Table 3-27: Linear Acceleration data representation

Unit	Representation
m/s^2	1 m/s^2 = 100 LSB
mg	1 mg = 1 LSB

3.7.4.7 Gravity Vector

Gravity Vector output only available in fusion operating modes.

The fusion algorithm output gravity vector data for each axis x/y/z, the output data can be read from the appropriate GRV_DATA_<axis>_LSB and GRV_DATA_<axis>_MSB registers.

Table 3-28 and Table 3-29 describe the output data type and data representation (depending on selected unit, see Table 3-9).

Table 3-28: Gravity Vector Data

Parameter	Data type	bytes
GRV_Data_X	signed	2
GRV_Data_Y	signed	2
GRV_Data_Z	signed	2

Table 3-29: Gravity Vector data representation

Unit	Representation
m/s^2	1 m/s^2 = 100 LSB
mg	1 mg = 1 LSB

3.7.4.8 Temperature

The temperature output data can be read from the TEMP register. Table 3-30 and Table 3-31 describe the output data type and data representation (depending on selected unit, see Table 3-9).
The temperature can be read from one of two sources, the temperature source can be selected by writing to the TEMP_SOURCE register as detailed in Table 3-32.

Table 3-30: Temperature Data

Parameter	Data type	bytes
TEMP	signed	1

Table 3-31: Temperature data representation

Unit	Representation
°C	1°C = 1 LSB
F	2 F = 1 LSB

Table 3-32: Temperature Source Selection

Source	[Reg Addr]: Register Value
Accelerometer	[TEMP_SOURCE]: xxxxxx00b
Gyroscope	[TEMP_SOURCE]: xxxxxx01b

3.7.4.9 Revision Id

The revision id for accelerometer, magnetometer and gyroscope can be read from the following register:

Parameter	Data type	bytes
ACC_REV_ID	unsigned	1
MAG_REV_ID	Unsigned	1
GYR_REV_ID	unsigned	1

3.7.5 **Interrupts**

3.7.5.1 Interrupt Pin

INT is configured as interrupt pin for signaling an interrupt to the host. The interrupt trigger is configured as raising edge and is latched on to the INT pin. Once an interrupt occurs, the INT pin is set to high and will remain high until it is reset by host. This can be done by setting RST_INT in SYS_TRIGGER register.

3.7.5.2 Interrupt Enable/Disable

Interrupts can be enabled by setting the corresponding bit in the interrupt enable register (INT_EN) and disabled when it is cleared.

3.7.5.3 Interrupt Pin Masking

Interrupts can be routed to the INT pin by setting the corresponding interrupt bit in the INT_MSK register.

3.7.5.4 Interrupt Status

Interrupt occurrences are stored in the interrupt status register (INT_STA). All bits in this register are cleared on read.

3.7.5.5 Interrupt Settings

3.7.5.5.1 Accelerometer Slow/No Motion Interrupt

The slow-motion/no-motion interrupt engine can be configured in two modes.

In slow-motion mode an interrupt is triggered when the measured slope of at least one enabled axis exceeds the programmable slope threshold for a programmable number of samples. Hence the engine behaves similar to the any-motion interrupt, but with a different set of parameters. In order to suppress false triggers, the interrupt is only generated (cleared) if a certain number *N* of consecutive slope data points is larger (smaller) than the slope threshold given by *slo_no_mot_dur<1:0>*. The number is *N* = *slo_no_mot_dur<1:0>* + 1.

In no-motion mode an interrupt is generated if the slope on all selected axes remains smaller than a programmable threshold for a programmable delay time. Figure 11 shows the timing diagram for the no-motion interrupt. The scaling of the threshold value is identical to that of the slow-motion interrupt. However, in no-motion mode register slo_no_mot_dur defines the delay time before the no-motion interrupt is triggered. Table 3-33 lists the delay times adjustable with register slo_no_mot_dur. The timer tick period is 1 second. Hence using short delay times can result in considerable timing uncertainty.

If bit *SM/NM* is set to '1' ('0'), the no-motion/slow-motion interrupt engine is configured in the no-motion (slow-motion) mode. Common to both modes, the engine monitors the slopes of the axes that have been enabled with bits *AM/NM_X_AXIS*, *AM/NM_Y_AXIS*, and *AM/NM_Z_AXIS* for the x-axis, y-axis and z-axis, respectively. The measured slope values are continuously compared against the threshold value defined in register ACC_NM_THRES. The scaling is such that 1 LSB of ACC_NM_THRES corresponds to 3.91 mg in 2g-range (7.81 mg in 4g-range, 15.6 mg in 8g-range and 31.3 mg in 16g-range). Therefore the maximum value is 996 mg in 2g-range (1.99g in 4g-range, 3.98g in 8g-range and 7.97g in 16g-range). The time difference between the successive acceleration samples depends on the selected bandwidth and equates to 1/(2 * bw).

Table 3-33: No-motion time-out periods

slo_no_mot_dur	**Delay time**	*slo_no_mot_dur*	*Delay time*	*slo_no_mot_dur*	*Delay Time*
0	1 s	16	40 s	32	88 s
1	2 s	17	48 s	33	96 s
2	3 s	18	56 s	34	104 s
...	...	19	64 s.	...	...
14	15 s	20	72 s	62	328 s
15	16 s	21	80 s	63	336 s

Note: slo_no_mot_dur values 22 to 31 are not specified

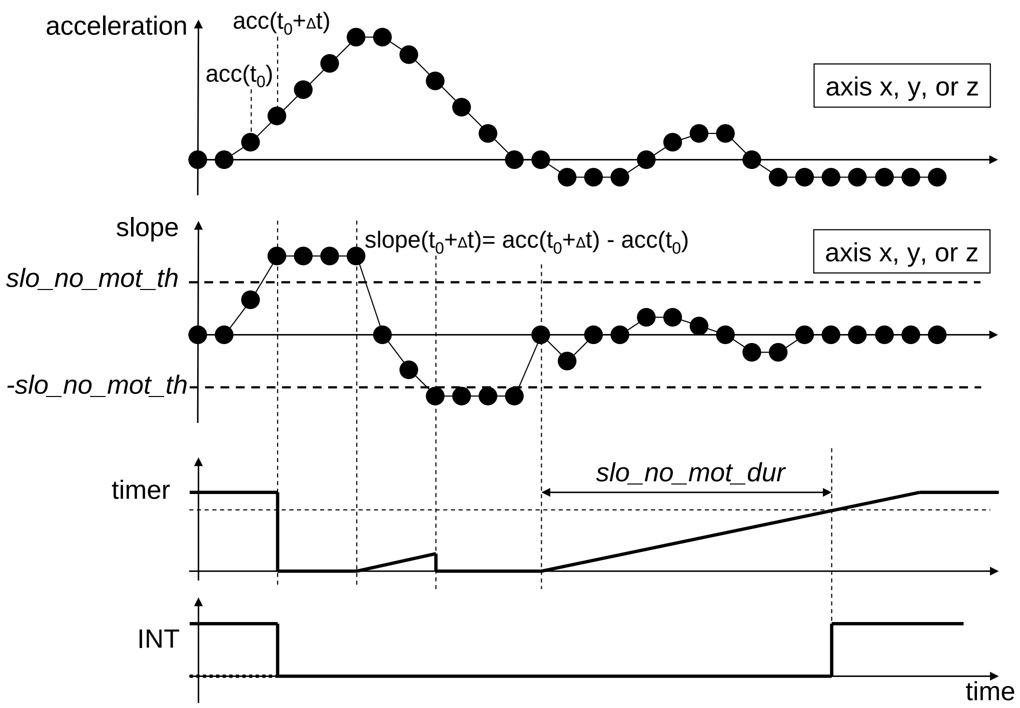


Table 3-34: Timing of No-motion interrupt

Params	Value	[Reg Addr]: Register Value
Detection Type	No Motion	[ACC_NM_SET]: xxxxxxx0b
	Slow Motion	[ACC_NM_SET]: xxxxxxx1b
Interrupt Parameters	Threshold	[ACC_NM_THRE]: bit7:bit0
	Duration	[ACC_NM_SET]: bit6:bit1
Axis selection	X-axis	[ACC_INT_Settings]: xxxxx1xxb
	Y-axis	[ACC_INT_Settings]: xxxx1xxxb
	Z-axis	[ACC_INT_Settings]: xxx1xxxxb

3.7.5.5.2 Accelerometer Any Motion Interrupt

The any-motion interrupt uses the slope between successive acceleration signals to detect changes in motion. An interrupt is generated when the slope (absolute value of acceleration difference) exceeds a preset threshold. It is cleared as soon as the slope falls below the threshold. The principle is made clear in Figure 2: Principle of any-motion detection.

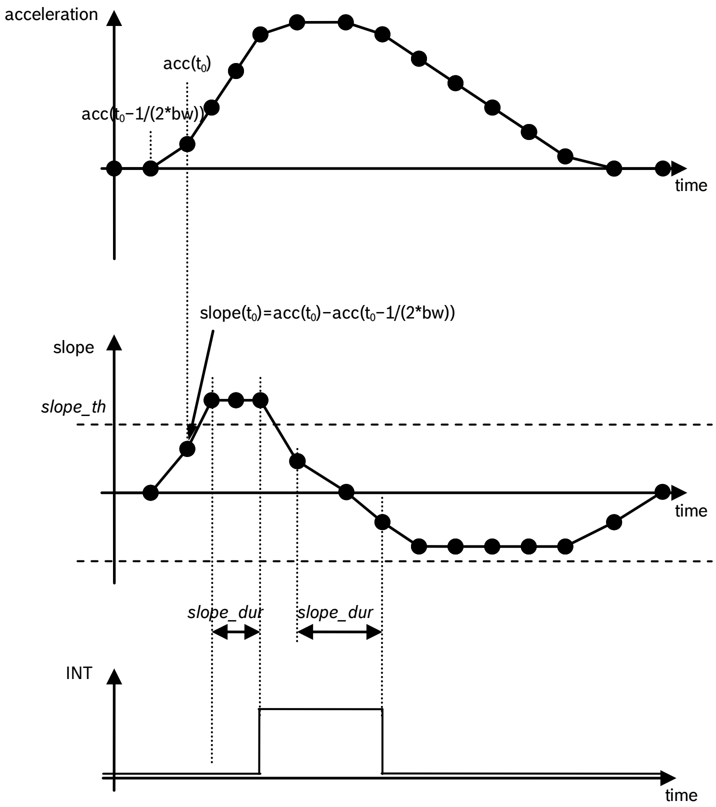


Figure 2: Principle of any-motion detection

The threshold is defined through register ACC_AM_THRES. In terms of scaling 1 LSB of ACC_AM_THRES corresponds to 3.91 mg in 2g-range (7.81 mg in 4g-range, 15.6 mg in 8g-range and 31.3 mg in 16g-range). Therefore the maximum value is 996 mg in 2g-range (1.99g in 4g-range, 3.98g in 8g-range and 7.97g in 16g-range).

The time difference between the successive acceleration signals depends on the selected bandwidth and equates to 1/(2*bandwidth) ()t=1/(2*bw)). In order to suppress false triggers, the interrupt is only generated (cleared) if a certain number *N* of consecutive slope data points is larger (smaller) than the slope threshold given by ACC_AM_THRES. This number is set by the AM_DUR bits. It is N = AM_DUR + 1.

Example: *AM_DUR* = 00b, ..., 11b = 1decimal, ..., 4decimal.

3.7.5.5.2.1 Enabling (disabling) for each axis

Any-motion detection can be enabled (disabled) for each axis separately by writing ´1´ (´0´) to bits AM/NM_X_AXIS, AM/NM_Y_AXIS, AM/NM_Z_AXIS. The criteria for any-motion detection are fulfilled and the slope interrupt is generated if the slope of any of the enabled axes exceeds the threshold ACC_AM_THRES for [AM_DUR +1] consecutive times. As soon as the slopes of all enabled axes fall or stay below this threshold for [AM_DUR +1] consecutive times the interrupt is cleared unless interrupt signal is latched.

Params	**Value**	**[Reg Addr]: Register Value**
Interrupt Parameters	Threshold	[ACC_AM_THRES]: bit7:bit0
	Duration	[ACC_INT_Settings]: bit1:bit0
Axis selection	X-axis	[ACC_INT_Settings]: xxxxx1xxb
	Y-axis	[ACC_INT_Settings]: xxxx1xxxb
	Z-axis	[ACC_INT_Settings]: xxx1xxxxb

3.7.5.5.3 Accelerometer High G Interrupt

This interrupt is based on the comparison of acceleration data against a high-g threshold for the detection of shock or other high-acceleration events.

The high-g interrupt is enabled (disabled) per axis by writing ´1´ (´0´) to bits ACC_HIGH_G in the INT_EN register and enabling the axis in with bits HG_X_AXIS, HG_Y_AXIS, and HG_Z_AXIS, respectively in the ACC_INT_Settings register. The high-g threshold is set through the ACC_HG_THRES register. The meaning of an LSB of ACC_HG_THRES depends on the selected g-range: it corresponds to 7.81 mg in 2g-range, 15.63 mg in 4g-range, 31.25 mg in 8g-range, and 62.5 mg in 16g-range (i.e. increment depends from g-range setting).

The high-g interrupt is generated if the absolute value of the acceleration of at least one of the enabled axes (´or´ relation) is higher than the threshold for at least the time defined by the ACC_HG_DURATION register. The interrupt is reset if the absolute value of the acceleration of all enabled axes (´and´ relation) is lower than the threshold for at least the time defined by the ACC_HG_DURATION register. The interrupt status is stored in bit ACC_HIGH_G in the INT_STA register. The relation between the content of ACC_HG_DURATION and the actual delay of the interrupt generation is delay [ms] = [ACC_HG_DURATION + 1] * 2 ms. Therefore, possible delay times range from 2 ms to 512 ms.

