

BNO055

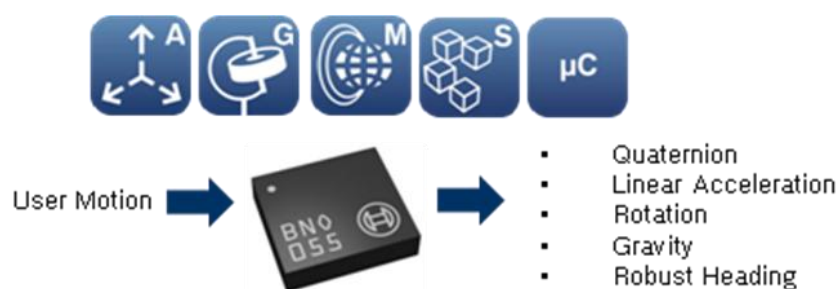
Intelligent 9-axis absolute orientation sensor

Bosch Sensortec



BOSCH

Invented for life



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
 - 3 sensors in one device
 - Small package
 - Power Management
 - Common voltage supplies
 - Digital interface
 - Consumer electronics suite
- Quaternion, Euler angles, Rotation vector,
Linear acceleration, Gravity, Heading
an advanced triaxial 16bit gyroscope, a versatile,
leading edge triaxial 14bit accelerometer and a
full performance geomagnetic sensor
LGA package 28 pins
Footprint 3.8 x 5.2 mm², height 1.13 mm²
Intelligent Power Management: normal,
low power and suspend mode available
V_{DD} voltage range: 2.4V to 3.6V
HID-I2C (Windows 8 compatible), I²C, UART
V_{DDIO} voltage range: 1.7V to 3.6V
MSL1, RoHS compliant, halogen-free
Operating temperature: -40° C ... +85° C

Key features of integrated sensors:

Accelerometer features

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

Gyroscope features

- Programmable functionality

Ranges switchable from $\pm 125^\circ/\text{s}$ to $\pm 2000^\circ/\text{s}$

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 $\pm 1300\mu\text{T}$ (x-, y-axis);
 $\pm 2500\mu\text{T}$ (z-axis)Magnetic field resolution of $\sim 0.3\mu\text{T}$

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 I²C and UART interfaces. The I²C 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.

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Specification

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

1.1 Electrical specification

Table 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 | $^{\circ}C$ |
| Total supply current normal mode at T_A (9DOF @100Hz output data rate) | $I_{DD} + I_{DDIO}$ | $V_{DD} = 3V, V_{DDIO} = 2.5V$ | -- | -- | 12.3 | mA |
| Total supply current Low power mode at T_A | I_{DD_LPM} | $V_{DD} = 3V, V_{DDIO} = 2.5V$ | -- | -- | 0.4 | mA |
| Total supply current suspend mode at T_A | I_{DD_SuM} | $V_{DD} = 3V, V_{DDIO} = 2.5V$ | -- | -- | 0.04 | 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. Fusion Output data rates | | | | |
| 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} | T _a =25°C, g _{FS2g} | | ±1 | ±4 | % |
| Sensitivity Temperature Drift | TCS | g _{FS2g} , Nominal V _{DD} supplies, Temp operating conditions | | ±0.03 | | %/K |
| Sensitivity Supply Volt. Drift | S _{VDD} | g _{FS2g} , T _A =25°C, V _{DD_min} ≤ V _{DD} ≤ V _{DD_max} | | 0.065 | 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} ≤ V _{DD} ≤ V _{DD_max} | | 1.5 | 2.5 | mg/V |
| Bandwidth h | bw ₈ | 2 nd order filter, bandwidth h programmable | | 8 | | Hz |
| | bw ₁₆ | | | 16 | | Hz |
| | bw ₃₁ | | | 31 | | Hz |
| | bw ₆₃ | | | 63 | | Hz |
| | bw ₁₂₅ | | | 125 | | Hz |
| | bw ₂₅₀ | | | 250 | | Hz |
| | bw ₅₀₀ | | | 500 | | Hz |

| | | | | | | |
|----------------------|-------------|---|--|-------|-----|--------------------------------|
| | bw_{1000} | | | 1,000 | | Hz |
| Nonlinearity | NL | best fit straight line, g_{FS2g} | | 0.5 | 2 | %FS |
| Output Noise Density | n_{rms} | g_{FS2g} , $T_A=25^\circ\text{C}$ Nominal V_{DD} supplies Normal mode | | 150 | 190 | $\mu\text{g}/\sqrt{\text{Hz}}$ |

MECHANICAL CHARACTERISTICS ACCELEROMETER

| Parameter | Symbol | Condition | Min | Typ | Max | Units |
|------------------------|--------|--|-----|-----|-----|-------|
| Cross Axis Sensitivity | CAS | relative contribution between any two of the three axes | | 1 | 2 | % |
| Alignment Error | E_A | relative to package outline | | 0.5 | 2 | ° |

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)

| | | | | | | |
|---|---|--|----|-------------|------------|-----------------|
| Sensitivity via register Map | S | $T_A=25^\circ\text{C}$ | | 16.0 900 | | LSB/°s rad/s |
| Sensitivity tolerance | S_{tol} | $T_A=25^\circ\text{C}$, R_{FS2000} | -- | ± 1 | ± 3 | % |
| Sensitivity Change over Temperature | TCS | Nominal V_{DD} supplies $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ R_{FS2000} | | ± 0.03 | ± 0.07 | %/K |
| Sensitivity Supply Volt. Drift | S_{VDD} | $T_A=25^\circ\text{C}$, $V_{DD_min} \leq V_{DD} \leq V_{DD_max}$ | | <0.4 | | %/V |
| Nonlinearity | NL | best fit straight line R_{FS1000} , R_{FS2000} | | ± 0.05 | ± 0.2 | %FS |
| Zero-rate Offset | Off Ω_x Ω_y and Ω_z | Nominal V_{DD} supplies $T_A=25^\circ\text{C}$, Slow and fast offset cancellation off | -3 | ± 1 | +3 | %s |
| Zero- Ω Offset Change over Temperature | TCO | Nominal V_{DD} supplies $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ R_{FS2000} | | ± 0.015 | ± 0.03 | %s per K |
| Zero- Ω Offset Supply Volt. Drift | Off Ω_{VDD} | $T_A=25^\circ\text{C}$, $V_{DD_min} \leq V_{DD} \leq V_{DD_max}$ | | 0.1 | | %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 | T _A =25°C | ±1200 | ±1300 | | μT |
| | Brg,z | | ±2000 | ±2500 | | μT |
| Magnetometer heading accuracy ² | As heading | 30μT horizontal geomagnetic field component, T _A =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, $T_A=25^\circ\text{C}$ Nominal V_{DD} supplies | | 1.0 | | μT |
| | $n_{rms,lp,m,z}$ | Low power preset z-axis, $T_A=25^\circ\text{C}$ Nominal V_{DD} supplies | | 1.4 | | μT |
| | $n_{rms,rg,m}$ | Regular preset $T_A=25^\circ\text{C}$ Nominal V_{DD} supplies | | 0.6 | | μT |
| | $n_{rms,eh,m}$ | Enhanced regular preset $T_A=25^\circ\text{C}$ Nominal V_{DD} supplies | | 0.5 | | μT |
| | $n_{rms,ha,m}$ | High accuracy preset $T_A=25^\circ\text{C}$ Nominal V_{DD} supplies | | 0.3 | | μT |
| Power Supply Rejection Rate | PSRR_m | $T_A=25^\circ\text{C}$ Nominal V_{DD} supplies | | ± 0.5 | | $\mu\text{T/V}$ |

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-supply} Pin | | -0.3 | V _{DDIO} + 0.3 | V |
| Passive Storage Temp. Range | Trps | ≤ 65% rel. H. | -50 | +150 | °C |
| Mechanical Shock | MechShock _{200µs} | Duration ≤ 200µs | | 10,000 | g |
| | MechShock _{1ms} | Duration ≤ 1.0ms | | 2,000 | g |
| | MechShock _{freefall} | Free fall onto hard surfaces | | 1.8 | m |
| ESD | ESD _{HBM} | HBM, at any Pin | | 2 | kV |
| | ESD _{CDM} | CDM | | 400 | V |
| | ESD _{MM} | MM | | 200 | V |

Note:

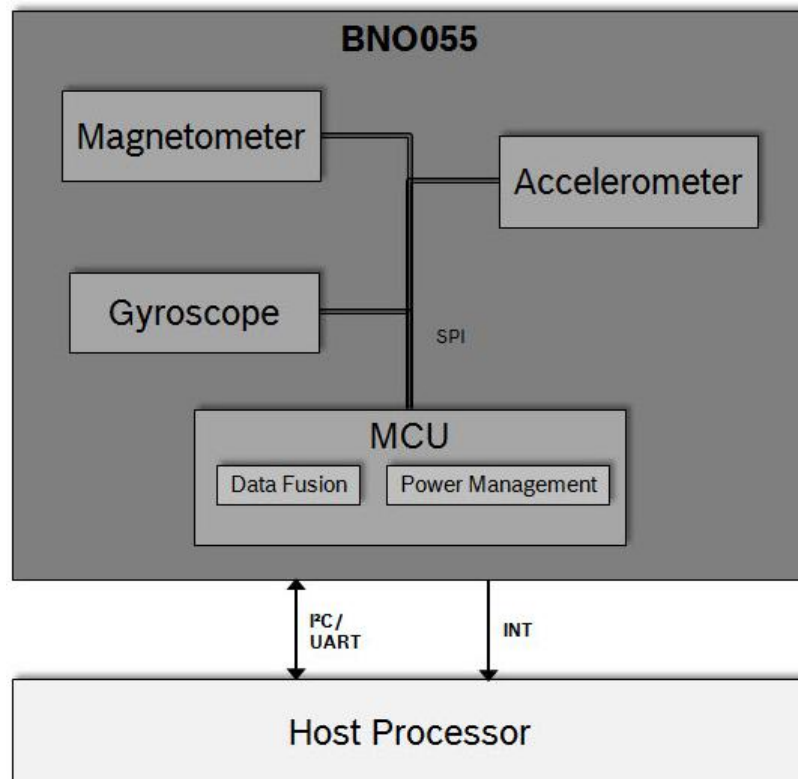
Stress above these limits may cause damage to the device. Exceeding the specified electrical limits may affect the device reliability or cause malfunction.

3. Functional Description

3.1 Architecture

The following figure shows the basic building blocks of the 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 sensor features a power-on reset (POR), initializing the register map with the default values and starting in CONFIG mode. The POR is executed at every power on and can also be triggered either by applying a low signal to the nRESET pin for at least 20ns or by setting the RST_SYS bit in the SYS_TRIGGER register.

