BMI088 - MM Feature Set
Application Note

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Index of Contents

1. Feature set

This application note describes the feature set for the firmware version BMI088-MM which can be applied for multiple use-cases. The BMI088_MM firmware version supports low power mode operation and the following features: Axis remapping, Any-motion, No-motion, High-g, Low-g, Orientation and data synchronization.
For complete details regarding BMI088_MM specifications (e.g. pin-out, power modes, interrupt pin configuration, temperature sensor, sensor Time, FIFO), digital interfaces (primary/secondary), landing pattern, HSMI and firmware image refer the following link:
https://www.bosch-sensortec.com/products/motion-sensors/imus/bmi088/
https://github.com/BoschSensortec

1.1. Interrupt Features

Global Configuration

The configuration of the interrupt feature set is described in the register FEATURES_IN.
In order to reconfigure the features, the user must perform a burst read of the whole content from the register FEATURES_IN, followed by a modification of the content, and finally a burst write of the modified content to the register FEATURES_IN. The content of the successive bytes read or written in burst mode correspond to the each bytes described in FEATURES_IN.

Ensure that the sensor is initialized before the feature configuration is performed (see datasheet chapter 4.2 Device Initialization)

The output of the interrupt features can be read from the status registers listed below.

Feature	Output Status
Any motion	ACC_INT_STAT_0.any_motion_out
No motion	ACC_INT_STAT_0.no_motion_out
Orientation	ACC_INT_STAT_0.orientation_out
High g	ACC_INT_STAT_0.high_g_out
Low g	ACC_INT_STAT_0.low_g_out
Error interrupt	ACC_INT_STAT_0. error_int_out
Data Synchronization	ACC_INT_STAT_0.data_sync_out

Table 1: Interrupt status register overview

The error interrupt signals indicate that the sensor has been stopped after a fatal error. In this condition the device re-initialization must be done for proper functioning of the sensor.

2. Features Description

2.1. Integrated feature set

2.1.1. Axis remapping for interrupt features

If the coordinate system of the end device differs from the sensor coordinate system the sensor axis must be remapped to use the orientation dependent features (e.g. orientation interrupt, High_g interrupt) properly.
Axis remapping register allows the host to freely map individual axis to the coordinate system of the used platform. Individual axis can be mapped to any other defined axis. The sign value of the axis can also be configured depending on the use case. For example x axis can be mapped to -x axis, +y axis, - y axis, +z axis or -z axis. Similarly, other axes also have their own combinations.
Invalid remapping's are signaled through the register INTERNAL_STATUS.axes_remap_error if an advanced feature is enabled.

Note:
The axis remapping applies only to the data fetched into the features. The data registers and FIFO are not affected and should be remapped accordingly on the driver level.

Configuration settings:

1. AXIS_REMAP_1.map_x_axis – describes which axis shall be mapped to x axis.
2. AXIS_REMAP_1.map_x_axis_sign – describes whether the mapped axis shall be inverted or not to be inverted.
3. AXIS_REMAP_1.map_y_axis – describes which axis shall be mapped to y axis.
4. AXIS_REMAP_1.map_y_axis_sign - describes whether the mapped axis shall be inverted or not to be inverted.
5. AXIS_REMAP_1.map_z_axis – describes which axis shall be mapped to z axis.
6. AXIS_REMAP_1.map_z_axis_sign - describes whether the mapped axis shall be inverted or not to be inverted.