Params	**Value**	**[Reg Addr]: Register Value**
Interrupt Parameters	Threshold	[ACC_HG_THRES]: bit7 : bit0
	Duration	[ACC_HG_DURATION]: bit7 : bit0
Axis selection	X-axis	[ACC_INT_Settings]: xx1xxxxxb
	Y-axis	[ACC_INT_Settings]: x1xxxxxxb
	Z-axis	[ACC_INT_Settings]: 1xxxxxxxb

3.7.5.5.4 Gyroscope High Rate Interrupt

This interrupt is based on the comparison of angular rate data against a high-rate threshold for the detection of shock or other high-angular rate events. The principle is made clear in Figure 3 below:

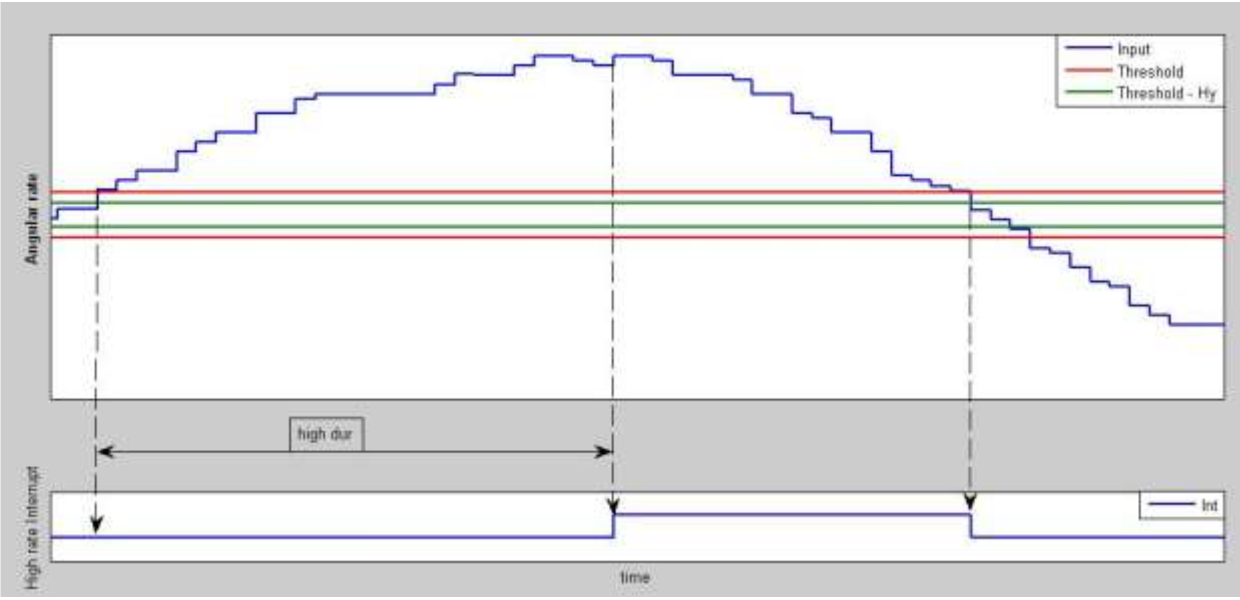


Figure 3: High rate interrupt

The high-rate interrupt is enabled (disabled) per axis by writing ´1´ (´0´) to bits *GYRO_HIGH_RATE* in the *INT_EN* register and for each axis by writing to the *HR_X_AXIS*, *HR_Y_AXIS*, and *HR_Z_AXIS*, respectively in the GYR_INT_SETTING register. The high-rate threshold is set through the *HR_<axis>_*Threshold bits in the appropriate *GYR_HR_<axis>_SET register*. The meaning of an LSB of *HR_<axis>_Threshold* depends on the selected °/s-range: it corresponds to 62.5°/s in 2000°/s-range, 31.25°/s in 1000°/s-range, 15.625°/s in 500°/s -range …). The *HR_<axis>_Threshold* register setting 0 corresponds to 62.26°/s in 2000°/s-range, 31.13°/s in 1000°/s-range, 15.56°/s in 500°/s-range …. Therefore the maximum value is 1999.76°/s in 2000°/s-range (999.87°/s 1000°/s-range, 499.93°/s in 500°/s -range …).
A hysteresis can be selected by setting the *HR_<axis>_THRES_HYST* bits. Analogously to threshold, the meaning of an LSB of *HR_<axis>_THRES_HYST* bits is °/s-range dependent: The *HR_<axis>_THRES_HYST* register setting 0 corresponds to an angular rate difference of 62.26°/s in 2000°/s-range, 31.13°/s in 1000°/s-range, 15.56°/s in 500°/s-range …. The meaning of an LSB of *HR_<axis>_THRES_HYST* depends on the selected °/s-range too: it corresponds to 62.5°/s in 2000°/s-range, 31.25°/s in 1000°/s-range, 15.625°/s in 500°/s -range …).

The high-rate interrupt is generated if the absolute value of the angular rate of at least one of the enabled axes (´or´ relation) is higher than the threshold for at least the time defined by the *GYR_DUR_<axis>* register. The interrupt is reset if the absolute value of the angular rate of all enabled axes (´and´ relation) is lower than the threshold minus the hysteresis. In bit *GYR_HIGH_RATE* in the *INT_STA* the interrupt status is stored. The relation between the content of *GYR_DUR_<axis>* and the actual delay of the interrupt generation is delay [ms] = [*GYR_DUR_<axis>* + 1] * 2.5 ms. Therefore, possible delay times range from 2.5 ms to 640 ms.

Params	Value	[Reg Addr]: Register Value
Axis selection	X-axis	[GYR_INT_SETTING]: xxxx1xxxb
	Y-axis	[GYR_INT_SETTING]: xxx1xxxxb
	Z-axis	[GYR_INT_SETTING]: xx1xxxxxb
High Rate Filter settings	Filtered	[GYR_INT_SETTING]: 0xxxxxxxb
	Unfiltered	[GYR_INT_SETTING]: 1xxxxxxxb
Interrupt Settings X-axis	Threshold	[GYR_HR_X_SET]: bit4 : bit0
	Duration	[GYR_DUR_X]: bit7 : bit0
	Hysteresis	[GYR_HR_X_SET]: bit6 : bit5
Interrupt Settings Y-axis	Threshold	[GYR_HR_Y_SET]: bit4 : bit0
	Duration	[GYR_DUR_Y]: bit7 : bit0
	Hysteresis	[GYR_HR_Y_SET]: bit6 : bit5
Interrupt Settings X-axis	Threshold	[GYR_HR_Z_SET]: bit4 : bit0
	Duration	[GYR_DUR_Z]: bit7 : bit0
	Hysteresis	[GYR_HR_Z_SET]: bit6 : bit5

3.7.5.5.5 Gyroscope Any Motion Interrupt

Any-motion (slope) detection uses the slope between successive angular rate signals to detect changes in motion. An interrupt is generated when the slope (absolute value of angular rate difference) exceeds a preset threshold. It is cleared as soon as the slope falls below the threshold. The principle is made clear in Figure 4.

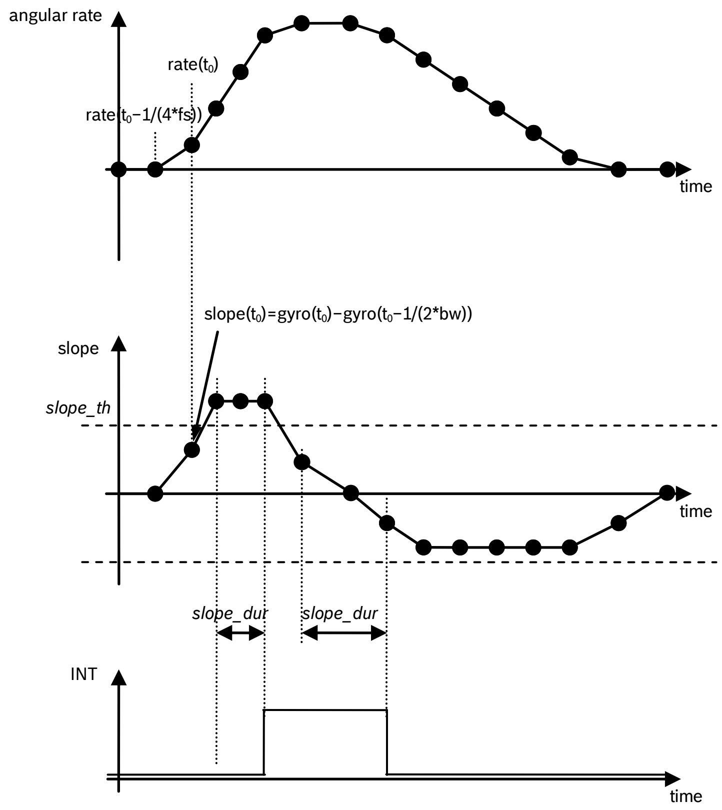


Figure 4: Principle of any-motion detection

The threshold is defined through register GYR_AM_THRES. In terms of scaling 1 LSB of GYR_AM_THRES corresponds to 1 °/s in 2000°/s-range (0.5°/s in 1000°/s-range, 0.25°/s in 500°/s -range ...). Therefore the maximum value is 125°/s in 2000°/s-range (62.5°/s 1000°/s-range, 31.25 in 500°/s -range ...).

The time difference between the successive angular rate signals depends on the selected update rate(fs) which is coupled to the bandwidth and equates to 1/(4*fs) (t=1/(4*fs)). For bandwidth settings with an update rate higher than 400Hz (bandwidth =0,1,2) fs is set to 400Hz.

In order to suppress false triggers, the interrupt is only generated (cleared) if a certain number *N* of consecutive slope data points is larger (smaller) than the slope threshold given by GYR_AM_THRES. This number is set by the Slope Samples bits in the GYR_AM_SET register. It is *N* = [Slope Samples + 1]*4. N is set in samples. Thus the time is scaling with the update rate (fs).

3.7.5.5.5.1 Enabling (disabling) for each axis
Any-motion detection can be enabled (disabled) for each axis separately by writing ´1´ (´0´) to bits *HR_X_AXIS*, *HR_Y_AXIS*, *HR_Z_AXIS in the GYR_INT_SETTING register*. The criteria for any-motion detection are fulfilled and the Any-Motion interrupt is generated if the slope of any of the enabled axes exceeds the threshold GYR_AM_THRES for [Slope Samples+1]*4 consecutive times. As soon as the slopes of all enabled axes fall or stay below this threshold for [Slope Samples +1]*4 consecutive times the interrupt is cleared unless interrupt signal is latched.

3.7.5.5.5.2 Axis of slope / any motion interrupt
The interrupt status is stored in bit *GYRO_AM* in the *INT_EN* register. The Any-motion interrupt supplies additional information about the detected slope.

Params	**Value**	**[Reg Addr]: Register Value**
Axis selection	X-axis	[GYR_INT_SETING]: xxxxxxx1b
	Y-axis	[GYR_INT_SETING]: xxxxxx1xb
	Z-axis	[GYR_INT_SETING]: xxxxx1xxb
Any Motion Filter settings	Filtered	[GYR_INT_SETING]: x0xxxxxxb
	Unfiltered	[GYR_INT_SETING]: x1xxxxxxb
Interrupt Settings	Threshold	[GYR_AM_THRES]: bit6 : bit0
	Slope Samples	[GYR_AM_SET]: bit1 : bit0
	Awake Duration	[GYR_AM_SET]: bit3 : bit2

3.7.6 **Self-Test**

3.7.6.1 Power on Self Test (POST)

During the device startup, a power on self test is executed. This feature checks that the connected sensors and microcontroller are responding / functioning correctly. Following tests are executed

Components	**Test type**
Accelerometer	Verify chip ID
Magnetometer	Verify chip ID
Gyroscope	Verify chip ID
Microcontroller	MBIST test

The results of the POST are stored at register ST_RESULT, were a bit set indicates test passed and cleared indicates self test failed.

3.7.6.2 Self-Test (BIST)

The host can trigger a self test from CONFIG MODE. The test can be triggered by setting bit SELF_TEST in the in the SYS_TRIGGER register, the results are stored in the ST_RESULT register. During the execution of the system test, all other features are paused.

Components	**Test type**
Accelerometer	built in self test
Magnetometer	built in self test
Gyroscope	built in self test
Microcontroller	No test performed

3.7.7 **Boot loader**

The boot loader is located at the start of the program memory and it is executed at each reset / power-on sequence. The boot loader first checks the status of a BOOT_LOAD_PIN.

If the BOOT_LOAD_PIN is pulled low during reset / power-on sequence, it continues execution in boot loader mode. Otherwise the device continues to boot in application mode.

For more details on the boot loader please contact your local Bosch Sensortec sales representative and ask for the “BNO Boot loader application note” document.

4. Register description

4.1 General Remarks

The entire communication with the device is performed by reading from and writing to registers. Registers have a width of 8 bits. There are several registers which are either completely or partially marked as ‘reserved’. Any reserved bit is ignored when it is written and no specific value is guaranteed when read. It is recommended not to use registers at all which are completely marked as ‘reserved’. Furthermore it is recommended to mask out (logical and with zero) reserved bits of registers which are partially marked as reserved.

Read-Only Registers are marked as shown in Table 4-1: Register Access Coding. Any attempt to write to these registers is ignored.
There are bits within some registers that trigger internal sequences. These bits are configured for write-only access and read as value ´0´.

4.2 Register map

The register map is separated into two logical pages, Page 1 contains sensor specific configuration data and Page 0 contains all other configuration parameters and output data.

At power-on Page 0 is selected, the PAGE_ID register can be used to identify the current selected page and change between page 0 and page 1.