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 [Power Modes](#)

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 the table below. As default at start-up the BNO055 will run in Normal mode.

Table 3-1: power modes selection

| Parameter | Value | [Reg Addr]: Reg Value |
|------------|----------------|-----------------------|
| Power Mode | Normal Mode | [PWR_MODE]: xxxxx00b |
| | Low Power Mode | [PWR_MODE]: xxxxx01b |
| | Suspend Mode | [PWR_MODE]: xxxxx10b |

3.2.1 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.

3.2.2 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.

Table 3-2: Low power modes - Interrupts

| Description | Parameter | Value | Reg Value | Restriction |
|---|----------------|----------------|--------------------------------|--|
| Entering to sleep: NO Motion Interrupt | Detection Type | No Motion | [ACC_NM_SET] : xxxxxx1b | n/a |
| | | Detection Axis | [ACC_INT_Settings] : bit4-bit2 | Shares common bit with Any Motion interrupt axis selection |
| | Params | Duration | [ACC_NM_SET] : bit6-bit1 | n/a |
| | | Threshold | [ACC_NM_THRE] : bit7-bit0 | n/a |

| Description | Parameter | Value | Reg Value |
|---------------------------------|----------------|----------------|--------------------------------|
| Waking up: Any Motion Interrupt | 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.

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 High-G and slow motion interrupts are not applicable in low power mode.
- Low power mode is not applicable where accelerometer is not employed.

3.2.3 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 3-1).

3.3 Operation Modes

The BNO055 provides a variety of output signals, which can be chosen by selecting the appropriate operation mode. The table below lists the different modes and the available sensor signals.

Table 3-3: Operating modes overview

| Operating Mode | | Available sensor signals | | | Fusion Data | |
|------------------|--------------|--------------------------|-----|------|----------------------|----------------------|
| | | Accel | Mag | Gyro | Relative orientation | Absolute orientation |
| | CONFIGMODE | - | - | - | - | - |
| Non-fusion modes | ACCONLY | X | - | - | - | - |
| | MAGONLY | - | X | - | - | - |
| | GYROONLY | - | - | X | - | - |
| | ACCMAG | X | X | - | - | - |
| | ACCGYRO | X | - | X | - | - |
| | MAGGYRO | - | X | X | - | - |
| | AMG | X | X | X | - | - |
| Fusion modes | IMU | X | - | X | X | - |
| | COMPASS | X | X | - | - | X |
| | M4G | X | X | | X | - |
| | NDOF_FMC_OFF | X | X | X | - | X |
| | NDOF | X | X | X | - | X |

The default operation mode after power-on is CONFIGMODE.

When the user changes to another operation mode, the sensors which are required in that particular sensor mode are powered, while the sensors whose signals are not required are set to suspend mode.

The BNO055 sets the following default settings for the sensors. The user can overwrite these settings in the register map when in CONFIGMODE.

Table 3-4: Default sensor settings

| Sensor | Range | Bandwidth |
|---------------|----------|-----------|
| Accelerometer | 4G | 62.5 Hz |
| Magnetometer | NA | 10 Hz |
| Gyroscope | 2000 dps | 32 Hz |

In any mode, the 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.

The operating mode can be selected by writing to the OPR_MODE register, possible register values and the corresponding operating modes are shown in the table below.

Table 3-5: operating modes selection

| Parameter | Value | [Reg Addr]: Reg Value |
|-----------------|--------------|-----------------------|
| CONFIG MODE | CONFIGMODE | [OPR_MODE]: xxx0000b |
| Non-Fusion Mode | ACCONLY | [OPR_MODE]: xxx0001b |
| | MAGONLY | [OPR_MODE]: xxx0010b |
| | GYROONLY | [OPR_MODE]: xxx0011b |
| | ACCMAG | [OPR_MODE]: xxx0100b |
| | ACCGYRO | [OPR_MODE]: xxx0101b |
| | MAGGYRO | [OPR_MODE]: xxx0110b |
| | AMG | [OPR_MODE]: xxx0111b |
| Fusion Mode | IMU | [OPR_MODE]: xxx1000b |
| | COMPASS | [OPR_MODE]: xxx1001b |
| | M4G | [OPR_MODE]: xxx1010b |
| | NDOF_FMC_OFF | [OPR_MODE]: xxx1011b |
| | NDOF | [OPR_MODE]: xxx1100b |

Table 3-6 below shows the time required to switch between CONFIGMODE and the other operating modes.

Table 3-6: Operating mode switching time

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

3.3.1 Config Mode

This mode is used to configure BNO, wherein all output data is reset to zero and sensor fusion is halted. This is the only mode in which all the writable register map entries can be changed. (Exceptions from this rule are the interrupt registers (INT and INT_MSK) and the operation mode register (OPR_MODE), which can be modified in any operation mode.)

As being said, this mode is the default operation mode after power-on or RESET. Any other mode must be chosen to be able to read any sensor data.

3.3.2 Non-Fusion Modes

3.3.2.1 ACCONLY

If the application requires only raw accelerometer data, this mode can be chosen. In this mode the other sensors (magnetometer, gyro) are suspended to lower the power consumption. In this mode, the BNO055 behaves like a stand-alone acceleration sensor.

3.3.2.1 MAGONLY

In MAGONLY mode, the BNO055 behaves like a stand-alone magnetometer, with acceleration sensor and gyroscope being suspended.

3.3.2.2 GYROONLY

In GYROONLY mode, the BNO055 behaves like a stand-alone gyroscope, with acceleration sensor and magnetometer being suspended.

3.3.2.3 ACCMAG

Both accelerometer and magnetometer are switched on, the user can read the data from these two sensors.

3.3.2.4 ACCGYRO

Both accelerometer and gyroscope are switched on; the user can read the data from these two sensors.

3.3.2.5 MAGGYRO

Both magnetometer and gyroscope are switched on, the user can read the data from these two sensors.

3.3.2.6 AMG (ACC-MAG-GYRO)

All three sensors accelerometer, magnetometer and gyroscope are switched on.

3.3.3 Fusion modes

Sensor fusion modes are meant to calculate measures describing the orientation of the device in space. It can be distinguished between non-absolute or relative orientation and absolute orientation. Absolute orientation means orientation of the sensor with respect to the earth and its magnetic field. In other words, absolute orientation sensor fusion modes calculate the direction of the magnetic north pole.

In non-absolute or relative orientation modes, the heading of the sensor can vary depending on how the sensor is placed initially.

All fusion modes provide the heading of the sensor as quaternion data or in Euler angles (roll, pitch and yaw angle). The acceleration sensor is both exposed to the gravity force and to accelerations applied to the sensor due to movement. In fusion modes it is possible to separate the two acceleration sources, and thus the sensor fusion data provides separately linear acceleration (i.e. acceleration that is applied due to movement) and the gravity vector.

3.3.3.1 IMU (Inertial Measurement Unit)

In the IMU mode the relative orientation of the BNO055 in space is calculated from the accelerometer and gyroscope data. The calculation is fast (i.e. high output data rate).

3.3.3.2 COMPASS

The COMPASS mode is intended to measure the magnetic earth field and calculate the geographic direction.

The earth magnetic field is a vector with the horizontal components x_y and the vertical z component. It depends on the position on the globe and natural iron occurrence. For heading calculation (direction of compass pointer) only the horizontal components x and y are used. Therefore the vector components of the earth magnetic field must be transformed in the horizontal plane, which requires the knowledge of the direction of the gravity vector. To summarize, the heading can only be calculated when considering gravity and magnetic field at the same time.

However, the measurement accuracy depends on the stability of the surrounding magnetic field. Furthermore, since the earth magnetic field is usually much smaller than the magnetic fields that occur around and inside electronic devices, the compass mode requires calibration ([see chapter 3.10](#))

3.3.3.3 M4G (Magnet for Gyroscope)

The M4G mode is similar to the IMU mode, but instead of using the gyroscope signal to detect rotation, the changing orientation of the magnetometer in the magnetic field is used. Since the magnetometer has much lower power consumption than the gyroscope, this mode is less power consuming in comparison to the IMU mode. There are no drift effects in this mode which are inherent to the gyroscope.

However, as for compass mode, the measurement accuracy depends on the stability of the surrounding magnetic field.

For this mode no magnetometer calibration is required and also not available.

3.3.3.4 NDOF_FMC_OFF

This fusion mode is same as NDOF mode, but with the Fast Magnetometer Calibration turned 'OFF'.

3.3.3.5 NDOF

This is a fusion mode with 9 degrees of freedom where the fused absolute orientation data is calculated from accelerometer, gyroscope and the magnetometer. The advantages of combining all three sensors are a **fast calculation**, resulting in **high output data rate**, and **high robustness from magnetic field distortions**. In this mode the Fast Magnetometer calibration is turned ON and thereby resulting in quick calibration of the magnetometer and higher output data accuracy. The current consumption is slightly higher in comparison to the NDOF_FMC_OFF fusion mode.

3.4 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).