4.2.1 **Register map Page 0**

Table 4-1: Register Access Coding

read/write	read only	write only	reserved

Table 4-2: Register Map Page 0

Register Address	Register Name	Default Value	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
7F-6B	Reserved	NA								
6A	MAG_RADIUS_MSB		Magnetometer Radius							
69	MAG_RADIUS_LSB		Magnetometer Radius							
68	ACC_RADIUS_MSB		Accelerometer Radius							
67	ACC_RADIUS_LSB		Accelerometer Radius							
66	GYR_OFFSET_Z_MSB	0x00	Gyroscope Offset Z <15:8>							
65	GYR_OFFSET_Z_LSB	0x00	Gyroscope Offset Z <7:0>							
64	GYR_OFFSET_Y_MSB	0x00	Gyroscope Offset Y <15:8>							
63	GYR_OFFSET_Y_LSB	0x00	Gyroscope Offset Y <7:0>							
62	GYR_OFFSET_X_MSB	0x00	Gyroscope Offset X <15:8>							
61	GYR_OFFSET_X_LSB	0x00	Gyroscope Offset X <7:0>							
60	MAG_OFFSET_Z_MSB	0x00	Magnetometer Offset Z <15:8>							
5F	MAG_OFFSET_Z_LSB	0x00	Magnetometer Offset Z <7:0>							
5E	MAG_OFFSET_Y_MSB	0x00	Magnetometer Offset Y <15:8>							
5D	MAG_OFFSET_Y_LSB	0x00	Magnetometer Offset Y <7:0>							
5C	MAG_OFFSET_X_MSB	0x00	Magnetometer Offset X <15:8>							
5B	MAG_OFFSET_X_LSB	0x00	Magnetometer Offset X <7:0>							
5A	ACC_OFFSET_Z_MSB	0x00	Accelerometer Offset Z <15:8>							
59	ACC_OFFSET_Z_LSB	0x00	Accelerometer Offset Z <7:0>							
58	ACC_OFFSET_Y_MSB	0x00	Accelerometer Offset Y <15:8>							
57	ACC_OFFSET_Y_LSB	0x00	Accelerometer Offset Y <7:0>							
56	ACC_OFFSET_X_MSB	0x00	Accelerometer Offset X <15:8>							
55	ACC_OFFSET_X_LSB	0x00	Accelerometer Offset X <7:0>							
43 - 54	SIC_MATRIX	0x00	Reserved for Soft Iron Calibration Matrix							

Register Address	Register Name	Default Value	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
42	AXIS_MAP_SIGN	TBD						Remapped X axis sign	Remapped Y axis sign	Remapped Z axis sign
41	AXIS_MAP_CONFIG	TBD			Remapped Z axis value		Remapped Y axis value		Remapped X axis value	
40	TEMP_SOURCE	0x02							TEMP_Source <1:0>	
3F	SYS_TRIGGER	0x00	CLK_SEL	RST_INT	RST_SYS					Self_Test
3E	PWR_MODE	0x00							Power Mode <1:0>	
3D	OPR_MODE	0x1C		Output Data Rate <2:0>			Operation Mode <3:0>			
3C	Reserved	0xFF								
3B	UNIT_SEL	0x00	ORI_Android_Windows			TEMP_Unit		EUL_Unit	GYR_Unit	ACC_Unit
3A	SYS_ERR	0x00	System Error Code							
39	SYS_STATUS	0x00	System Status Code							
38	SYS_CLK_STATUS	0x00								ST_MAIN_CLK
37	INT_STA	0x00	ACC_NM	ACC_AM	ACC_HIGH_G		GYR_HIGH_RATE	GYRO_AM		
36	ST_RESULT	0x0F					ST_MCU	ST_GYR	ST_MAG	ST_ACC
35	CALIB_STAT	0x00	SYS Calib Status 0:3		GYR Calib Status 0:3		ACC Calib Status 0:3		MAG Calib Status 0:3	
34	TEMP	0x00	Temperature							
33	GRV_Data_Z_MSB	0x00	Gravity Vector Data Z <15:8>							
32	GRV_Data_Z_LSB	0x00	Gravity Vector Data Z <7:0>							
31	GRV_Data_Y_MSB	0x00	Gravity Vector Data Y <15:8>							
30	GRV_Data_Y_LSB	0x00	Gravity Vector Data Y <7:0>							
2F	GRV_Data_X_MSB	0x00	Gravity Vector Data X <15:8>							
2E	GRV_Data_X_LSB	0x00	Gravity Vector Data X <7:0>							
2D	LIA_Data_Z_MBS	0x00	Linear Acceleration Data Z <15:8>							
2C	LIA_Data_Z_LSB	0x00	Linear Acceleration Data Z <7:0>							
2B	LIA_Data_Y_MBS	0x00	Linear Acceleration Data Y <15:8>							
2A	LIA_Data_Y_LSB	0x00	Linear Acceleration Data Y <7:0>							
29	LIA_Data_X_MBS	0x00	Linear Acceleration Data X <15:8>							
28	LIA_Data_X_LSB	0x00	Linear Acceleration Data X <7:0>							
27	QUA_Data_z_MSB	0x00	Quaternion z Data <15:8>							
26	QUA_Data_z_LSB	0x00	Quaternion z Data <7:0>							
25	QUA_Data_y_MSB	0x00	Quaternion y Data <15:8>							
24	QUA_Data_y_LSB	0x00	Quaternion y Data <7:0>							
23	QUA_Data_x_MSB	0x00	Quaternion x Data <15:8>							
22	QUA_Data_x_LSB	0x00	Quaternion x Data <7:0>							
21	QUA_Data_w_MSB	0x00	Quaternion w Data <15:8>							
20	QUA_Data_w_LSB	0x00	Quaternion w Data <7:0>							

Register Address	Register Name	Default Value	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
1F	EUL_Pitch_MSB	0x00	Pitch Data <15:8>							
1E	EUL_Pitch_LSB	0x00	Pitch Data <7:0>							
1D	EUL_Roll_MSB	0x00	Roll Data <15:8>							
1C	EUL_Roll_LSB	0x00	Roll Data <7:0>							
1B	EUL_Heading_MSB	0x00	Heading Data <15:8>							
1A	EUL_Heading_LSB	0x00	Heading Data <7:0>							
19	GYR_DATA_Z_MSB	0x00	Gyroscope Data Z <15:8>							
18	GYR_DATA_Z_LSB	0x00	Gyroscope Data Z <7:0>							
17	GYR_DATA_Y_MSB	0x00	Gyroscope Data Y <15:8>							
16	GYR_DATA_Y_LSB	0x00	Gyroscope Data Y <7:0>							
15	GYR_DATA_X_MSB	0x00	Gyroscope Data X <15:8>							
14	GYR_DATA_X_LSB	0x00	Gyroscope Data X <7:0>							
13	MAG_DATA_Z_MSB	0x00	Magnetometer Data Z <15:8>							
12	MAG_DATA_Z_LSB	0x00	Magnetometer Data Z <7:0>							
11	MAG_DATA_Y_MSB	0x00	Magnetometer Data Y <15:8>							
10	MAG_DATA_Y_LSB	0x00	Magnetometer Data Y <7:0>							
F	MAG_DATA_X_MSB	0x00	Magnetometer Data X <15:8>							
E	MAG_DATA_X_LSB	0x00	Magnetometer Data X <7:0>							
D	ACC_DATA_Z_MSB	0x00	Acceleration Data Z <15:8>							
C	ACC_DATA_Z_LSB	0x00	Acceleration Data Z <7:0>							
B	ACC_DATA_Y_MSB	0x00	Acceleration Data Y <15:8>							
A	ACC_DATA_Y_LSB	0x00	Acceleration Data Y <7:0>							
9	ACC_DATA_X_MSB	0x00	Acceleration Data X <15:8>							
8	ACC_DATA_X_LSB	0x00	Acceleration Data X <7:0>							
7	Page ID	0x00	Page ID							
6	BL_Rev_ID	NA	Bootloader Version							
5	SW_REV_ID_MSB	NA	SW Revision ID <15:8>							
4	SW_REV_ID_LSB	NA	SW Revision ID <7:0>							
3	GYR_ID	0x0F	GYRO chip ID							
2	MAG_ID	0x32	MAG chip ID							
1	ACC_ID	0xFB	ACC chip ID							
0	CHIP_ID	0xA0	BNO055 CHIP ID							

4.2.2 **Register map Page 1**

Table4-3: Register Map Page 1

Register Address	Register Name	Default Value	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
7F-60	Reserved	0x00								
5F - 50	UNIQUE_ID	n.a.	BNO unique ID							
4F - 20	Reserved	0x00								
1F	GYR_AM_SET	0x0A					Awake Duration <1:0>		Slope Samples <1:0>	
1E	GYR_AM_THRES	0x04		Gyro Any Motion Threshold <6:0>						
1D	GYR_DUR_Z	0x19	HR_Z_Duration							
1C	GYR_HR_Z_SET	0x01		HR_Z_THRES_HYST <1:0>		HR_Z_Threshold <4:0>				
1B	GYR_DUR_Y	0x19	HR_Y_Duration							
1A	GYR_HR_Y_SET	0x01		HR_Y_THRES_HYST <1:0>		HR_Y_Threshold <4:0>				
19	GYR_DUR_X	0x19	HR_X_Duration							
18	GYR_HR_X_SET	0x01		HR_X_THRES_HYST <1:0>		HR_X_Threshold <4:0>				
17	GYR_INT_SETING	0x00	HR_FILT	AM_FILT	HR_Z_AXIS	HR_Y_AXIS	HR_X_AXIS	AM_Z_AXIS	AM_Y_AXIS	AM_X_AXIS
16	ACC_NM_SET	0x0B		NO/SLOW Motion Duration <5:0>						SMNM
15	ACC_NM_THRE	0x0A	Accelerometer NO/SLOW motion threshold							
14	ACC_HG_THRES	0xC0	Accelerometer High G Threshold							
13	ACC_HG_DURATION	0x0F	Accelerometer High G Duration							
12	ACC_INT_Settings	0x03	HG_Z_AXIS	HG_Y_AXIS	HG_X_AXIS	AM/NM_Z_AXIS	AM/NM_Y_AXIS	AM/NM_X_AXIS	AM_DUR <1:0>	
11	ACC_AM_THRES	0x14	Accelerometer Any motion threshold							
10	INT_EN	0x00	ACC_NM	ACC_AM	ACC_HIGH_G		GYR_HIGH_RATE	GYRO_AM		
F	INT_MSK	0x00	ACC_NM	ACC_AM	ACC_HIGH_G		GYR_HIGH_RATE	GYRO_AM		
E	Reserved	0x00								
D	GYR_Sleep_Config	0x00			AUTO_SLP_DURATION <2:0>			SLP_DURATION <2:0>		
C	ACC_Sleep_Config	0x00				SLP_DURATION <3:0>				SLP_MODE
B	GYR_Config_1	0x00						GYR_Power_Mode <2:0>		
A	GYR_Config_0	0x38			GYR_Bandwidth <2:0>			GYR_Range <2:0>		
9	MAG_Config	0x6D		MAG_Power_mode <1:0>		MAG_OPR_Mode <1:0>		MAG_Data_output_rate <2:0>		
8	ACC_Config	0x0D	ACC_PWR_Mode <2:0>			ACC_BW <2:0>			ACC_Range <1:0>	
7	Page ID	0x01	Page ID							
6 - 0	Reserved	n.a.								

4.3 Register description (Page 0)

4.3.1 CHIP_ID 0x00

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	1	0	1	0	0	0	0	0
Content	BNO055 CHIP ID							

DATA	bits	Description
BNO055 CHIP ID	**<7:0>**	Chip identification code, read-only fixed value 0xA0

4.3.2 ACC_ID 0x01

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	R	r
Reset	0xFB							
Content	ACC chip ID							

DATA	bits	Description
ACC chip ID	<7:0>	Chip ID of the Accelerometer device, read-only fixed value 0xFB

4.3.3 MAG_ID 0x02

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	R	r
Reset	0x32							
Content	MAG chip ID							

DATA	bits	Description
MAG chip ID	<7:0>	Chip ID of the Magnetometer device, read-only fixed value 0x32

4.3.4 GYR_ID 0x03

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	R	r
Reset	0x0F							
Content	GRYO chip ID							

DATA	bits	Description
GYRO chip ID	<7:0>	Chip ID of the Gyroscope device, read-only fixed value 0x0F

4.3.5 SW_REV_ID_LSB 0x04

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r

Reset								
Content	SW Revision ID <7:0>							

DATA	bits	Description
SW Revision ID <7:0>	<7:0>	Lower byte of SW Revision ID, read-only fixed value depending on SW revision programmed on microcontroller

4.3.6 **SW_REV_ID_MSB 0x05**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset								
Content	SW Revision ID <15:8>							

DATA	bits	Description
SW Revision ID <15:8>	<7:0>	Upper byte of SW Revision ID, read-only fixed value depending on SW revision programmed on microcontroller

4.3.7 **BL_REV_ID 0x06**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset								
Content	Bootloader Version							

DATA	bits	Description
Bootloader Version	<7:0>	Identifies the version of the bootloader in the microcontroller, read-only

4.3.8 **Page ID 0x07**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	0	0	0	0
Content	Page ID							

DATA	bits	Description
Page ID	<7:0>	Read: Number of currently selected page Write: Change page, 0x00 or 0x01

4.3.9 ACC_DATA_X_LSB 0x08

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Acceleration Data X <7:0>							

DATA	bits	Description
Acceleration Data X <7:0>	<7:0>	Lower byte of X axis Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.10 ACC_DATA_X_MSB 0x09

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Acceleration Data X <15:8>							

DATA	bits	Description
Acceleration Data X <15:8>	<7:0>	Upper byte of X axis Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.11 ACC_DATA_Y_LSB 0x0A

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Acceleration Data Y <7:0>							

DATA	bits	Description
Acceleration Data Y <7:0>	<7:0>	Lower byte of Y axis Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.12 ACC_DATA_Y_MSB 0x0B

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Acceleration Data Y <15:8>							

DATA	bits	Description
Acceleration Data Y <15:8>	<7:0>	Upper byte of Y axis Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.13 ACC_DATA_Z_LSB 0x0C

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Acceleration Data Z <7:0>							

DATA	bits	Description
Acceleration Data Z <7:0>	<7:0>	Lower byte of Z axis Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.14 ACC_DATA_Z_MSB 0x0D

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Acceleration Data Z <15:8>							

DATA	bits	Description
Acceleration Data Z <15:8>	<7:0>	Upper byte of Z axis Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.15 MAG_DATA_X_LSB 0x0E

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Magnetometer Data X <7:0>							

DATA	bits	Description
Magnetometer Data X <7:0>	<7:0>	Lower byte of X axis Magnetometer data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.16 MAG_DATA_X_MSB 0x0F

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Magnetometer Data X <15:8>							

DATA	bits	Description
Magnetometer Data X <15:8>	<7:0>	Upper byte of X axis Magnetometer data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.17 **MAG_DATA_Y_LSB 0x10**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Magnetometer Data Y <7:0>							

DATA	bits	Description
Magnetometer Data Y <7:0>	<7:0>	Lower byte of Y axis Magnetometer data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.18 **MAG_DATA_Y_MSB 0x11**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Magnetometer Data Y <15:8>							

DATA	bits	Description
Magnetometer Data Y <15:8>	<7:0>	Upper byte of Y axis Magnetometer data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.19 **MAG_DATA_Z_LSB 0x12**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Magnetometer Data Z <7:0>							

DATA	bits	Description
Magnetometer Data Z <7:0>	<7:0>	Lower byte of Z axis Magnetometer data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.20 **MAG_DATA_Z_MSB 0x13**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Magnetometer Data Z <15:8>							

DATA	bits	Description
Magnetometer Data Z <15:8>	<7:0>	Upper byte of Z axis Magnetometer data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.21 GYR_DATA_X_LSB 0x14

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gyroscope Data X <7:0>							

DATA	bits	Description
Gyroscope Data X <7:0>	<7:0>	Lower byte of X axis Gyroscope data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.22 GYR_DATA_X_MSB 0x15