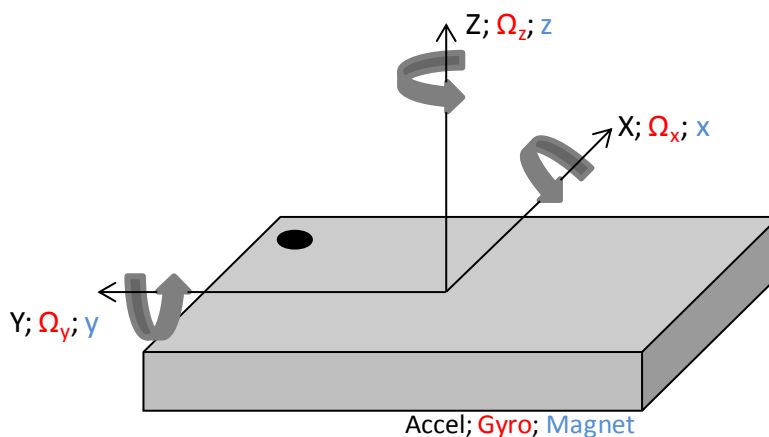
Axis sign configuration byte: Register Address: **AXIS_MAP_SIGN**

| 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 |

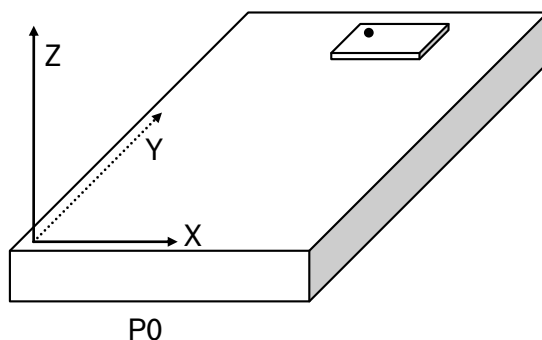
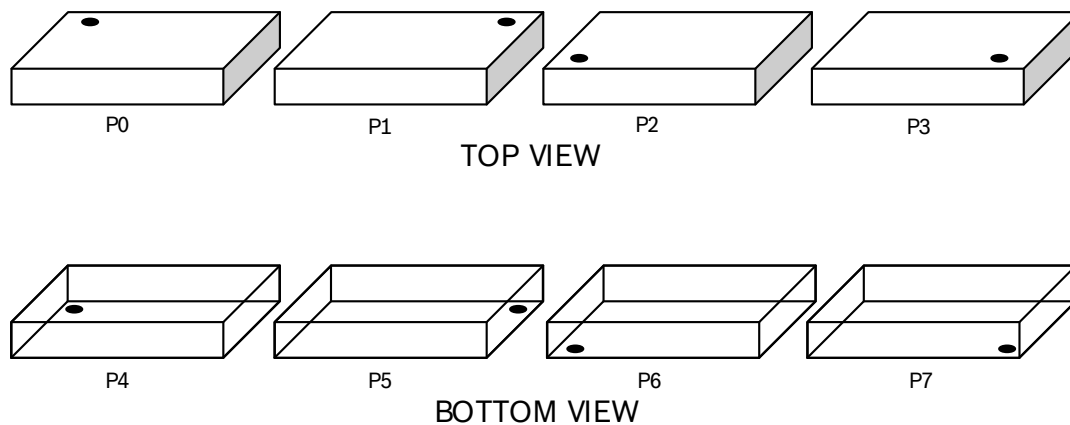
| Value | Sign |
|-------|----------|
| 0 | Positive |
| 1 | Negative |

The default value is 0x00.

The default values correspond to the following coordinate system



Some example placement for axis vs. register settings:



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 |

3.5 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. In any of the sensor modes the configuration settings can be updated by writing to the configuration registers as defined in the following sections.

3.5.1 Default sensor configuration

At power-on the sensors are configured with the default settings as defined in Table 3-8 below.

Table 3-7: 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 |

3.5.2 Accelerometer configuration

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 below shows different Accelerometer configurations

Table 3-8: Accelerometer configurations

| Parameter | Values | [Reg Addr]: Reg Value | Restrictions |
|----------------|--------------|------------------------|--------------------------------|
| G Range | 2G | [ACC_Config]: xxxxx00b | User selectable in all modes |
| | 4G | [ACC_Config]: xxxxx01b | |
| | 8G | [ACC_Config]: xxxxx10b | |
| | 16G | [ACC_Config]: xxxxx11b | |
| Bandwidth | 7.81Hz | [ACC_Config]: xxx000xb | Auto controlled in fusion mode |
| | 15.63Hz | [ACC_Config]: xxx001xb | |
| | 31.25Hz | [ACC_Config]: xxx010xb | |
| | 62.5Hz | [ACC_Config]: xxx011xb | |
| | 125Hz | [ACC_Config]: xxx100xb | |
| | 250Hz | [ACC_Config]: xxx101xb | |
| | 500Hz | [ACC_Config]: xxx110xb | |
| | 1000Hz | [ACC_Config]: xxx111xb | |
| Operation Mode | Normal | [ACC_Config]: 000xxxxb | Auto controlled in fusion mode |
| | Suspend | [ACC_Config]: 001xxxxb | |
| | Low Power 1 | [ACC_Config]: 010xxxxb | |
| | Standby | [ACC_Config]: 011xxxxb | |
| | Low Power 2 | [ACC_Config]: 100xxxxb | |
| | Deep Suspend | [ACC_Config]: 101xxxxb | |

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.

3.5.3 Gyroscope configuration

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 below shows different Gyroscope configurations

Table 3-9: Gyroscope configurations

| Parameter | Values | [Reg Addr]: Register value | Restrictions |
|----------------|--------------------|----------------------------|--------------------------------|
| Range | 2000 dps | [GYR_Config_0]: xxxx000b | Auto controlled in fusion mode |
| | 1000 dps | [GYR_Config_0]: xxxx001b | |
| | 500dps | [GYR_Config_0]: xxxx010b | |
| | 250 dps | [GYR_Config_0]: xxxx011b | |
| | 125 dps | [GYR_Config_0]: xxxx100b | |
| Bandwidth | 523Hz | [GYR_Config_0]: xx00xxxb | |
| | 230Hz | [GYR_Config_0]: xx001xxb | |
| | 116Hz | [GYR_Config_0]: xx010xxb | |
| | 47Hz | [GYR_Config_0]: xx011xxb | |
| | 23Hz | [GYR_Config_0]: xx100xxb | |
| | 12Hz | [GYR_Config_0]: xx101xxb | |
| | 64Hz | [GYR_Config_0]: xx110xxb | |
| | 32Hz | [GYR_Config_0]: xx111xxb | |
| Operation Mode | Normal | [GYR_Config_1]: xxxx000b | |
| | Fast Power up | [GYR_Config_1]: xxxx001b | |
| | Deep Suspend | [GYR_Config_1]: xxxx010b | |
| | Suspend | [GYR_Config_1]: xxxx011b | |
| | Advanced Powersave | [GYR_Config_1]: xxxx100b | |

3.5.4 Magnetometer configuration

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 below shows different Magnetometer configurations.

Table 3-10: Magnetometer configurations

| Parameter | Values | [Reg Addr]: Register value | Restrictions |
|------------------|------------------|----------------------------|--------------------------------|
| Data output rate | 2Hz | [MAG_Config]: xxxx000b | Auto controlled in fusion mode |
| | 6Hz | [MAG_Config]: xxxx001b | |
| | 8Hz | [MAG_Config]: xxxx010b | |
| | 10Hz | [MAG_Config]: xxxx011b | |
| | 15Hz | [MAG_Config]: xxxx100b | |
| | 20Hz | [MAG_Config]: xxxx101b | |
| | 25Hz | [MAG_Config]: xxxx110b | |
| | 30Hz | [MAG_Config]: xxxx111b | |
| Operation Mode | Low Power | [MAG_Config]: xx00xxb | |
| | Regular | [MAG_Config]: xx01xxb | |
| | Enhanced Regular | [MAG_Config]: xx10xxb | |
| | High Accuracy | [MAG_Config]: xx11xxb | |
| Power Mode | Normal | [MAG_Config]: x00xxxxb | |
| | Sleep | [MAG_Config]: x01xxxxb | |
| | Suspend | [MAG_Config]: x10xxxxb | |
| | Force Mode | [MAG_Config]: x11xxxxb | |

3.6 Output data

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

3.6.1 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 3-11: unit selection

| Data | Units | [Reg Addr]: Register Value |
|--|------------------|----------------------------|
| Acceleration, Linear Acceleration, Gravity vector | m/s ² | [UNIT_SEL] : xxxxxx0b |
| | mg | [UNIT_SEL] : xxxxxx1b |
| Magnetic Field Strength | Micro Tesla | NA |
| Angular Rate | Dps | [UNIT_SEL] : xxxxx0xb |
| | Rps | [UNIT_SEL] : xxxxx1xb |
| Euler Angles | Degrees | [UNIT_SEL] : xxxxx0xb |
| | Radians | [UNIT_SEL] : xxxxx1xb |
| Quaternion | Quaternion units | NA |
| Temperature | °C | [UNIT_SEL] : xxx0xxx |
| | °F | [UNIT_SEL] : xxx1xxx |

3.6.2 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 3-12: Fusion data output format

| Parameter | Values | [Reg Addr]: Register value |
|---------------------------|---------|----------------------------|
| Fusion data output format | Windows | [UNIT_SEL]: 0xxxxxx |
| | Android | [UNIT_SEL]: 1xxxxxx |

The output data format is based on the following convention regarding the rotation angles for roll, pitch and heading / yaw (compare also section 3.4):

Table 3-13: Rotation angle conventions

| Rotation angle | Range (Android format) | Range (Windows format) |
|----------------|---|---|
| Pitch | +180° to -180° (turning clockwise decreases values) | -180° to +180° (turning clockwise increases values) |
| Roll | -90° to +90° (increasing with increasing inclination) | |
| Heading / Yaw | 0° to 360° (turning clockwise increases values) | |

3.6.3 Fusion Output data rates

Table 3-14: Fusion output data rates

| 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 |

3.6.4 Sensor calibration data

The following section describes the register holding the calibration data of the sensors (see chapter 3.10). The offset and radius data can be read from these registers and stored in the host system, which could be later used to get the correct orientation data after 'Power on Reset' of the sensor.

3.6.4.1 Accelerometer offset

The accelerometer offset can be configured in the following registers, shown in the table below. 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).

Table 3-15: Accelerometer Default-Reg settings

| 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 |

The range of the offsets varies based on the G-range of accelerometer sensor.

Table 3-16: Accelerometer G-range settings

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

Table 3-17: Accelerometer Unit settings

| Unit | Representation |
|------------------|------------------------------|
| m/s ² | 1 m/s ² = 100 LSB |
| mg | 1 mg = 1 LSB |

3.6.4.2 Magnetometer offset

The magnetometer offset can be configured in the following registers,

Table 3-18: Magnetometer Default-Reg settings

| 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.

Table 3-19: Magnetometer Unit settings

| Unit | Representation |
|------|----------------|
| μT | 1 μT = 16 LSB |

3.6.4.3 Gyroscope offset

The gyroscope offset can be configured in the following registers, shown in the table below

Table 3-20: Gyroscope Default Reg-settings

| 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.

Table 3-21: Gyroscope range settings

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

Table 3-22: Gyroscope unit settings

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

3.6.4.4 Radius

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

Table 3-23: Radius Default-Reg settings

| 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.

Table 3-24: Radius range settings

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

3.6.5 Output data registers

3.6.5.1 Acceleration data

In non-fusion 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. Refer table below for information regarding the data types for the acceleration data.

Table 3-25: Acceleration data

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

3.6.5.2 Magnetic Field Strength

In non-fusion 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. Refer table below for information regarding the data types for the magnetic field strength.

Table 3-26: Magnetic field strength data

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

3.6.5.3 Angular Velocity

In non-fusion 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. Refer table below for information regarding the data types for the angular velocity.

Table 3-27: Yaw rate data

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

3.6.5.4 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. Refer table below for information regarding the data types and the unit representation for the Euler angle format.

Table 3-28: Compensated orientation data in Euler angles format

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

Table 3-29: Euler angle data representation

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

3.6.5.5 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. Refer table below for information regarding the data types and the unit representation for the Orientation output.

Table 3-30: 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 3-31: Quaternion data representation

| Unit | Representation |
|------------------------|---|
| Quaternion (unit less) | 1 Quaternion (unit less) = 2^{14} LSB |

3.6.5.6 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. Refer table below for further information regarding the data types and the unit representation for Linear acceleration

Table 3-32: Linear Acceleration Data

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

Table 3-33: Linear Acceleration data representation

| Unit | Representation |
|----------------|-------------------------------------|
| m/s^2 | $1 \text{ m/s}^2 = 100 \text{ LSB}$ |
| mg | $1 \text{ mg} = 1 \text{ LSB}$ |

3.6.5.7 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. Refer table below for further information regarding the data types and the unit representation for the Gravity vector.

Table 3-34: Gravity Vector Data

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

Table 3-35: Gravity Vector data representation

| Unit | Representation |
|----------------|-------------------------------------|
| m/s^2 | $1 \text{ m/s}^2 = 100 \text{ LSB}$ |
| mg | $1 \text{ mg} = 1 \text{ LSB}$ |

3.6.5.8 Temperature

The temperature output data can be read from the TEMP register. The table below describes the output data type and data representation (depending on selected unit).

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 below.

Table 3-36: Temperature Data

| Parameter | Data type | bytes |
|-----------|-----------|-------|
| TEMP | signed | 1 |

Table 3-37: Temperature data representation

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

Table 3-38: Temperature Source Selection

| Source | [Reg Addr]: Register Value |
|---------------|----------------------------|
| Accelerometer | [TEMP_SOURCE]: xxxx00b |
| Gyroscope | [TEMP_SOURCE]: xxxx01b |

3.7 Interrupts

3.7.1 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.

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

Interrupt Pin Masking

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

Interrupt Status

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

3.7.2 Interrupt Settings

3.7.2.1 Accelerometer Slow/No Motion Interrupt

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

Slow-motion 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 3-39 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 3-39: No-motion time-out periods

| <i>slo_no_mot_dur</i> | Delay time | <i>slo_no_mot_dur</i> | Delay time | <i>slo_no_mot_dur</i> | 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

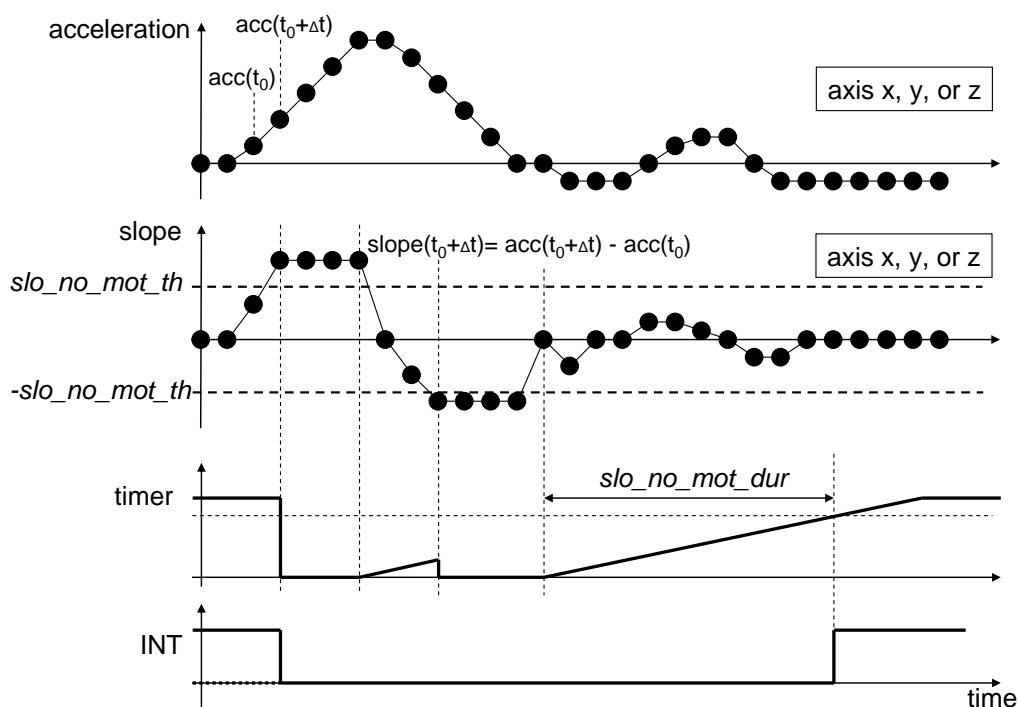


Table 3-40: Timing of No-motion interrupt

| Params | Value | [Reg Addr]: Register Value |
|----------------------|-------------|-----------------------------|
| Detection Type | No Motion | [ACC_NM_SET]: xxxxxx0b |
| | Slow Motion | [ACC_NM_SET]: xxxxxx1b |
| Interrupt Parameters | Threshold | [ACC_NM_THRE]: bit7:bit0 |
| | Duration | [ACC_NM_SET]: bit6:bit1 |
| Axis selection | X-axis | [ACC_INT_Settings]: xxxx1xb |
| | Y-axis | [ACC_INT_Settings]: xxx1xxb |
| | Z-axis | [ACC_INT_Settings]: xx1xxxb |

3.7.2.2 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.

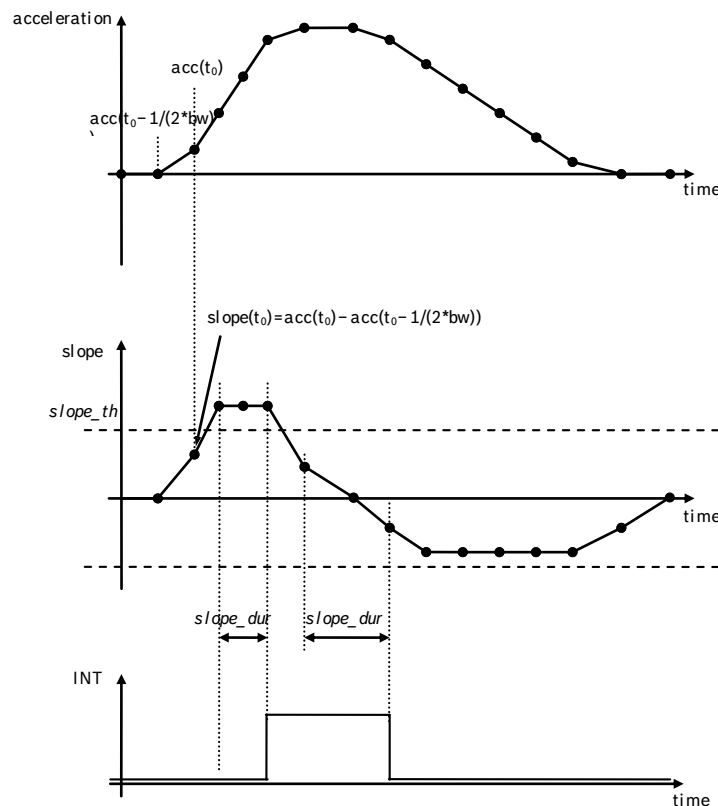


Figure 2: Principle of any-motion detection

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 $1/(2 \cdot \text{bandwidth})$ ($t = 1/(2 \cdot bw)$). 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 $N = \text{AM_DUR} + 1$.

Example: $\text{AM_DUR} = 00b, \dots, 11b = 1\text{decimal}, \dots, 4\text{decimal}$.

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.

Table 3-41: Any-motion Interrupt parameters and Axis selection

| 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]: xxxx1xxb |
| | Y-axis | [ACC_INT_Settings]: xxx1xxx b |
| | Z-axis | [ACC_INT_Settings]: xx1xxxxb |

3.7.2.3 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 $\text{delay [ms]} = [\text{ACC_HG_DURATION} + 1] * 2 \text{ ms}$. Therefore, possible delay times range from 2 ms to 512 ms.

Table 3-42: High-G Interrupt parameters and Axis selection

| 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]: xx1xxxxb |
| | Y-axis | [ACC_INT_Settings]: x1xxxxxb |
| | Z-axis | [ACC_INT_Settings]: 1xxxxxxb |

3.7.2.4 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:

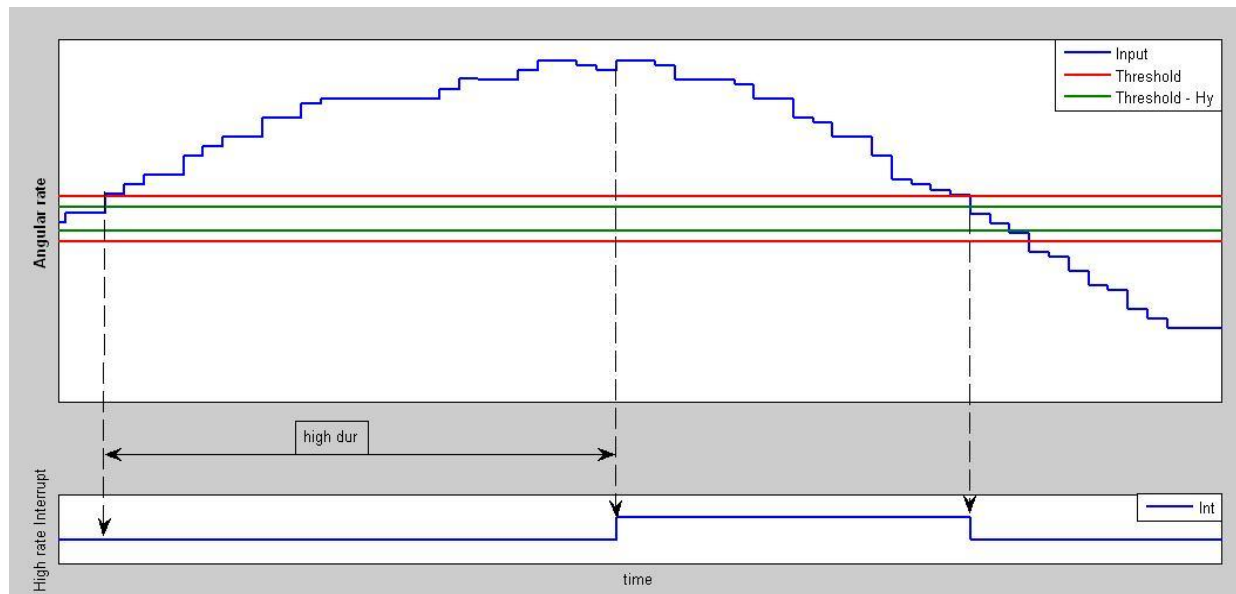


Figure 3: High rate interrupt

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 $\text{delay [ms]} = [\text{GYR_DUR_<axis>} + 1] \cdot 2.5 \text{ ms}$. Therefore, possible delay times range from 2.5 ms to 640 ms.