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gyroscope Data X <15:8>							

DATA	bits	Description
Gyroscope Data X <15:8>	<7:0>	Upper byte of X axis Gyroscope data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.23 GYR_DATA_Y_LSB 0x16

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gyroscope Data Y <7:0>							

DATA	bits	Description
Gyroscope Data Y <7:0>	<7:0>	Lower byte of Y axis Gyroscope data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.24 GYR_DATA_Y_MSB 0x17

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gyroscope Data Y <15:8>							

DATA	bits	Description
Gyroscope Data Y <15:8>	<7:0>	Upper byte of Y axis Gyroscope data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.25 **GYR_DATA_Z_LSB 0x18**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gyroscope Data Z <7:0>							

DATA	bits	Description
Gyroscope Data Z <7:0>	<7:0>	Lower byte of Z axis Gyroscope data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.26 **GYR_DATA_Z_MSB 0x19**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gyroscope Data Z <15:8>							

DATA	bits	Description
Gyroscope Data Z <15:8>	<7:0>	Upper byte of Z axis Gyroscope data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.27 **EUL_DATA_X_LSB 0x1A**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Heading Data <7:0>							

DATA	bits	Description
Heading Data <7:0>	<7:0>	Lower byte of heading data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.28 **EUL_DATA_X_MSB 0x1B**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Heading Data <15:8>							

DATA	bits	Description
Heading Data <15:8>	<7:0>	Upper byte of heading data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.29 **EUL_DATA_Y_LSB 0x1C**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Roll Data <7:0>							

DATA	bits	Description
Roll Data <7:0>	<7:0>	Lower byte of roll data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.30 **EUL_DATA_Y_MSB 0x1D**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Roll Data <15:8>							

DATA	bits	Description
Roll Data <15:8>	<7:0>	Upper byte of Y axis roll data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.31 **EUL_DATA_Z_LSB 0x1E**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Pitch Data <7:0>							

DATA	bits	Description
Pitch Data <7:0>	<7:0>	Lower byte of pitch data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.32 **EUL_DATA_Z_MSB 0x1F**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Pitch Data <15:8>							

DATA	bits	Description
Pitch Data <15:8>	<7:0>	Upper byte of pitch data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.33 QUA_DATA_W_LSB 0x20

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Quaternion Data W <7:0>							

DATA	bits	Description
Quaternion Data W <7:0>	<7:0>	Lower byte of w axis Quaternion data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.34 QUA_DATA_W_MSB 0x21

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Quaternion Data W <15:8>							

DATA	bits	Description
Quaternion Data W <15:8>	<7:0>	Upper byte of w axis Quaternion data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.35 QUA_DATA_X_LSB 0x22

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Quaternion Data X <7:0>							

DATA	bits	Description
Quaternion Data X <7:0>	<7:0>	Lower byte of X axis Quaternion data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.36 QUA_DATA_X_MSB 0x23

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Quaternion Data X <15:8>							

DATA	bits	Description
Quaternion Data X <15:8>	<7:0>	Upper byte of X axis Quaternion data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.37 QUA_DATA_Y_LSB 0x24

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Quaternion Data Y <7:0>							

DATA	bits	Description
Quaternion Data Y <7:0>	<7:0>	Lower byte of Y axis Quaternion data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.38 QUA_DATA_Y_MSB 0x25

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Quaternion Data Y <15:8>							

DATA	bits	Description
Quaternion Data Y <15:8>	<7:0>	Upper byte of Y axis Quaternion data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.39 QUA_DATA_Z_LSB 0x26

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Quaternion Data Z <7:0>							

DATA	bits	Description
Quaternion Data Z <7:0>	<7:0>	Lower byte of Z axis Quaternion data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.40 QUA_DATA_Z_MSB 0x27

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Quaternion Data Z <15:8>							

DATA	bits	Description
Quaternion Data Z <15:8>	<7:0>	Upper byte of Z axis Quaternion data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.41 **LIA_DATA_X_LSB 0x28**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Linear Acceleration Data X <7:0>							

DATA	bits	Description
Linear Acceleration Data X <7:0>	<7:0>	Lower byte of X axis Linear Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.42 **LIA_DATA_X_MSB 0x29**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Linear Acceleration Data X <15:8>							

DATA	bits	Description
Linear Acceleration Data X <15:8>	<7:0>	Upper byte of X axis Linear Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.43 **LIA_DATA_Y_LSB 0x2A**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Linear Acceleration Data Y <7:0>							

DATA	bits	Description
Linear Acceleration Data Y <7:0>	<7:0>	Lower byte of Y axis Linear Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.44 **LIA_DATA_Y_MSB 0x2B**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Linear Acceleration Data Y <15:8>							

DATA	bits	Description
Linear Acceleration Data Y <15:8>	<7:0>	Upper byte of Y axis Linear Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.45 **LIA_DATA_Z_LSB 0x2C**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Linear Acceleration Data Z <7:0>							

DATA	bits	Description
Linear Acceleration Data Z <7:0>	<7:0>	Lower byte of Z axis Linear Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.46 **LIA_DATA_Z_MSB 0x2D**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Linear Acceleration Data Z <15:8>							

DATA	bits	Description
Linear Acceleration Data Z <15:8>	<7:0>	Upper byte of Z axis Linear Acceleration data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.47 **GRV_DATA_X_LSB 0x2E**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gravity Vector Data X <7:0>							

DATA	bits	Description
Gravity Vector Data X <7:0>	<7:0>	Lower byte of X axis Gravity Vector data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.48 **GRV_DATA_X_MSB 0x2F**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gravity Vector Data X <15:8>							

DATA	bits	Description
Gravity Vector Data X <15:8>	<7:0>	Upper byte of X axis Gravity Vector data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.49 **GRV_DATA_Y_LSB 0x30**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gravity Vector Data Y <7:0>							

DATA	bits	Description
Gravity Vector Data Y <7:0>	<7:0>	Lower byte of Y axis Gravity Vector data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.50 **GRV_DATA_Y_MSB 0x31**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gravity Vector Data Y <15:8>							

DATA	bits	Description
Gravity Vector Data Y <15:8>	<7:0>	Upper byte of Y axis Gravity Vector data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.51 **GRV_DATA_Z_LSB 0x32**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gravity Vector Data Z <7:0>							

DATA	bits	Description
Gravity Vector Data Z <7:0>	<7:0>	Lower byte of Z axis Gravity Vector data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.52 **GRV_DATA_Z_MSB 0x33**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Gravity Vector Data Z <15:8>							

DATA	bits	Description
Gravity Vector Data Z <15:8>	<7:0>	Upper byte of Z axis Gravity Vector data, read only The output units can be selected using the UNIT_SEL register and data output type can be changed by updating the Operation Mode in the OPR_MODE register, see section 3.3

4.3.53 TEMP 0x34

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Temperature							

DATA	bits	Description
Temperature	<7:0>	Temperature data, read only The output units can be selected using the UNIT_SEL register and data output source can be selected by updating the TEMP_SOURCE register, see section 3.7.4.8

4.3.54 CALIB_STAT 0x35

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	SYS Calib Status <0:1>		GYR Calib Status <0:1>		ACC Calib Status <0:1>		MAG Calib Status <0:1>	

DATA	bits	Description
SYS Calib Status <0:1>	<7:6>	Current system calibration status, depends on status of all sensors, read-only Read: 3 indicates fully calibrated; 0 indicates not calibrated
GYR Calib Status <0:1>	<5:4>	Current calibration status of Gyroscope, read-only Read: 3 indicates fully calibrated; 0 indicates not calibrated
ACC Calib Status <0:1>	<3:2>	Current calibration status of Accelerometer, read-only Read: 3 indicates fully calibrated; 0 indicates not calibrated
MAG Calib Status <0:1>	<1:0>	Current calibration status of Magnetometer, read-only Read: 3 indicates fully calibrated; 0 indicates not calibrated

For more details on how to calibrate the sensors in the BNO055 please contact your local Bosch Sensortec sales representative and ask for the “BNO055 calibration application note” document.

4.3.55 ST_RESULT 0x36

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset					1	1	1	1
Content	Reserved				ST_MCU	ST_GYR	ST_MAG	ST_ACC

DATA	bits	Description
ST_MCU	3	Microcontroller self test result. Read: 1 indicated test passed; 0 indicates test failed
ST_GYR	2	Gyroscope self test result. Read: 1 indicated test passed; 0 indicates test failed
ST_MAG	1	Magnetometer self test result. Read: 1 indicated test passed; 0 indicates test failed
ST_ACC	0	Accelerometer self test result. Read: 1 indicated test passed; 0 indicates test failed

4.3.56 **INT_STA 0x37**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0		0	0		
Content	ACC_NM	ACC_AM	ACC_HIGH_G	Reserved	GYR_HIGH_RATE	GYRO_AM	Reserved	Reserved

DATA	bits	Description
ACC_NM	7	Status of Accelerometer no motion or slow motion interrupt, read only Read: 1 indicates interrupt triggered; 0 indicates no interrupt triggered
ACC_AM	6	Status of Accelerometer any motion interrupt, read only Read: 1 indicates interrupt triggered; 0 indicates no interrupt triggered
ACC_HIGH_G	5	Status of Accelerometer high-g interrupt, read only Read: 1 indicates interrupt triggered; 0 indicates no interrupt triggered
GYR_HIGH_RATE	3	Status of gyroscope high rate interrupt, read only Read: 1 indicates interrupt triggered; 0 indicates no interrupt triggered
GYRO_AM	2	Status of gyroscope any motion interrupt, read only Read: 1 indicates interrupt triggered; 0 indicates no interrupt triggered

4.3.57 **SYS_CLK_STATUS 0x38**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	ST_MAIN_CLK

DATA	bits	Description
0	0	Indicates that, it is Free to configure the CLK SRC (External or Internal)
1	0	Indicates that, it is in Configuration state

4.3.58 **SYS_STATUS 0x39**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	0
Content	System Status Code							

DATA	bits	Description
System Status Code	<7:0>	Read: 0 System idle, 1 System Error, 2 Initializing peripherals 3 System Initialization 4 Executing selftest, 5 Sensor fusion algorithm running, 6 System running without fusion algorithm

4.3.59 **SYS_ERR 0x3A**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset								
Content	System Error Code							

DATA	bits	Description
System Error Code	<7:0>	Read the error status from this register if the SYS_STATUS (0x39) register is SYSTEM ERROR (0x01) Read : 0 No error 1 Peripheral initialization error 2 System initialization error 3 Self test result failed 4 Register map value out of range 5 Register map address out of range 6 Register map write error 7 BNO low power mode not available for selected operation mode 8 Accelerometer power mode not available 9 Fusion algorithm configuration error A Sensor configuration error

4.3.60 **UNIT_SEL 0x3B**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0			0	0	0	0	0
Content	ORI_Android_Windows	reserved		TEMP_Unit	reserved	EUL_Unit	GYR_Unit	ACC_Unit

DATA	bits	Description
ORI_Android_Windows	7	Read: Current selected orientation mode Write: Select orientation mode 0: Windows orientation 1: Android orientation See section 3.7.3.1 for more details
TEMP_Unit	5	Read: Current selected temperature units Write: Select temperature units 0: Celsius 1: Fahrenheit See section 3.7.1 for more details
EUL_Unit	3	Read: Current selected Euler units Write: Select Euler units 0: Degrees 1: Radians See section 3.7.1 for more details
GYR_Unit	2	Read: Current selected angular rate units Write: Select angular rate units 0: dps 1: rps See section 3.7.1 for more details
ACC_Unit	1	Read: Current selected acceleration units Write: Select acceleration units 0: m/s^2 1: mg See section 3.7.1 for more details

4.3.61 **OPR_MODE 0x3D**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access		r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Reserved	Output Data Rate <2:0>			Operation Mode <3:0>			

DATA	bits	Description
Output Data Rate <2:0>	<6:4>	Read: Current selected data rate mode Write: Select data rate mode See section 3.7.3.2 for details
Operation Mode <3:0>	<3:0>	Read: Current selected operation mode Write: Select operation mode See section 3.3 for details

4.3.62 PWR_MODE 0x3E

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access							r/w	r/w
Reset								
Content	Reserved						Power Mode <1:0>	

DATA	bits	Description
Power Mode <1:0>	<1:0>	Read: Current selected power mode Write: Select power mode See section 3.4 for details

4.3.63 SYS_TRIGGER 0x3F

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	w	w	w					w
Reset	0	0	0					0
Content	CLK_SEL	RST_INT	RST_SYS					Self_Test

DATA	bits	Description
CLK_SEL	7	0: Use internal oscillator 1: Use external oscillator. Set this bit only if external crystal is connected
RST_INT	6	Set to reset all interrupt status bits, and INT output
RST_SYS	5	Set to reset system
Self_Test	0	Set to trigger self test

4.3.64 TEMP_SOURCE 0x40

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access							r/w	r/w
Reset								
Content	Reserved						TEMP_Source <1:0>	

DATA	bits	Description
TEMP_Source <1:0>	<1:0>	See section 3.7.4.8 for details

4.3.65 AXIS_MAP_CONFIG 0x41

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access			r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Reserved		Remapped Z axis value		Remapped Y axis value		Remapped X axis value	

DATA	bits	Description
Remapped Z axis value	<5:4>	See section 3.5 for details
Remapped Y axis value	<3:2>	See section 3.5 for details
Remapped X axis value	<1:0>	See section 3.5 for details

4.3.66 AXIS_MAP_SIGN 0x42

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access						r/w	r/w	r/w
Reset								
Content	Reserved					Remapped X axis sign	Remapped Y axis sign	Remapped Z axis sign

DATA	bits	Description
Remapped X axis sign	2	See section 3.5 for details
Remapped Y axis sign	1	See section 3.5 for details
Remapped Z axis sign	0	See section 3.5 for details

4.3.67 **SIC_MATRIX 0x43 – 0x53**

Registers reserved for soft iron calibration (SIC) matrix data, this feature is described in a separate application note and should only be used when a distortion free magnetic environment is available to create the required calibration matrix data.

For more details please refer to the appropriate soft iron correction application note.