Table 3-43: High Rate Interrupt parameters and Axis selection

| Params | Value | [Reg Addr]: Register Value |
|---------------------------|------------|-----------------------------|
| Axis selection | X-axis | [GYR_INT_SETTING]: xxx1xxxb |
| | Y-axis | [GYR_INT_SETTING]: xx1xxxxb |
| | Z-axis | [GYR_INT_SETTING]: x1xxxxxb |
| High Rate Filter settings | Filtered | [GYR_INT_SETTING]: 0xxxxxxb |
| | Unfiltered | [GYR_INT_SETTING]: 1xxxxxxb |
| 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 Z-axis | Threshold | [GYR_HR_Z_SET]: bit4 : bit0 |
| | Duration | [GYR_DUR_Z]: bit7 : bit0 |
| | Hysteresis | [GYR_HR_Z_SET]: bit6 : bit5 |

3.7.2.5 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.

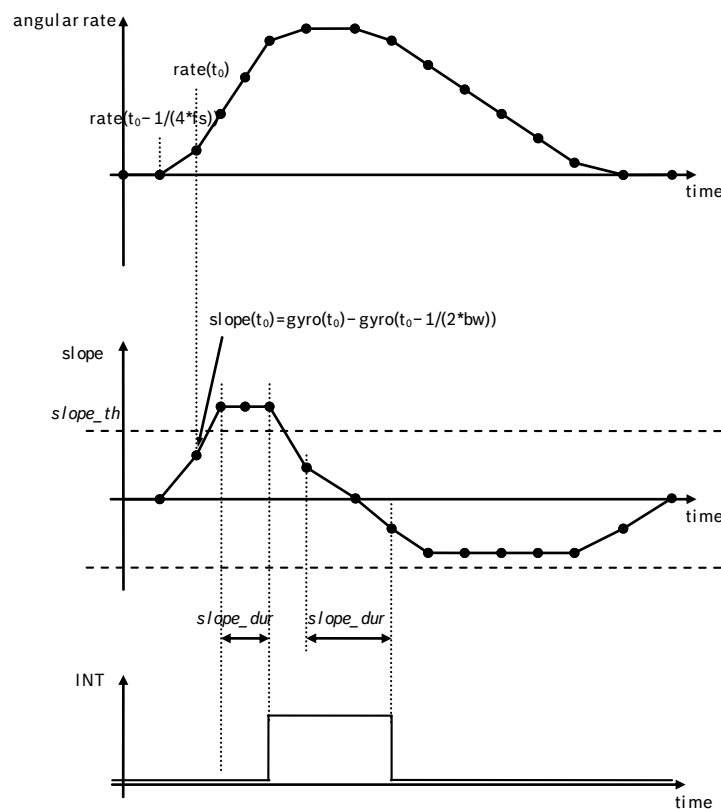


Figure 4: Principle of any-motion detection

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(f_s) which is coupled to the bandwidth and equates to $1/(4 \cdot f_s)$ ($t = 1/(4 \cdot f_s)$). For bandwidth settings with an update rate higher than 400Hz (bandwidth = 0,1,2) f_s 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 $N = [\text{Slope Samples} + 1] \cdot 4$. N is set in samples. Thus the time is scaling with the update rate (f_s).

3.7.2.6 Enabling (disabling) for each axis

Any-motion detection can be enabled (disabled) for each axis separately by writing '1' ('0') to bits *AM_X_AXIS*, *AM_Y_AXIS*, *AM_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.

3.7.2.7 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.

Table 3-44: Axis selection and any motion interrupt

| Params | Value | [Reg Addr]: Register Value |
|----------------------------|----------------|------------------------------|
| Axis selection | X-axis | [GYR_INT_SETTING]: xxxxxx1b |
| | Y-axis | [GYR_INT_SETTING]: xxxxxx1xb |
| | Z-axis | [GYR_INT_SETTING]: xxxxx1xb |
| Any Motion Filter settings | Filtered | [GYR_INT_SETTING]: x0xxxxxb |
| | Unfiltered | [GYR_INT_SETTING]: x1xxxxxb |
| Interrupt Settings | Threshold | [GYR_AM_THRES]: bit6 : bit0 |
| | Slope Samples | [GYR_AM_SET]: bit1 : bit0 |
| | Awake Duration | [GYR_AM_SET]: bit3 : bit2 |

3.8 Self-Test

3.8.1 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

Table 3-45: Power on Self Test

| Components | Test type |
|-----------------|---------------------------|
| Accelerometer | Verify chip ID |
| Magnetometer | Verify chip ID |
| Gyroscope | Verify chip ID |
| Microcontroller | Memory Build In Self Test |

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

3.8.2 Build In 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.

Table 3-46: Power on Self Test

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

3.9 Boot loader

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

If the nBOOT_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.

In case there is a firmware update, then an application note would be available in time with the necessary information to upgrade at the host side. Nevertheless it is recommended that the nBOOT_LOAD_PIN is connected as shown in [section 5](#).

3.10 Calibration

Though the sensor fusion software runs the calibration algorithm of all the three sensors (accelerometer, gyroscope and magnetometer) in the background to remove the offsets, some preliminary steps had to be ensured for this automatic calibration to take place.

The accelerometer and the gyroscope are relatively less susceptible to external disturbances, as a result of which the offset is negligible. Whereas the magnetometer is susceptible to external magnetic field and therefore to ensure proper heading accuracy, the calibration steps described below have to be taken.

Depending on the sensors been selected, the following simple steps had to be taken after every 'Power on Reset' for proper calibration of the device.

3.10.1 Accelerometer Calibration

- Place the device in 6 different stable positions for a period of few seconds to allow the accelerometer to calibrate.
- Make sure that there is slow movement between 2 stable positions
- The 6 stable positions could be in any direction, but make sure that the device is lying at least once perpendicular to the x, y and z axis.
- The register [CALIB_STAT](#) can be read to see the calibration status of the accelerometer.

3.10.2 Gyroscope Calibration

- Place the device in a single stable position for a period of few seconds to allow the gyroscope to calibrate
- The register [CALIB_STAT](#) can be read to see the calibration status of the gyroscope.

3.10.3 Magnetometer Calibration

Magnetometer in general are susceptible to both hard-iron and soft-iron distortions, but majority of the cases are rather due to the former. And the steps mentioned below are to calibrate the magnetometer for hard-iron distortions.

Nevertheless certain precautions need to be taken into account during the positioning of the sensor in the PCB which is described in our HSMI (Handling, Soldering and Mounting Instructions) application note to avoid unnecessary magnetic influences.

Compass, M4G & NDOF_FMC_OFF:

- Make some random movements (for example: writing the number '8' on air) until the CALIB_STAT register indicates fully calibrated.
- It takes more calibration movements to get the magnetometer calibrated than in the NDOF mode.

NDOF:

- The same random movements have to be made to calibrate the sensor as in the FMC_OFF mode, but here it takes relatively less calibration movements (and slightly higher current consumption) to get the magnetometer calibrated.
- The register [CALIB_STAT](#) can be read to see the calibration status of the magnetometer.

3.10.4 Reuse of Calibration Profile

Once the device is calibrated, the calibration profile can be reused to get the correct orientation data immediately after 'Power of Reset' (prior to going through the steps mentioned in the above section). However, once the sensor enters the internal calibration routine, the calibration profile is overwritten with the newly obtained sensor offsets and sensor radius. Depending on the application, necessary steps had to be ensured for proper calibration of the sensor.

Reading Calibration profile

The calibration profile includes sensor offsets and sensor radius. Host system can read the offsets and radius only after a full calibration is achieved and the operation mode is switched to CONFIG_MODE. Refer to sensor offsets and sensor radius registers.

Setting Calibration profile

It is important that the correct offsets and corresponding sensor radius are used. Incorrect offsets may result in unreliable orientation data even at calibration accuracy level 3. To set the calibration profile the following steps need to be taken

1. Select the operation mode to CONFIG_MODE
2. Write the corresponding sensor offsets and radius data
3. Change operation mode to fusion mode

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 | Reserved | 0x00 | | | | | | | | |

| Register Address | Register Name | Default Value | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|------------------|-----------------|---------------|-----------------------------------|---------|-----------------------|-----------|-----------------------|----------------------|-----------------------|----------------------|
| 42 | AXIS_MAP_SIG_N | 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 | | | | | Operation Mode <3:0> | | | |
| 3C | Reserved | 0xFF | | | | | | | | |
| 3B | UNIT_SEL | 0x80 | 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_N_M | ACC_A_M | ACC_HIGH_G | | GYR_HIGH_RATE | GYRO_A_M | | |
| 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_MSB | 0x00 | Linear Acceleration Data Z <15:8> | | | | | | | |
| 2C | LIA_Data_Z_LSB | 0x00 | Linear Acceleration Data Z <7:0> | | | | | | | |
| 2B | LIA_Data_Y_MSB | 0x00 | Linear Acceleration Data Y <15:8> | | | | | | | |
| 2A | LIA_Data_Y_LSB | 0x00 | Linear Acceleration Data Y <7:0> | | | | | | | |
| 29 | LIA_Data_X_MSB | 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> | | | | | | | |
| 1F | EUL_Pitch_MSB | 0x00 | Pitch Data <15:8> | | | | | | | |
| 1E | EUL_Pitch_LSB | 0x00 | Pitch Data <7:0> | | | | | | | |

| Register Address | Register Name | Default Value | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|------------------|-----------------|-------------------|----------------------------|------|------|------|------|------|------|------|
| 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 | 0x03 ⁵ | SW Revision ID <15:8> | | | | | | | |
| 4 | SW_REV_ID_LSB | 0x08 ⁶ | 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 | | | | | | | |

⁵ The current software version is 0.3.0.8 and therefore the SW_REV_ID_MSB is 0x03. However the register default value is subject to change with respect to the updated software.

⁶ The current software version is 0.3.0.8 and therefore the SW_REV_ID_LSB is 0x08. However the register default value is subject to change with respect to the updated software.

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_SETTING | 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_THRESHOLD | 0x0A | Accelerometer NO/SLOW motion threshold | | | | | | | | |
| 14 | ACC_HG_THRESHOLD | 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_THRESHOLD | 0x14 | Accelerometer Any motion threshold | | | | | | | | |
| 10 | INT_EN | 0x00 | ACC_N_M | ACC_A_M | ACC_HI_GH_G | | GYR_HI_GH_RATE | GYRO_A_M | | | |
| F | INT_MSK | 0x00 | ACC_N_M | ACC_A_M | ACC_HI_GH_G | | GYR_HI_GH_RATE | GYRO_A_M | | | |
| 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 | GYRO 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 3.6.5.8 |

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 |

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 3.6.2 for more details |
| TEMP_Unit | 5 | Read: Current selected temperature units Write: Select temperature units 0: Celsius 1: Fahrenheit See section 3.6.1 for more details |
| EUL_Unit | 3 | Read: Current selected Euler units Write: Select Euler units 0: Degrees 1: Radians See section 3.6.1 for more details |
| GYR_Unit | 2 | Read: Current selected angular rate units Write: Select angular rate units 0: dps 1: rps See section 3.6.1 for more details |
| ACC_Unit | 1 | Read: Current selected acceleration units Write: Select acceleration units 0: m/s ² 1: mg See section 3.6.1 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 |
| Reset | | | | | | | | |
| Content | Reserved | | | | Operation Mode <3:0> | | | |

| DATA | bits | Description |
|----------------------|-------|--|
| 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 0 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 3.6.5.8 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 3.4 for details |
| Remapped Y axis value | <3:2> | See section 3.4 for details |
| Remapped X axis value | <1:0> | See section 3.4 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 3.4 for details |
| Remapped Y axis sign | 1 | See section 3.4 for details |
| Remapped Z axis sign | 0 | See section 3.4 for details |

4.3.67 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 3.6.4 for details |

4.3.68 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 3.6.4 for details |

4.3.69 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 3.6.4 for details |

4.3.70 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 3.6.4 for details |

4.3.71 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 3.6.4 for details |

4.3.72 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 3.6.4 for details |

4.3.73 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 3.6.4 for details |

4.3.74 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 3.6.4 for details |

4.3.75 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 3.6.4 for details |

4.3.76 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 3.6.4 for details |

4.3.77 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 3.6.4 for details |

4.3.78 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 3.6.4 for details |

4.3.79 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 3.6.4 for details |

4.3.80 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 3.6.4 for details |

4.3.81 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 3.6.4 for details |

4.3.82 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 3.6.4 for details |

4.3.83 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 3.6.4 for details |

4.3.84 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 3.6.4 for details |

4.3.85 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 3.6.4 for details |

4.3.86 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 3.6.4 for details |

4.3.87 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 3.6.4 for details |

4.3.88 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 3.6.4 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 3.5.2 |
| ACC_BW <2:0> | <4:3> | Read: current selected bandwidth Write: can only be changed in sensor mode, see section 3.5.2 |
| ACC_Range <1:0> | <2:0> | Read: current selected range Write: can only be changed in sensor mode, see section 3.5.2 |

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 3.5.4 |
| MAG_OPR_Mode <1:0> | <4:3> | Read: current selected operation mode Write: can only be changed in sensor mode, see section 3.5.4 |
| MAG_Data_output_rate <2:0> | <2:0> | Read: current selected data output rate Write: can only be changed in sensor mode, see section 3.5.4 |

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 3.5.3 |
| GYR_Range <2:0> | <2:0> | Read: current selected range Write: can only be changed in sensor mode, see section 3.5.3 |

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_Mode <2:0> | <2:0> | Read: current selected power mode Write: can only be changed in sensor mode, see section 3.5.3 |

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. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | <table><tr><th>SLP_DURATION</th><th>Accelerometer Sleep Phase Duration</th></tr><tr><td>0000b</td><td>0.5 ms</td></tr><tr><td>0001b</td><td>0.5 ms</td></tr><tr><td>0010b</td><td>0.5 ms</td></tr><tr><td>0011b</td><td>0.5 ms</td></tr><tr><td>0100b</td><td>0.5 ms</td></tr><tr><td>0101b</td><td>0.5 ms</td></tr><tr><td>0110b</td><td>1 ms</td></tr><tr><td>0111b</td><td>2 ms</td></tr><tr><td>1000b</td><td>4 ms</td></tr><tr><td>1001b</td><td>6 ms</td></tr><tr><td>1010b</td><td>10 ms</td></tr><tr><td>1011b</td><td>25 ms</td></tr><tr><td>1100b</td><td>50 ms</td></tr><tr><td>1101b</td><td>100 ms</td></tr><tr><td>1110b</td><td>500 ms</td></tr><tr><td>1111b</td><td>1 ms</td></tr></table> | 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 |
| | | 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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> | | |

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

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 = $(255 + 256 * \text{HR_X_THRES_HYST}) * 4 \text{ LSB}$ 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 |

4.4.21 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 = $(255 + 256 * \text{HR_Z_THRES_HYST}) * 4 \text{ LSB}$ 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 ... |

4.4.22 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 = $(1 + \text{HR_Z_Duration}) * 2.5 \text{ ms}$ |

4.4.23 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 ... |

4.4.24 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 slave and host device: I²C 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 I ² C Interface |
| 0 | 1 | HID over I ² C |
| 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 | I ² C Interfaces (PS1=0b0) | UART Interface (PS1.PS0=0b10) |
|------|--|----------------------------------|
| COM0 | SDA | Tx |
| COM1 | SCL | Rx |
| COM2 | GNDIO | |
| COM3 | I ² C 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 |
| I ² C 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 | | μs |
| Idle time between write accesses, normal mode, standby mode, low-power mode 2 | t _{IDLE_wacc_nm} | | 2 | | |
| Idle time between write accesses, suspend mode, low-power mode 1 | t _{IDLE_wacc_su m} | | 450 | | |

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

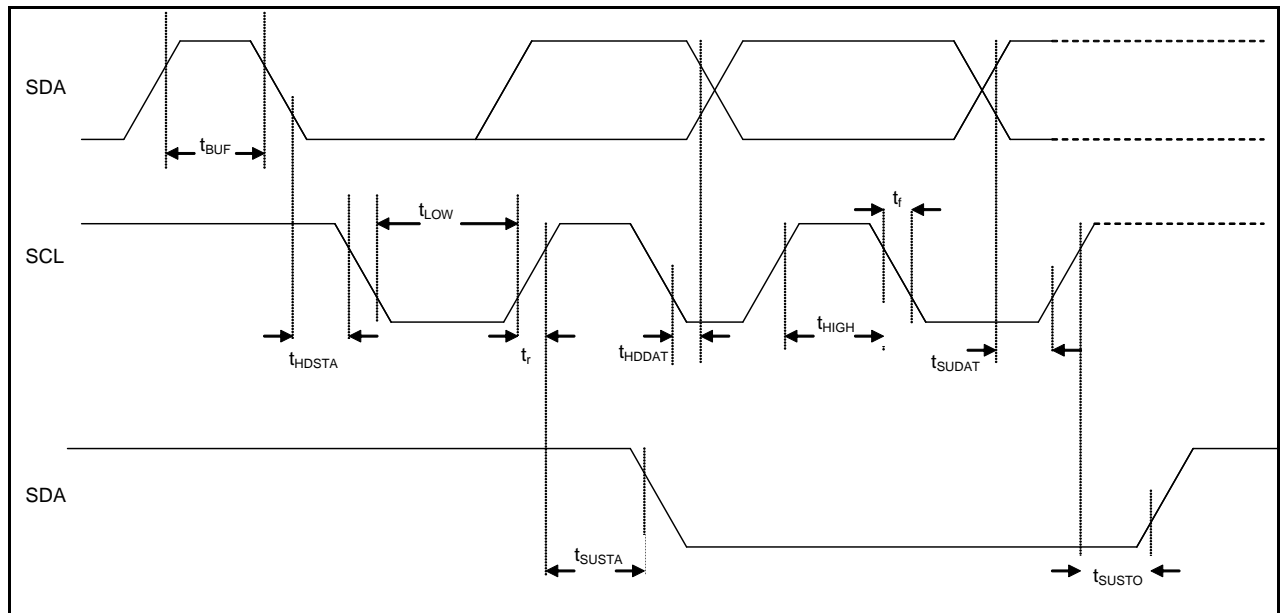


Figure 5: I²C timing diagram

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 (i2c address in this case: 0101000b = 0x28):

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

| Start | Slave address | | | | | | | RW | ACKS | Read data (0x08) | | | | | | | | ACKM | Read data (0x09) | | | | | | | | ACKM |
|-------|---------------|---|---|---|---|---|---|----|------|------------------|---|---|---|---|---|---|---|------|------------------|---|---|---|---|---|---|---|------|
| Sr | 0 | 1 | 0 | 1 | 0 | 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) | | | | | | | | ACKM | NACKM | Stop |
|------|------------------|---|---|---|---|---|---|---|------|------------------|---|---|---|---|---|---|---|------|-------|------|
| A | x | x | x | x | x | x | x | x | A | x | x | x | x | x | x | x | x | A | NA | P |

Figure 7: I²C multiple read

4.7 UART Protocol

The BNO055 supports 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.

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 |

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

HID over I2C is a standard interface protocol to connect devices with hosts via I2C. The main advantage of HID is that there exist generic drivers for different input devices (such as sensors) which can be used with sensors that implement the corresponding well defined HID profiles. HID over I2C describes how messages (reports and events) are exchanged between the device and the host. A descriptor of the structure of these reports is provided by the device and read by the host during initialization of the device at host system start.

For detailed information on HID please refer to the HID over I2C documentation from Microsoft.