4.3.68 **ACC_OFFSET_X_LSB 0x55**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Accelerometer Offset X <7:0>							

DATA	bits	Description
Accelerometer Offset X <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.69 **ACC_OFFSET_X_MSB 0x56**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Accelerometer Offset X <15:8>							

DATA	bits	Description
Accelerometer Offset X <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.70 ACC_OFFSET_Y_LSB 0x57

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Accelerometer Offset Y <7:0>							

DATA	bits	Description
Accelerometer Offset Y <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.71 ACC_OFFSET_Y_MSB 0x58

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Accelerometer Offset Y <15:8>							

DATA	bits	Description
Accelerometer Offset Y <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.72 ACC_OFFSET_Z_LSB 0x59

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Accelerometer Offset Z <7:0>							

DATA	bits	Description
Accelerometer Offset Z <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.73 ACC_OFFSET_Z_MSB 0x5A

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Accelerometer Offset Z <15:8>							

DATA	bits	Description
Accelerometer Offset Z <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.74 MAG_OFFSET_X_LSB 0x5B

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Reset								
Content	Magnetometer Data X <7:0>							

DATA	bits	Description
Magnetometer Offset X <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.75 **MAG_OFFSET_X_MSB 0x56C**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Magnetometer Offset X <15:8>							

DATA	bits	Description
Magnetometer Offset X <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.76 **MAG_OFFSET_Y_LSB 0x5D**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Magnetometer Offset Y <7:0>							

DATA	bits	Description
Magnetometer Offset Y <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.77 MAG_OFFSET_Y_MSB 0x5E

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Magnetometer Offset Y <15:8>							

DATA	bits	Description
Magnetometer Offset Y <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.78 MAG_OFFSET_Z_LSB 0x5F

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Magnetometer Offset Z <7:0>							

DATA	bits	Description
Magnetometer Offset Z <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.79 MAG_OFFSET_Z_MSB 0x60

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Magnetometer Offset Z <15:8>							

DATA	bits	Description
Magnetometer Offset Z <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.80 GYR_OFFSET_X_LSB 0x61

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Gyroscope Data X <7:0>							

DATA	bits	Description
Gyroscope Offset X <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.81 GYR_OFFSET_X_MSB 0x62

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Reset								
Content	Gyroscope Offset X <15:8>							

DATA	bits	Description
Gyroscope Offset X <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.82 **GYR_OFFSET_Y_LSB 0x63**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Gyroscope Offset Y <7:0>							

DATA	bits	Description
Gyroscope Offset Y <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.83 **GYR_OFFSET_Y_MSB 0x64**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Gyroscope Offset Y <15:8>							

DATA	bits	Description
Gyroscope Offset Y <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.84 GYR_OFFSET_Z_LSB 0x65

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Gyroscope Offset Z <7:0>							

DATA	bits	Description
Gyroscope Offset Z <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.85 GYR_OFFSET_Z_MSB 0x66

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Gyroscope Offset Z <15:8>							

DATA	bits	Description
Gyroscope Offset Z <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.86 ACC_RADIUS_LSB 0x67

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Accelerometer Radius <7:0>							

DATA	bits	Description
Gyroscope Offset Z <7:0>	<7:0>	See section 3.7.3.4for details

4.3.87 ACC_RADIUS_MSB 0x68

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Accelerometer Radius <15:8>							

DATA	bits	Description
Gyroscope Offset Z <15:8>	<7:0>	See section 3.7.3.4 for details

4.3.88 MAG_RADIUS_LSB 0x69

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Magnetometer Radius <7:0>							

DATA	bits	Description

Gyroscope Offset Z <7:0>	<7:0>	See section 3.7.3.4 for details

4.3.89 **MAG_RADIUS_MSB 0x6A**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	Magnetometer Radius <15:8>							

DATA	bits	Description
Gyroscope Offset Z <15:8>	<7:0>	See section 3.7.3.4 for details

4.4 Register description (Page 1)

4.4.1 Page ID 0x07

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	0	0	0	0
Content	Page ID							

DATA	bits	Description
Page ID	<7:0>	Read: Number of currently selected page Write: Change page, 0x00 or 0x01

4.4.2 ACC_Config 0x08

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	1	1	0	1
Content	ACC_PWR_Mode <2:0>			ACC_BW <2:0>			ACC_Range <1:0>	

DATA	bits	Description
ACC_PWR_Mode <2:0>	<7:5>	Read: current selected power mode Write: can only be changed in sensor mode, see section 3.6.1
ACC_BW <2:0>	<4:3>	Read: current selected bandwidth Write: can only be changed in sensor mode, see section 3.6.1
ACC_Range <1:0>	<2:0>	Read: current selected range Write: can only be changed in sensor mode, see section 3.6.1

4.4.3 MAG_Config 0x09

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	1	0	1	1
Content	reserved	MAG_Power_mode <1:0>		MAG_OPR_Mode <1:0>		MAG_Data_output_rate <2:0>		

DATA	bits	Description
MAG_Power_mode <1:0>	<6:5>	Read: current selected power mode Write: can only be changed in sensor mode, see section 3.6.3
MAG_OPR_Mode <1:0>	<4:3>	Read: current selected operation mode Write: can only be changed in sensor mode, see section 3.6.3
MAG_Data_output_rate <2:0>	<2:0>	Read: current selected data output rate Write: can only be changed in sensor mode, see section 3.6.3

4.4.4 **GYR_Config_0 0x0A**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	1	1	1	0	0	0
Content	reserved		GYR_Bandwidth <2:0>			GYR_Range <2:0>		

DATA	bits	Description
GYR_Bandwidth <2:0>	<5:3>	Read: current selected bandwidth Write: can only be changed in sensor mode, see section 3.6.2
GYR_Range <2:0>	<2:0>	Read: current selected range Write: can only be changed in sensor mode, see section 3.6.2

4.4.5 **GYR_Config_1 0x0B**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	0	0	0	0
Content	reserved					GYR_Power_Mode <2:0>		

DATA	bits	Description
GYR_Power_Mod e <2:0>	<2:0>	Read: current selected power mode Write: can only be changed in sensor mode, see section 3.6.2

4.4.6 **ACC_Sleep_Config 0x0C**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	reserved			SLP_DURATION <3:0>				SLP_MODE

DATA	bits	Description
SLP_DURATION <3:0>	<4:1>	Write: The sleep duration for accelerometer low power mode can be only configured in the sensor operation mode where no fusion library is running. Following sleep phase duration is possible to set.
SLP_MODE	0	The sleep timer mode for accelerometer low power mode can be only configured in the sensor operation mode where no fusion library is running Write 0: use event driven time-base mode 1: use equidistant sampling time-base mode

SLP_DURATION	Accelerometer Sleep Phase Duration
0000b	0.5 ms
0001b	0.5 ms
0010b	0.5 ms
0011b	0.5 ms
0100b	0.5 ms
0101b	0.5 ms
0110b	1 ms
0111b	2 ms
1000b	4 ms
1001b	6 ms
1010b	10 ms
1011b	25 ms
1100b	50 ms
1101b	100 ms
1110b	500 ms
1111b	1 ms

4.4.7 **GYR_Sleep_Config 0x0D**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset								
Content	reserved		AUTO_SLP_DURATION <2:0>			SLP_DURATION <2:0>		

<table>
<tr><th>DATA</th><th>bits</th><th>Description</th></tr>
<tr><td>AUTO_SLP_DURATION <2:0></td><td><5:3></td><td>The Gyroscope can be configures in the advanced power mode to optimize the power consumption. This can be only done if the selected operation mode in sensor mode. The auto sleep duration is the wake up duration of gyroscope during the duty cycling between normal and fast-power up mode. Possible configuration for auto sleep duration are:
<table>
<tr><td>Auto sleep duration</td><td>Time (ms)</td></tr>
<tr><td>000b</td><td>Not allowed</td></tr>
<tr><td>001b</td><td>4 ms</td></tr>
<tr><td>010b</td><td>5 ms</td></tr>
<tr><td>011b</td><td>8 ms</td></tr>
<tr><td>100b</td><td>10 ms</td></tr>
<tr><td>101b</td><td>15 ms</td></tr>
<tr><td>110b</td><td>20 ms</td></tr>
<tr><td>111b</td><td>40 ms</td></tr>
</table></td></tr>
<tr><td>SLP_DURATION <2:0></td><td><2:0></td><td>The Gyroscope can be configures in the advanced power mode to optimize the power consumption. This can be only done if the selected operation mode in sensor mode. The sleep duration is the sleep time of gyroscope during the duty cycling between normal and fast-power up mode. Possible configuration for sleep duration are:
<table>
<tr><td>Sleep duration</td><td>Time (ms)</td></tr>
<tr><td>000b</td><td>2 ms</td></tr>
<tr><td>001b</td><td>4 ms</td></tr>
<tr><td>010b</td><td>5 ms</td></tr>
<tr><td>011b</td><td>8 ms</td></tr>
<tr><td>100b</td><td>10 ms</td></tr>
<tr><td>101b</td><td>15 ms</td></tr>
<tr><td>110b</td><td>18 ms</td></tr>
<tr><td>111b</td><td>20 ms</td></tr>
</table></td></tr>
</table>

The only restriction for the use of the power save mode comes from the configuration of the digital filter bandwidth of gyroscope. For each bandwidth configuration, minimum auto sleep duration must be ensured. For example, for bandwidth = 47Hz, the minimum auto sleep duration is 5ms. This is specified in the table below. For sleep duration, there is no restriction.

Gyroscope bandwidth (Hz)	Mini Autosleep duration (ms)
32 Hz	20 ms
64 Hz	10 ms
12 Hz	20 ms
23 Hz	10 ms
47 Hz	5 ms
116 Hz	4 ms
230 Hz	4 ms
Unfiltered (523 Hz)	4 ms

4.4.8 **INT_MSK 0x0F**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0		0	0		
Content	ACC_NM	ACC_AM	ACC_HIGH_G	reserved	GYR_HIGH_RATE	GYRO_AM	reserved	reserved

DATA	bits	Description
ACC_NM	7	Masking of Accelerometer no motion or slow motion interrupt, when enabled the interrupt will update the INT_STA register and trigger a change on the INT pin, when disabled only the INT_STA register will be updated. Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable
ACC_AM	6	Masking of Accelerometer any motion interrupt, when enabled the interrupt will update the INT_STA register and trigger a change on the INT pin, when disabled only the INT_STA register will be updated. Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable
ACC_HIGH_G	5	Masking of Accelerometer high-g interrupt, when enabled the interrupt will update the INT_STA register and trigger a change on the INT pin, when disabled only the INT_STA register will be updated. Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable
GYR_HIGH_RATE	3	Masking of gyroscope high rate interrupt, when enabled the interrupt will update the INT_STA register and trigger a change on the INT pin, when disabled only the INT_STA register will be updated. Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable
GYRO_AM	2	Masking of gyroscope any motion interrupt, when enabled the interrupt will update the INT_STA register and trigger a change on the INT pin, when disabled only the INT_STA register will be updated. Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable

4.4.9 **INT_EN 0x10**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0		0	0		
Content	ACC_NM	ACC_AM	ACC_HIGH_G	reserved	GYR_HIGH_RATE	GYRO_AM	reserved	reserved

DATA	bits	Description
ACC_NM	7	Status of Accelerometer no motion or slow motion interrupt Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable interrupt
ACC_AM	6	Status of Accelerometer any motion interrupt Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable interrupt
ACC_HIGH_G	5	Status of Accelerometer high-g interrupt Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable interrupt
GYR_HIGH_RATE	3	Status of gyroscope high rate interrupt Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable interrupt
GYRO_AM	2	Status of gyroscope any motion interrupt Read: 1: Enabled / 0: Disabled Write: 1: Enable / 0: Disable interrupt

4.4.10 **ACC_AM_THRES 0x11**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	1	0	1	0	0
Content	Accelerometer Any motion threshold							

DATA	bits	Description
Accelerometer Any motion threshold	<7:0>	Threshold used for the any-motion interrupt. The threshold value is dependent on the accelerometer range selected in the ACC_Config register. 1 LSB = 3.91 mg (2-g range) 1 LSB = 7.81 mg (4-g range) 1 LSB = 15.63 mg (8-g range) 1 LSB = 31.25 mg (16-g range)

4.4.11 **ACC_INT_Settings 0x12**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	0	0	1	1
Content	HG_Z_AXIS	HG_Y_AXIS	HG_X_AXIS	AM/NM_Z_AXIS	AM/NM_Y_AXIS	AM/NM_X_AXIS	AM_DUR <1:0>	

DATA	bits	Description
HG_Z_AXIS	7	Select which axis of the accelerometer is used to trigger a high-G interrupt 1: Enabled; 0: Disabled
HG_Y_AXIS	6	Select which axis of the accelerometer is used to trigger a high-G interrupt 1: Enabled; 0: Disabled
HG_X_AXIS	5	Select which axis of the accelerometer is used to trigger a high-G interrupt 1: Enabled; 0: Disabled
AM/NM_Z_AXIS	4	Select which axis of the accelerometer is used to trigger a any motion or no motion interrupt 1: Enabled; 0: Disabled
AM/NM_Y_AXIS	3	Select which axis of the accelerometer is used to trigger a any motion or no motion interrupt 1: Enabled; 0: Disabled
AM/NM_X_AXIS	2	Select which axis of the accelerometer is used to trigger a any motion or no motion interrupt 1: Enabled; 0: Disabled
AM_DUR <1:0>	<1:0>	Any motion interrupt triggers if [AM_DUR<1:0>+1] consecutive data points are above the any motion interrupt threshold define in ACC_AM_THRES register

4.4.12 **ACC_HG_DURATION 0x13**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	1	1	1	1
Content	Accelerometer High G Duration							

DATA	bits	Description
Accelerometer High G Duration	<7:0>	The high-g interrupt trigger delay according to [ACC_HG_DURATION + 1] * 2 ms in a range from 2 ms to 512 ms;

4.4.13 **ACC_HG_THRES 0x14**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	1	1	0	0	0	0	0	0
Content	Accelerometer High G Threshold							

DATA	bits	Description
Accelerometer High G Threshold	<7:0>	Threshold used high-g interrupt. The threshold value is dependent on the accelerometer range selected in the ACC_Config register. 1 LSB = 7.81 mg (2-g range 1 LSB = 15.63 mg (4-g range) 1 LSB = 31.25 mg (8-g range) 1 LSB = 62.5 mg (16-g range)

4.4.14 **ACC_NM_THRES 0x15**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0

Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	1	0	1	0
Content	Accelerometer NO/SLOW motion threshold							

DATA	bits	Description
Accelerometer NO/SLOW motion threshold	<7:0>	Threshold used for the Slow motion or no motion interrupt. The threshold value is dependent on the accelerometer range selected in the ACC_Config register. 1 LSB = 3.91 mg (2-g range) 1 LSB = 7.81 mg (4-g range) 1 LSB = 15.63 mg (8-g range) 1 LSB = 31.25 mg (16-g range)

4.4.15 **ACC_NM_SET 0x16**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset		0	0	0	1	0	1	1
Content	reserved	slo_no_mot_dur <5:0>						SMNM

DATA	bits	Description
slo_no_mot_dur <5:0>	<6:1>	Function depends on whether the slow-motion or no-motion interrupt function has been selected. If the slow-motion interrupt function has been enabled (SMNM = ‘0’) then [slo_no_mot_dur<1:0>+1] consecutive slope data points must be above the slow/no-motion threshold (ACC_NM_THRES) for the slow-/no-motion interrupt to trigger. If the no-motion interrupt function has been enabled (SMNM = ‘1’) then slo_no_motion_dur<5:0> defines the time for which no slope data points must exceed the slow/no-motion threshold (ACC_NM_THRES) for the slow/no-motion interrupt to trigger. The delay time in seconds may be calculated according with the following equation: slo_no_mot_dur<5:4>=’b00’ → [slo_no_mot_dur<3:0> + 1] slo_no_mot_dur<5:4>=’b01’ → [slo_no_mot_dur<3:0> * 4 + 20] slo_no_mot_dur<5>=’1’ → [slo_no_mot_dur<4:0> * 8 + 88]
SMNM	0	Select slow motion or no motion interrupt 1: Slow motion; 0: No motion

4.4.16 GYR_INT_SETTING 0x17

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	0	0	0	0
Content	HR_FILT	AM_FILT	HR_Z_AXIS	HR_Y_AXIS	HR_X_AXIS	AM_Z_AXIS	AM_Y_AXIS	AM_X_AXIS

DATA	bits	Description
HR_FILT	7	‘1’ (‘0’) selects unfiltered (filtered) data for high rate interrupt
AM_FILT	6	‘1’ (‘0’) selects unfiltered (filtered) data for any motion interrupt
HR_Z_AXIS	5	1’ (‘0’) enables (disables) high rate interrupt for z-axis
HR_Y_AXIS	4	1’ (‘0’) enables (disables)) high rate interrupt for y-axis
HR_X_AXIS	3	1’ (‘0’) enables (disables)) high rate interrupt for x-axis
AM_Z_AXIS	2	1’ (‘0’) enables (disables) any motion interrupt for z-axis
AM_Y_AXIS	1	1’ (‘0’) enables (disables) any motion interrupt for y-axis
AM_X_AXIS	0	1’ (‘0’) enables (disables) any motion interrupt for x-axis

4.4.17 GYR_HR_X_SET 0x18

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	0	0	0	1
Content	reserved	HR_X_THRES_HYST <1:0>		HR_X_Threshold <4:0>				

DATA	bits	Description
HR_X_THRES_HYST <1:0>	<6:5>	High rate hysteresis for X axis = (255 + 256 * HR_X_THRES_HYST) *4 LSB The high rate value scales with the range setting 1 LSB = 62.26°/s in 2000°/s-range 1 LSB = 31.13°/s in 1000°/s-range 1 LSB = 15.56°/s in 500°/s -range ...
HR_X_Threshold <4:0>	<4:0>	High rate threshold is for the gyroscope X axis. The threshold value is dependent on the gyroscope range selected in the GRY_Config_0 register. 1 LSB = 62.5°/s in 2000°/s-range 1 LSB = 31.25°/s in 1000°/s-range 1 LSB = 15.625°/s in 500°/s -range ...

4.4.18 GYR_DUR_X 0x19

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	1	1	0	0	1
Content	HR_X_Duration							

DATA	bits	Description
HR_X_Duration	<7:0>	High rate duration = (1 + HR_X_Duration)*2.5ms

4.4.19 GYR_HR_Y_SET 0x1A

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	1
Content	reserved	HR_Y_THRES_HYST <1:0>		HR_Y_Threshold <4:0>				

DATA	bits	Description
HR_Y_THRES_HYST <1:0>	<6:5>	High rate hysteresis for Y axis = (255 + 256 * HR_Y_THRES_HYST) *4 LSB The high rate value scales with the range setting 1 LSB = 62.26°/s in 2000°/s-range 1 LSB = 31.13°/s in 1000°/s-range 1 LSB = 15.56°/s in 500°/s -range ...
HR_Y_Threshold <4:0>	<4:0>	High rate threshold is for the gyroscope Y axis. The threshold value is dependent on the gyroscope range selected in the GRY_Config_0 register. 1 LSB = 62.5°/s in 2000°/s-range 1 LSB = 31.25°/s in 1000°/s-range 1 LSB = 15.625°/s in 500°/s -range ...

4.4.20 GYR_DUR_Y 0x1B

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	1	1	0	0	1
Content	HR_Y_Duration							

DATA	bits	Description
HR_Y_Duration	<7:0>	High rate duration = (1 + HR_Y_Duration)*2.5ms

GYR_HR_Z_SET 0x1C

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r	r	r	r	r	r	r	r
Reset	0	0	0	0	0	0	0	1
Content	reserved	HR_Z_THRES_HYST <1:0>		HR_Z_Threshold <4:0>				

DATA	bits	Description
HR_Z_THRES_HYST <1:0>	<6:5>	High rate hysteresis for Z axis = (255 + 256 * HR_Z_THRES_HYST) *4 LSB The high rate value scales with the range setting 1 LSB = 62.26°/s in 2000°/s-range 1 LSB = 31.13°/s in 1000°/s-range 1 LSB = 15.56°/s in 500°/s -range …
HR_Z_Threshold <4:0>	<4:0>	High rate threshold is for the gyroscope Z axis. The threshold value is dependent on the gyroscope range selected in the GRY_Config_0 register. 1 LSB = 62.5°/s in 2000°/s-range 1 LSB = 31.25°/s in 1000°/s-range 1 LSB = 15.625°/s in 500°/s -range …

4.4.21 GYR_DUR_Z 0x1D

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	1	1	0	0	1
Content	HR_Z_Duration							

DATA	bits	Description
HR_Z_Duration	<7:0>	High rate duration = (1 + HR_Z_Duration)*2.5ms

4.4.22 GYR_AM_THRES 0x1E

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	0	1	0	0
Content	reserved	Gyro Any Motion Threshold <6:0>						

DATA	bits	Description
Gyro Any Motion Threshold <6:0>	<6:0>	Any motion threshold is for the gyroscope any motion interrupt. The threshold value is dependent on the gyroscope range selected in the GRY_Config_0 register. 1 LSB = 1 °/s in 2000°/s-range 1 LSB = 0.5°/s in 1000°/s-range 1 LSB = 0.25°/s in 500°/s -range …

4.4.23 **GYR_AM_SET 0x1F**

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Access	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
Reset	0	0	0	0	1	0	1	0
Content	reserved				Awake Duration <1:0>		Slope Samples <1:0>	

DATA	bits	Description
Awake Duration <1:0>	<3:2>	0=8 samples, 1=16 samples, 2=32 samples, 3=64 samples
Slope Samples <1:0>	<1:0>	Any motion interrupt triggers if [Slope Samples + 1]*4 consecutive data points are above the any motion interrupt threshold define in GYRO_AM_THRES register

4.5 Digital Interface

The BNO055 supports two digital interfaces for communication between the salve and host device: I^2C which supports the HID-I2C protocol and I2C Standard and Fast modes; and the UART interface.

The active interface is selected by the state of the protocol select pins (PS1 and PS0), Table 4-4 shows the mapping between the protocol select pins and the selected interface mode.

Table 4-4: protocol select pin mapping

PS1	PS0	Functionality
0	0	Standard/Fast I2C Interface
0	1	HID over I2C
1	0	UART Interface
1	1	Reserved

It is not allowed to keep the protocol select pins floating.

Both digital interfaces share partially the same pins, the pin mapping for each interface is shown in Table 4-5.

Table 4-5: Mapping of digital interface pins

PIN	I2C Interfaces (PS1=0b0)	UART Interface (PS1.PS0=0b10)
COM0	SDA	Tx
COM1	SCL	Rx
COM2	GNDIO	
COM3	I2C address select	

The following table shows the electrical specifications of the interface pins:

Table 4-6: Electrical specification of the interface pins

Parameter	Symbol	Condition	Min	Typ	Max	Units
Pull-up Resistance, COM3 pin	R_{up}	Internal Pull-up Resistance to VDDIO	20	40	60	kΩ
Input Capacitance	C_{in}			5	10	pF
I²C Bus Load Capacitance (max. drive capability)	C_{I2C_Load}				400	pF

4.6 I2C Protocol

The I²C bus uses SCL (= SCx pin, serial clock) and SDA (= SDx pin, serial data input and output) signal lines. Both lines are connected to V_{DDIO} externally via pull-up resistors so that they are pulled high when the bus is free.

The I²C interface of the BNO055 is compatible with the I²C Specification UM10204 Rev. 03 (19 June 2007), available at http://www.nxp.com. The BNO055 supports I²C standard mode and fast mode, only 7-bit address mode is supported. The BNO055 I²C interface uses clock stretching.

The default I²C address of the BNO055 device is 0101001b (0x29). The alternative address 0101000b (0x28), in I2C mode the input pin COM3 can be used to select between the primary and alternative I2C address as shown in Table 4-7.

Table 4-7: I2C address selection

I2C configuration	COM3_state	I2C address
Slave	HIGH	0x29
Slave	LOW	0x28
HID-I2C	X	0x40

The timing specification for I²C of the BNO055 is given in Table 4-8: I²C timings:

Table 4-8: I²C timings

Parameter	Symbol	Condition	Min	Max	Units
Clock Frequency	f_{SCL}			400	kHz
SCL Low Period	t_{LOW}		1.3		µs
SCL High Period	t_{HIGH}		0.6		
SDA Setup Time	t_{SUDAT}		0.1		
SDA Hold Time	t_{HDDAT}		0.0		
Setup Time for a repeated Start Condition	t_{SUSTA}		0.6		
Hold Time for a Start Condition	t_{HDSTA}		0.6		
Setup Time for a Stop Condition	t_{SUSTO}		0.6		
Time before a new Transmission can start	t_{BUF}		1.3		
Idle time between write accesses, normal mode, standby mode, low-power mode 2	$t_{IDLE\_wacc\_nm}$		2		µs
Idle time between write accesses, suspend mode, low-power mode 1	$t_{IDLE\_wacc\_sum}$		450		µs

Figure 5: I²C timing diagram shows the definition of the I²C timings given in Table 4-8:

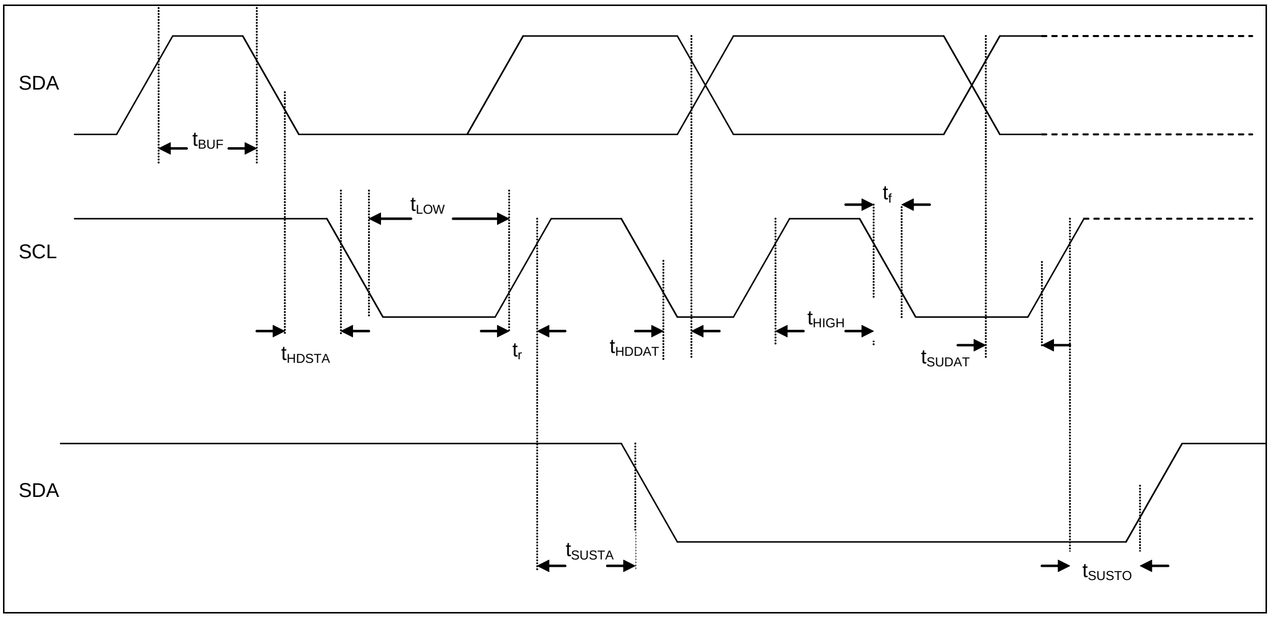


Figure 5: I²C timing diagram

The I²C protocol works as follows:

START: Data transmission on the bus begins with a high to low transition on the SDA line while SCL is held high (start condition (S) indicated by I²C bus master). Once the START signal is transferred by the master, the bus is considered busy.

STOP: Each data transfer should be terminated by a Stop signal (P) generated by master. The STOP condition is a low to HIGH transition on SDA line while SCL is held high.

ACK: Each byte of data transferred must be acknowledged. It is indicated by an acknowledge bit sent by the receiver. The transmitter must release the SDA line (no pull down) during the acknowledge pulse while the receiver must then pull the SDA line low so that it remains stable low during the high period of the acknowledge clock cycle.

In the following diagrams these abbreviations are used:

S	Start
P	Stop
ACKS	Acknowledge by slave
ACKM	Acknowledge by master
NACKM	Not acknowledge by master
RW	Read / Write

A START immediately followed by a STOP (without SCL toggling from ´VDDIO´ to ´GND´) is not supported. If such a combination occurs, the STOP is not recognized by the device.

I²C write access:
I²C write access can be used to write a data byte in one sequence.

The sequence begins with start condition generated by the master, followed by 7 bits slave address and a write bit (RW = 0). The slave sends an acknowledge bit (ACK = 0) and releases the bus. Then the master sends the one byte register address. The slave again acknowledges the transmission and waits for the 8 bits of data which shall be written to the specified register address. After the slave acknowledges the data byte, the master generates a stop signal and terminates the writing protocol.

Example of an I²C write access to the BNO055:

Start	Slave address							RW	ACKS	dummy	Register address (0x00 .. 0x7F)							ACKS	Data								ACKS	Stop
S	0	0	1	0	1	0	0	0	A	x	x	x	x	x	x	x	x	A	x	x	x	x	x	x	x	x	A	P

Figure 6: I²C write

I²C read access:
I²C read access also can be used to read one or multiple data bytes in one sequence.