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

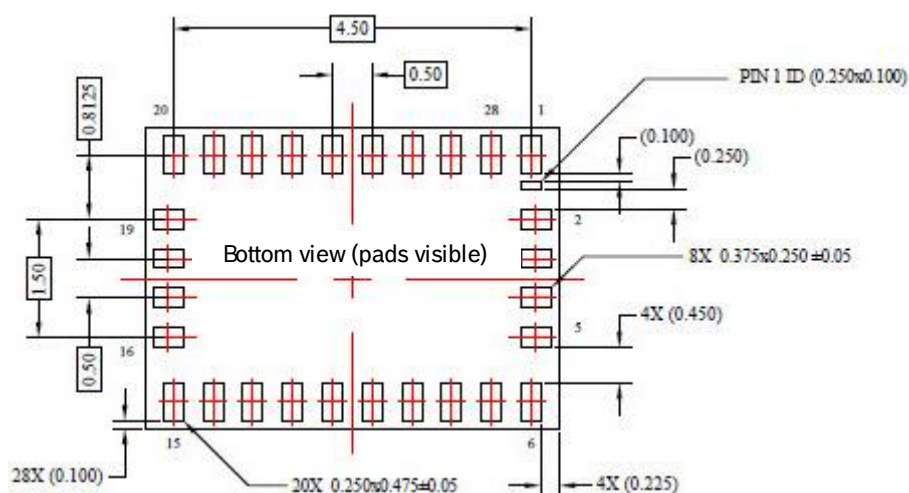
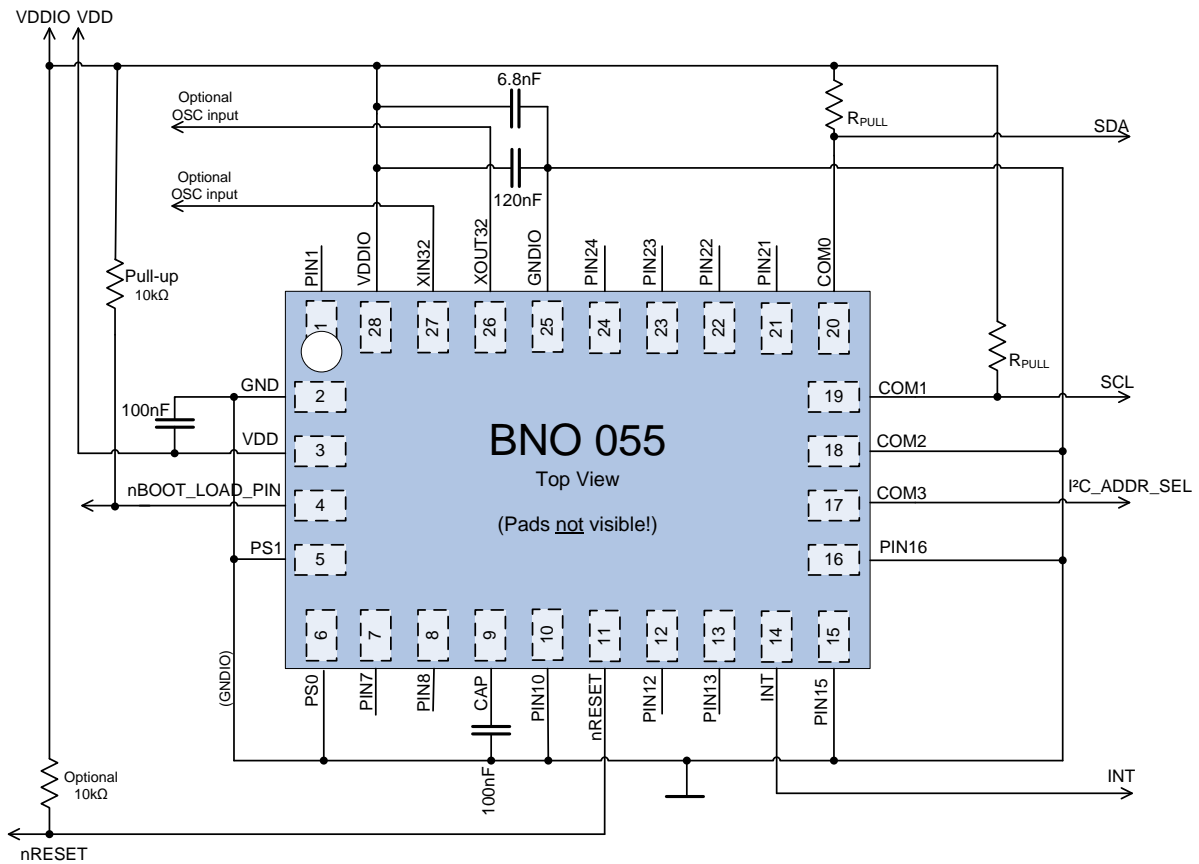


Table 5-1: Pin description

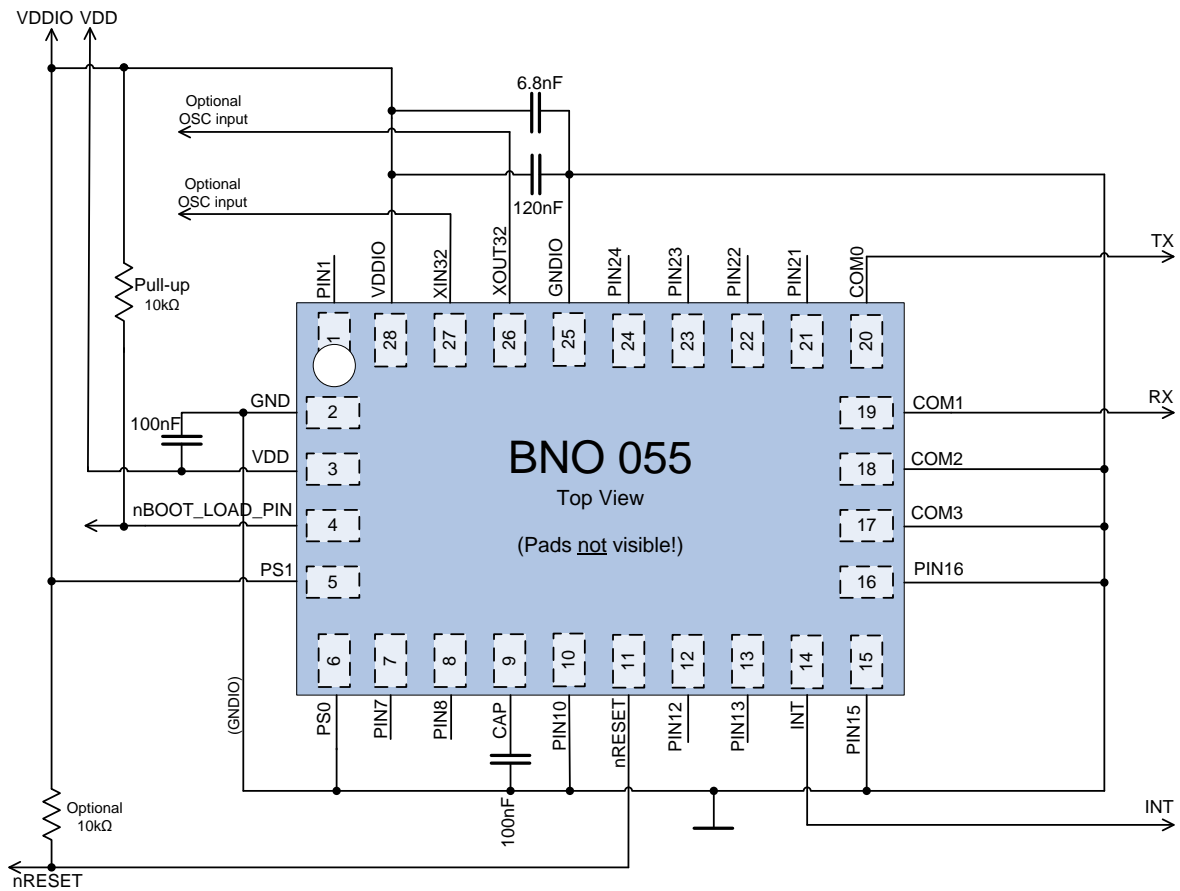
| Pin # | Name | I/O Type | Description | Function | | |
|-------|----------------|-------------|---|--------------------|-------|---------|
| | | | | I2C | UART | HID-I2C |
| 1 | PIN1 | -- | Do not connect | DNC | | |
| 2 | GND | Ground | GND | GND | | |
| 3 | VDD | Supply | VDD | VDD | | |
| 4 | nBOOT_LOAD_PIN | Digital I/O | Bootloader mode select pin (active low) | nBOOT_LOAD_PIN | | |
| 5 | PS1 | Digital in | Protocol select pin 1 | GNDIO | VDDIO | GNDIO |
| 6 | PS0 | Digital in | Protocol select pin 2 | GNDIO | GNDIO | VDDIO |
| 7 | PIN7 | -- | Do not connect | DNC | | |
| 8 | PIN8 | -- | Do not connect | DNC | | |
| 9 | CAP | -- | External capacitor | CAP | | |
| 10 | PIN10 | Ground | connect to GNDIO | GNDIO | | |
| 11 | nRESET | -- | Reset pin (active low) | nRESET | | |
| 12 | PIN12 | -- | Do not connect | DNC | | |
| 13 | PIN13 | -- | Do not connect | DNC | | |
| 14 | INT | Digital Out | Interrupt output | Interrupt | | |
| 15 | PIN15 | Ground | Connect to GNDIO | GNDIO | | |
| 16 | PIN16 | Ground | Connect to GNDIO | GNDIO | | |
| 17 | COM3 | Digital I/O | Digital interface pin 3 | I2C address select | GNDIO | GNDIO |
| 18 | COM2 | Digital I/O | Digital interface pin 2 | GNDIO | | |
| 19 | COM1 | Digital I/O | Digital interface pin 1 | SCL | Rx | SCL |
| 20 | COM0 | Digital I/O | Digital interface pin 0 | SDA | Tx | SDA |
| 21 | PIN21 | -- | Do not connect | DNC | | |
| 22 | PIN22 | -- | Do not connect | DNC | | |
| 23 | PIN23 | -- | Do not connect | DNC | | |
| 24 | PIN24 | -- | Do not connect | DNC | | |
| 25 | GNDIO | Ground | GNDIO | GNDIO | | |
| 26 | XOUT32 | Digital Out | Optional OSC port | OSC Output | | |
| 27 | XIN32 | Digital In | Optional OSC port | OSC Input | | |
| 28 | VDDIO | Supply | VDDIO | VDDIO | | |