A read sequence consists of a one-byte I²C write phase followed by the I²C read phase. The two parts of the transmission must be separated by a repeated start condition (Sr). The I²C write phase addresses the slave and sends the register address to be read. After slave acknowledges the transmission, the master generates again a start condition and sends the slave address together with a read bit (RW = 1). Then the master releases the bus and waits for the data bytes to be read out from slave. After each data byte the master has to generate an acknowledge bit (ACK = 0) to enable further data transfer. A NACKM (ACK = 1) from the master stops the data being transferred from the slave. The slave releases the bus so that the master can generate a STOP condition and terminate the transmission.
The register address is automatically incremented and, therefore, more than one byte can be sequentially read out. Once a new data read transmission starts, the start address will be set to the register address specified in the latest I²C write command. By default the start address is set at 0x00. In this way repetitive multi-bytes reads from the same starting address are possible.

Example of an I²C read access to the BNO055:

Start	Slave address							RW	ACKS	dummy	Register address (0x08)							ACKS
S	0	0	1	0	1	0	0	0	A	x	0	0	0	1	0	0	0	A

Start	Slave address							RW	ACKS	Read data (0x08)								ACKM	Read data (0x09)								ACKM	
Sr	0	0	1	0	1	0	0	1	A	x	x	x	x	x	x	x	x	A	x	x	x	x	x	x	x	x	A	...

	ACKS	Read data (0x0A)								ACKM	Read data (0x0B)								ACKM	
...	A	x	x	x	x	x	x	x	x	A	x	x	x	x	x	x	x	x	A	...

	ACKS	Read data (0x0C)								ACKM	Read data (0x0D)								NACKM	Stop
...	A	x	x	x	x	x	x	x	x	A	x	x	x	x	x	x	x	x	NA	P

Figure 7: I²C multiple read

4.7 UART Protocol

The BNO055 supports communication over UART interface with the following settings: 115200 bps, 8N1 (8 data bits, no parity bit, one stop bit). The maximum length support for read and write is 128 Byte. The packet structure for register read and write are described below.

4.7.1 **Register write**

Command:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	.....	Byte (n+4)
Start Byte	Write	Reg addr	Length	Data 1	.....	Data n
0xAA	0x00	<..>	<..>	<..>	.....	<..>

Acknowledge Response:

Byte 1	Byte 2
Response Header	Status
0xEE	0x01: WRITE_SUCCESS 0x03: WRITE_FAIL 0x04: REGMAP_INVALID_ADDRESS 0x05: REGMAP_WRITE_DISABLED 0x06: WRONG_START_BYTE 0x07: BUS_OVER_RUN_ERROR 0X08: MAX_LENGTH_ERROR 0x09: MIN_LENGTH_ERROR 0x0A: RECEIVE_CHARACTER_TIMEOUT

4.7.2 **Register read**

Command:

Byte 1	Byte 2	Byte 2	Byte 3
Start Byte	Read	Reg addr	Length
0xAA	0x01	<..>	<..>

Read Success Response:

Byte 1	Byte 2	Byte 3	.....	Byte (n+2)
ResponseByte	length	Data 1	.....	Data n
0xBB	<..>			

Read Failure or Acknowledge Response:

Byte 1	Byte 2
Response Header	Status
0xEE	0x02: READ_FAIL 0x04: REGMAP_INVALID_ADDRESS 0x05: REGMAP_WRITE_DISABLED 0x06: WRONG_START_BYTE 0x07: BUS_OVER_RUN_ERROR 0X08: MAX_LENGTH_ERROR 0x09: MIN_LENGTH_ERROR 0x0A: RECEIVE_CHARACTER_TIMEOUT

4.8 HID over I2C

For more details on the using the BNO055 in HID over I2C mode please contact your local Bosch Sensortec sales representative and ask for the appropriate BNO055 HID-I2C application note.

5. **Pin-out and connection diagram**

5.1 Pin-out

The pin-out of the LGA package is shown in Figure 8 and the pin function is described in Table 5-1.

Figure 8: Pin-out bottom view

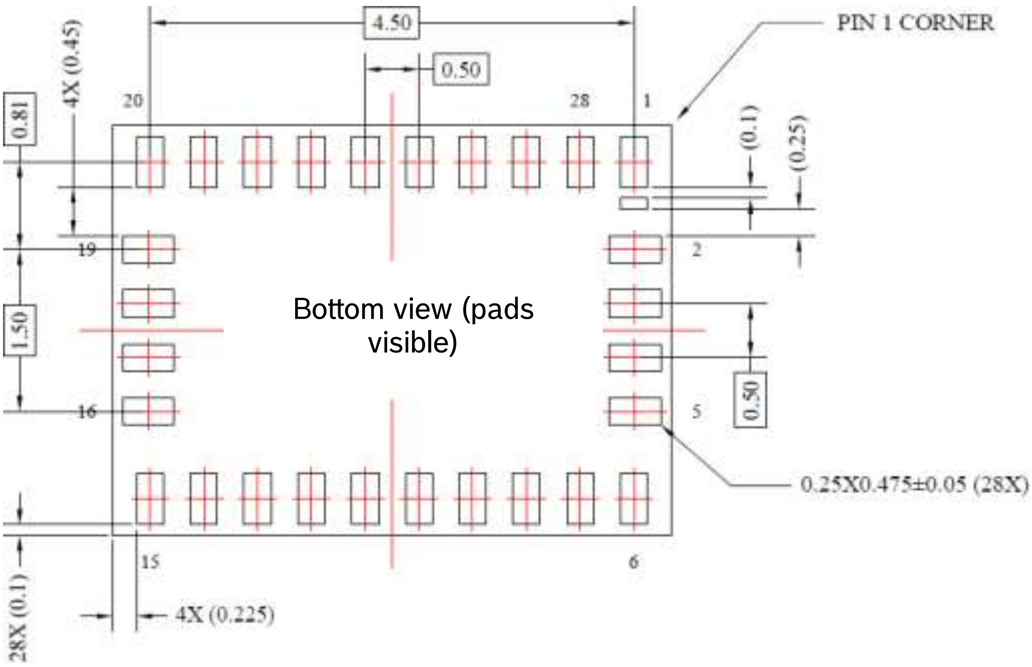
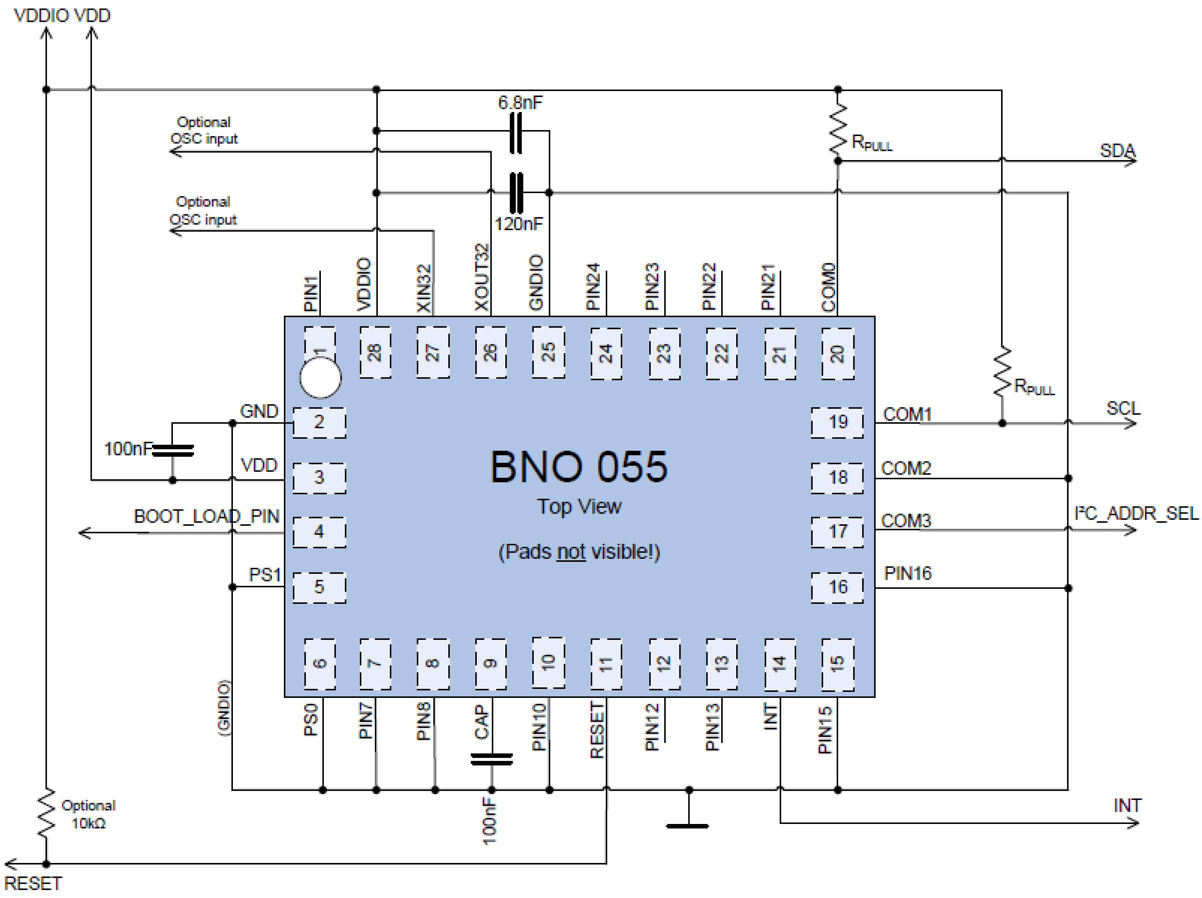


Table 5-1: Pin description

Pin No.	Pin Name	Function
1	PIN1	do not connect
2	GND	GND
3	VDD	VDD
4	BOOT_LOAD_PIN	Bootloader mode select pin
5	PS1	Protocol select pin 1
6	PS0	Protocol select pin 2
7	PIN7	connect to GNDIO
8	PIN8	connect to GNDIO
9	CAP	External capacitor
10	PIN10	connect to GNDIO
11	RESET	RESET
12	PIN12	do not connect
13	PIN13	do not connect
14	INT	Interrupt output
15	PIN15	connect to GNDIO
16	PIN16	connect to GNDIO
17	COM3	Digital interface pin 3
18	COM2	Digital interface pin 2
19	COM1	Digital interface pin 1
20	COM0	Digital interface pin 0
21	PIN21	do not connect
22	PIN22	do not connect
23	PIN23	do not connect
24	PIN24	do not connect
25	GNDIO	GNDIO
26	XOUT32	Optional OSC port
27	XIN32	Optional OSC port
28	VDDIO	VDDIO