5.2 Connection diagram I²C

Figure 9: I²C connection diagram


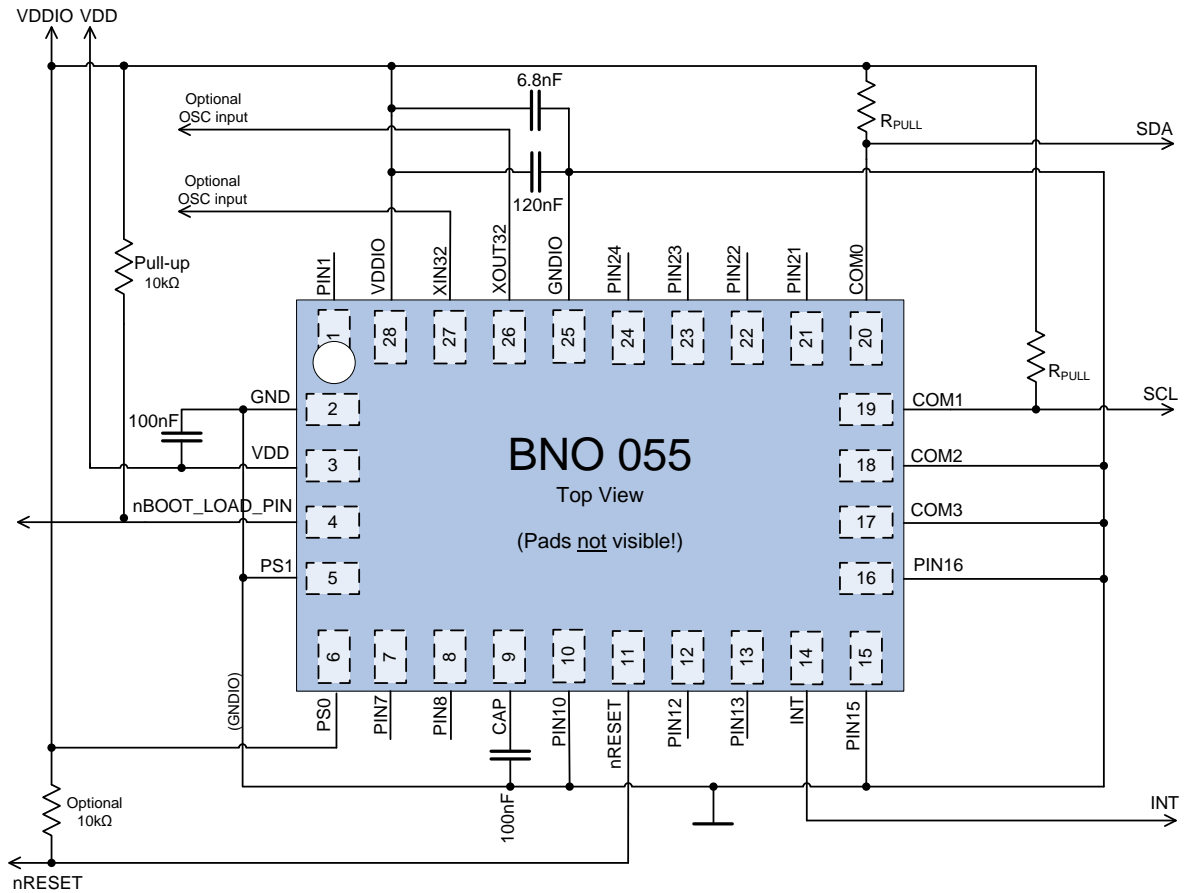
5.3 Connection diagram UART

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 32 KHz clock source. By default, the internal clock is selected.

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

To get the best performance out of BNO055, it is recommended to use the external crystal.

5.5.1 External 32kHz Crystal Oscillator

Figure 12 : External 32kHz Crystal Oscillator with Load Capacitor

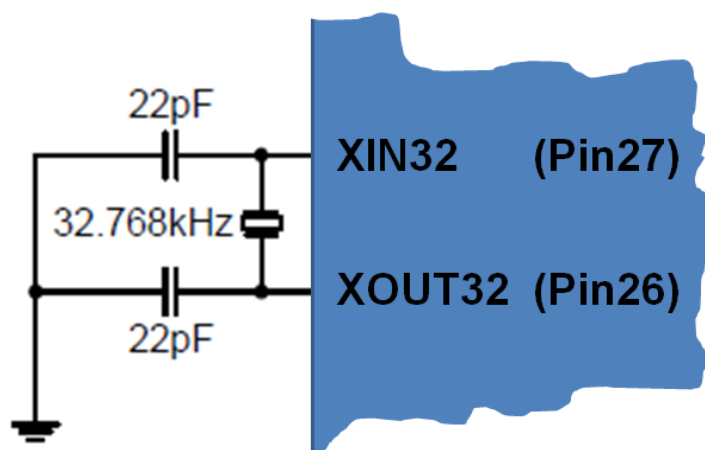


Table 5-2: Crystal Oscillator Source Connections

| Pin Name | Recommended Pin Connection | Description |
|---------------|-----------------------------------|-------------------------|
| XIN32 | Load capacitor 22pF ⁷⁸ | Timer oscillator input |
| XOUT32 | Load capacitor 22pF ⁷⁸ | 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. The internal clock of the BNO055 can have clock deviation up to $\pm 3\%$

⁷ These values are given only as typical example.

⁸ 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 ± 0.1 mm. The [chapter 3.5](#) provides information regarding the sensor axis orientation.

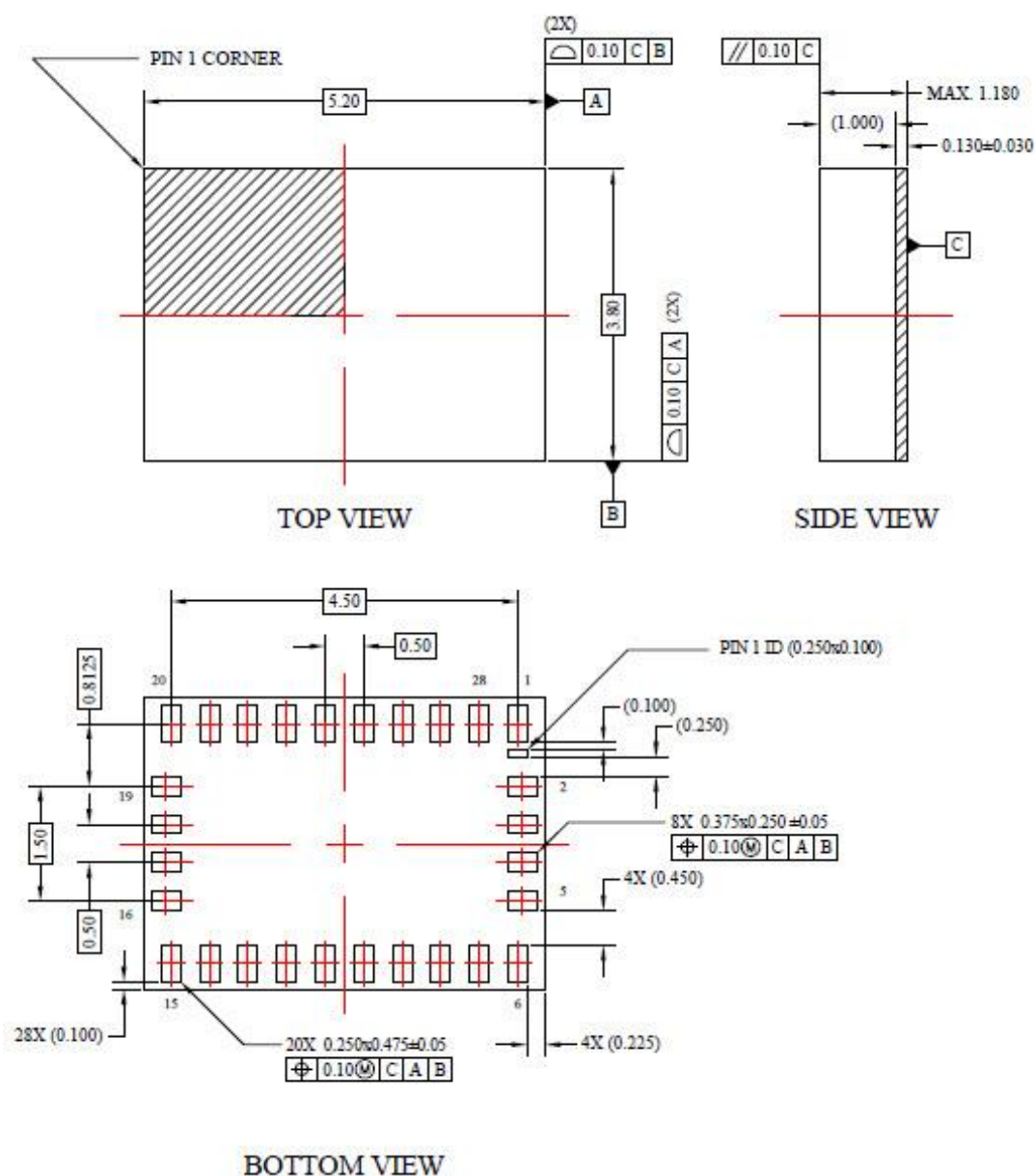
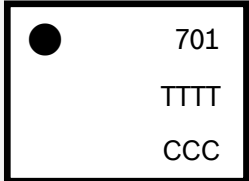


Figure 13: Outline dimensions

6.2 Marking

Table 6-1: Marking of mass production parts

| Labeling | Name | Symbol | Remark |
|---|------------------|--------|--|
|  | Pin 1 identifier | • | --- |
| | Product number | 701 | 3 numeric digits, internal identification for product type |
| | Second Row | T | Internal use |
| | Third Row | C | Numerical counter |

6.3 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.

6.4 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.

6.5 Tape and reel specification

The BNO055 is shipped in a standard cardboard box. For details please refer to the 'Shipment packaging details' document.

6.6 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.*

6.6.1 Halogen content

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

6.6.2 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 BNO055 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.

The resale and/or use of products are at the purchaser's own risk and his own responsibility. The examination of fitness for the intended use is the sole responsibility of the Purchaser.

The purchaser shall indemnify Bosch Sensortec from all third party claims arising from any product use not covered by the parameters of this product data sheet or not approved by Bosch Sensortec and reimburse Bosch Sensortec for all costs in connection with such claims.

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

With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Bosch Sensortec hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights or copyrights of any third party. The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics. They are provided for illustrative purposes only and no evaluation regarding infringement of intellectual property rights or copyrights or regarding functionality, performance or error has been made.

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 |
| 1.1 | 3 | Rearrangement of subsections in chapter 3 for better readability. | 2014-11-05 |
| | 3.3 | Table 3.1 is updated for better readability and all the operation modes are elaborated | |
| | 3.11 | Chapter on calibration included | |
| | 3.7, 3.10 | Update | |
| | 4.2 | The default value of the UNIT_SEL register is updated | |
| | 4.6 | I2C communication example figures are updated. | |
| | 5.1, 5.2, 5.3, 5.4 | Included table 5.1 Pin description. Connection diagram updated | |
| 1.2 | 5 | Updated pin description and connection diagram | 2014-11-30 |
| | 6.1 | Updated outline dimensions | |
| | 6.2 | Chapter removed and the respective information is updated in the Handling, soldering and mounting instructions application note. | |

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