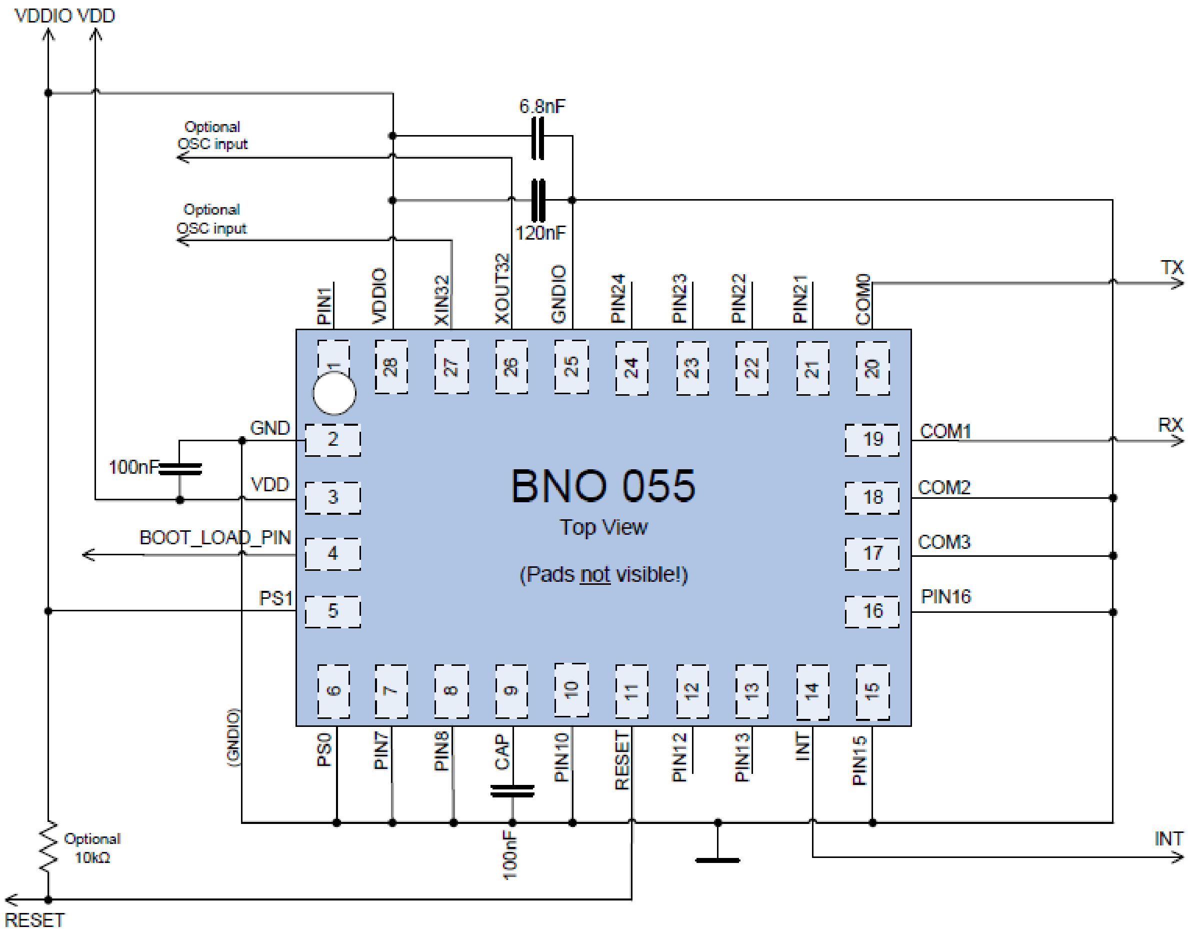
5.2 Connection diagram I²C

Figure 9: I²C connection diagram



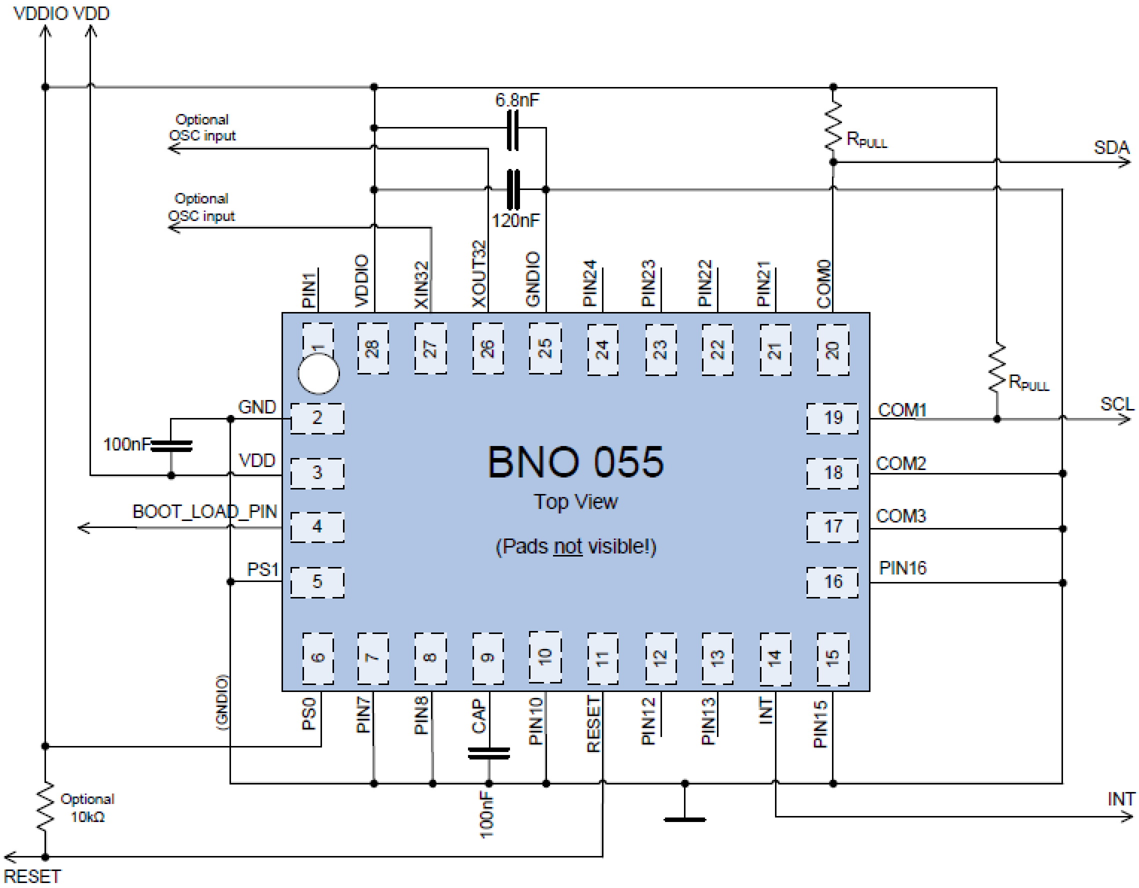
5.3 Connection diagram UART

Figure 10: UART connection diagram



5.4 Connection diagram HID-I2C

Figure 11 : HID via IC connection diagram



5.5 XOUT32 & XIN32 Connections

The BNO055 can run from an internal or external 32kHz clock source. By default, the internal clock is selected.External clock mode

An External clock can be selected by setting bit CLK_SEL in the SYSTEM_TRIGGER register. An external 32kHz crystal oscillator has to be connected to the pins XIN32 and XOUT32 as shown below.

5.5.1 **External 32kHz Crystal Oscillator**

Figure 12 : External 32kHz Crystal Oscillator with Load Capacitor

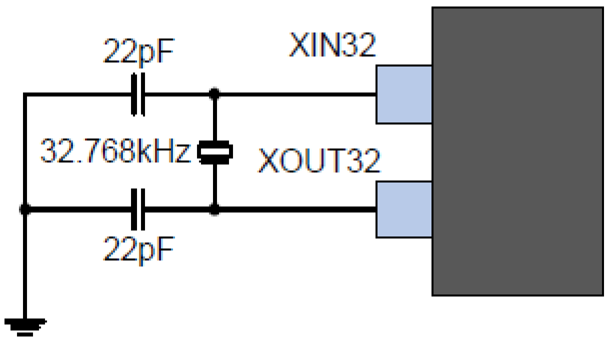


Table 0-1: Crystal Oscillator Source Connections

Signal Name	Recommended Pin Connection	Description
XIN	Load capacitor 22pF[8,9]	Timer oscillator input
XOUT	Load capacitor 22pF[8,9]	Timer oscillator output

5.5.2 **Internal clock mode**

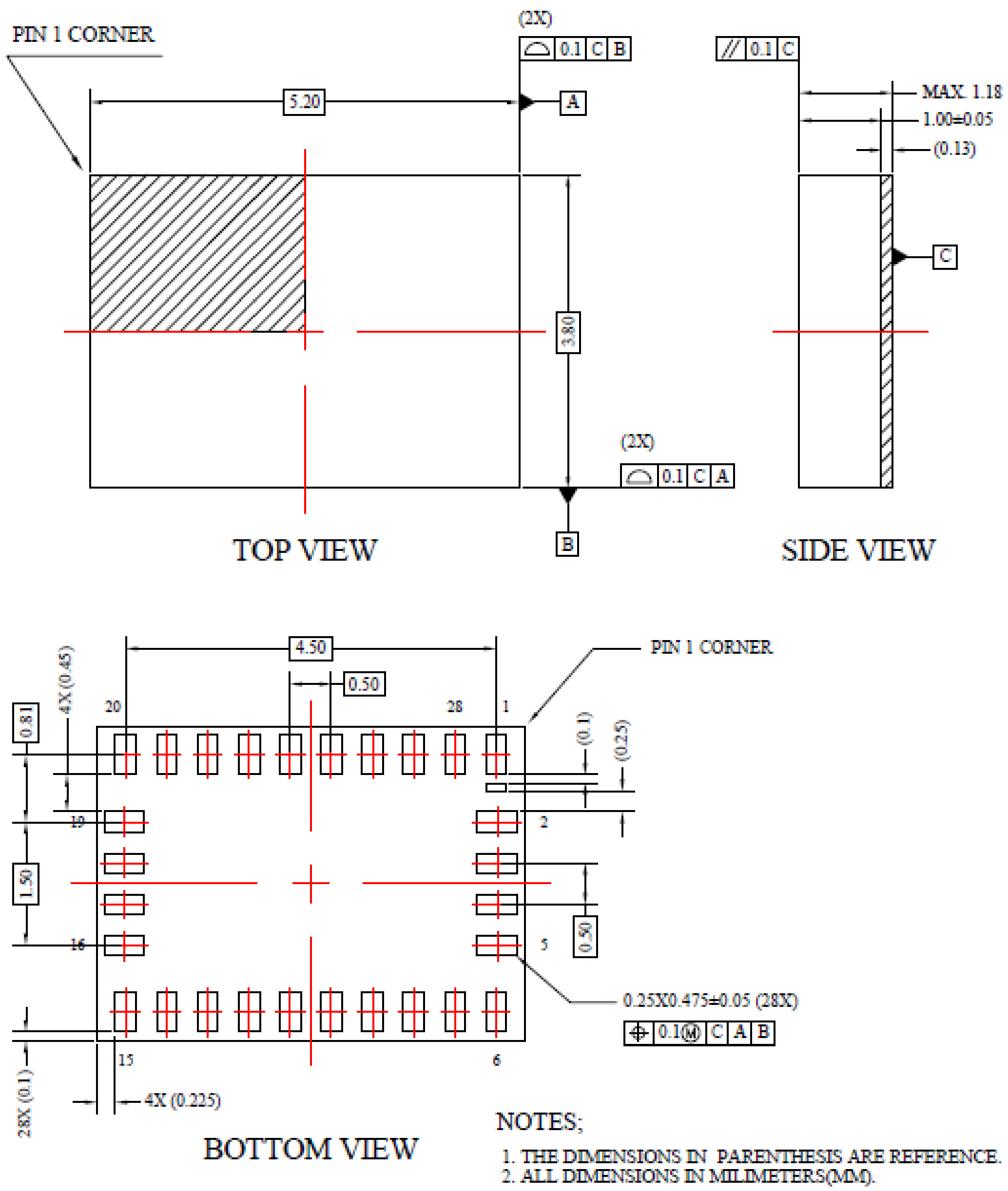
The internal clock can be selected by clearing bit CLK_SEL in the SYSTEM_TRIGGER register. When an internal clock is used, both pins XIN32 and XOUT32 can be left open.

[8] These values are given only as typical example.
[9] Decoupling capacitor should be placed close to the device for each supply pin pair in the signal group.

6. **Package**

6.1 Outline dimensions

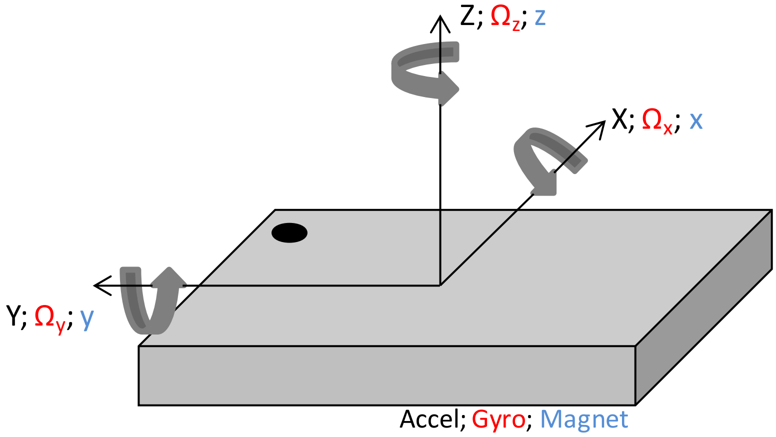
The sensor package is a standard LGA package; dimensions are shown in the following diagram. Units are in mm. Note: Unless otherwise specified tolerance = decimal ±0.1mm.



6.2 Sensing Axes Orientation

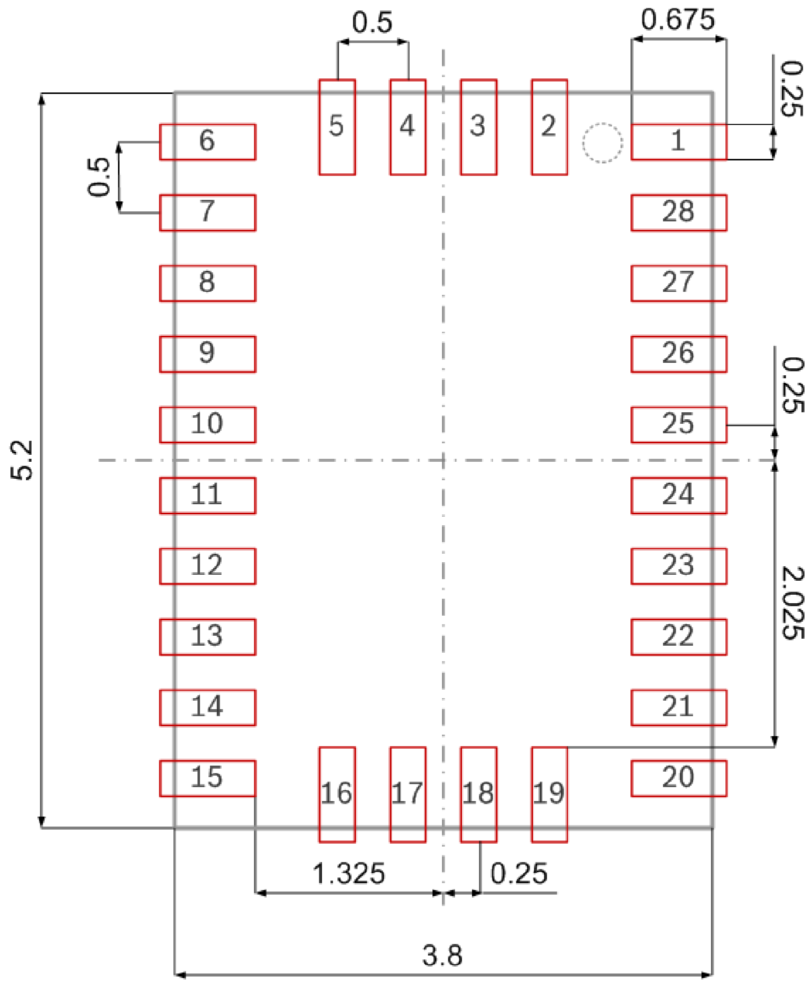
The default device axis orientation is shown in Figure 13 below; this orientation is valid for all sensor outputs (physical and virtual).

Figure 13: device axis orientation



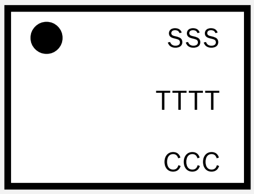
6.3 Landing pattern recommendation

Figure 14: Landing pattern recommendation



6.4 Marking

Table 6-1: 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

6.5 Soldering Guidelines

The moisture sensitivity level of the BNO055 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.

6.6 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.

6.7 Tape and reel specification

The BNO055 is shipped in a standard cardboard box. For details please refer to the handling, soldering and mounting instructions for BNO055.

6.8 Environmental safety

The BNO055 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.

6.8.1 **Halogen content**

The BNO055 is halogen-free. For more details on the analysis results please contact your Bosch Sensortec representative.

6.8.2 **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 LGA package of the BNO055.

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 BMNO55 product.

7. Legal disclaimer

7.1 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.

7.2 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 security sensitive systems. Security sensitive systems are those for which a malfunction is expected to lead to bodily harm or significant property damage. In addition, they are not fit for use in products which interact with motor vehicle systems.

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The purchaser must monitor the market for the purchased products, particularly with regard to product safety, and inform Bosch Sensortec without delay of all security relevant incidents.

7.3 Application examples and hints

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8. Document history and modifications

Rev. No	Chapter	Description of modification/changes	Date
0.1		Initial version	2013-09-02
0.2		Completely revised version (BMF055 added)	2013-10-15
0.9		Preliminary version with feature set of Firmware version 0.2.B.0	2014-04-25
1.0		Complete review	2014-07-11

Bosch Sensortec GmbH
Gerhard-Kindler-Strasse 8
72770 Reutlingen / Germany

contact@bosch-sensortec.com
www.bosch-sensortec.com

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