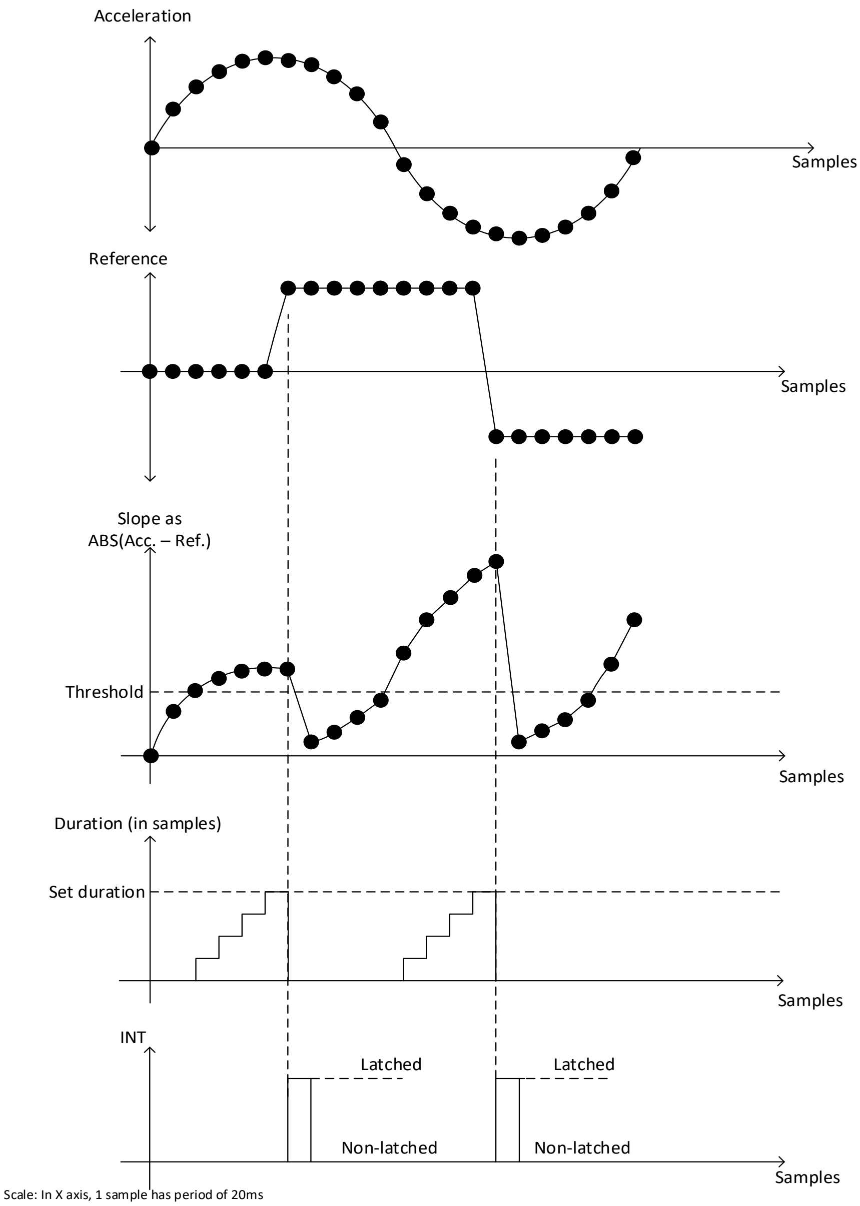
2.1.2. Any motion/ no motion detection

Any-motion detection:
Any-motion detection uses the slope between current input and reference acceleration samples to detect the motion status of the device. The interrupt is configured by setting enable flag ANYMO_1.enable along with at least one of the following flags:
ANYMO_2.x_en, ANYMO_2.y_en and ANYMO_2.z_en, respectively for each axis.

Any-motion provides an interrupt when the absolute value of the slope exceeds the configurable ANYMO_1.threshold for consecutive ANYMO_2.duration samples for at-least one of the enabled sensing axis.

Reference acceleration sample is updated only when an any-motion interrupt is triggered. The interrupt status is reset as soon as the slope falls below the set ANYMO_1.threshold value. The signals and timings relevant to the any-motion interrupt functionality are depicted in the figure below:

Signal and timing diagram for any-motion interrupt detection



Configuration settings:

1. ANYMO_1.enable - Enable the feature.
2. ANYMO_1.threshold – the slope threshold.
3. ANYMO_2.duration the number of consecutive data points for which the threshold condition must be respected, for interrupt assertion.
4. ANYMO_2.x_en – indicates if this feature is enabled for x axis
5. ANYMO_2.y_en – indicates if this feature is enabled for y axis
6. ANYMO_2.z_en –indicates if this feature is enabled for z axis

Output details:

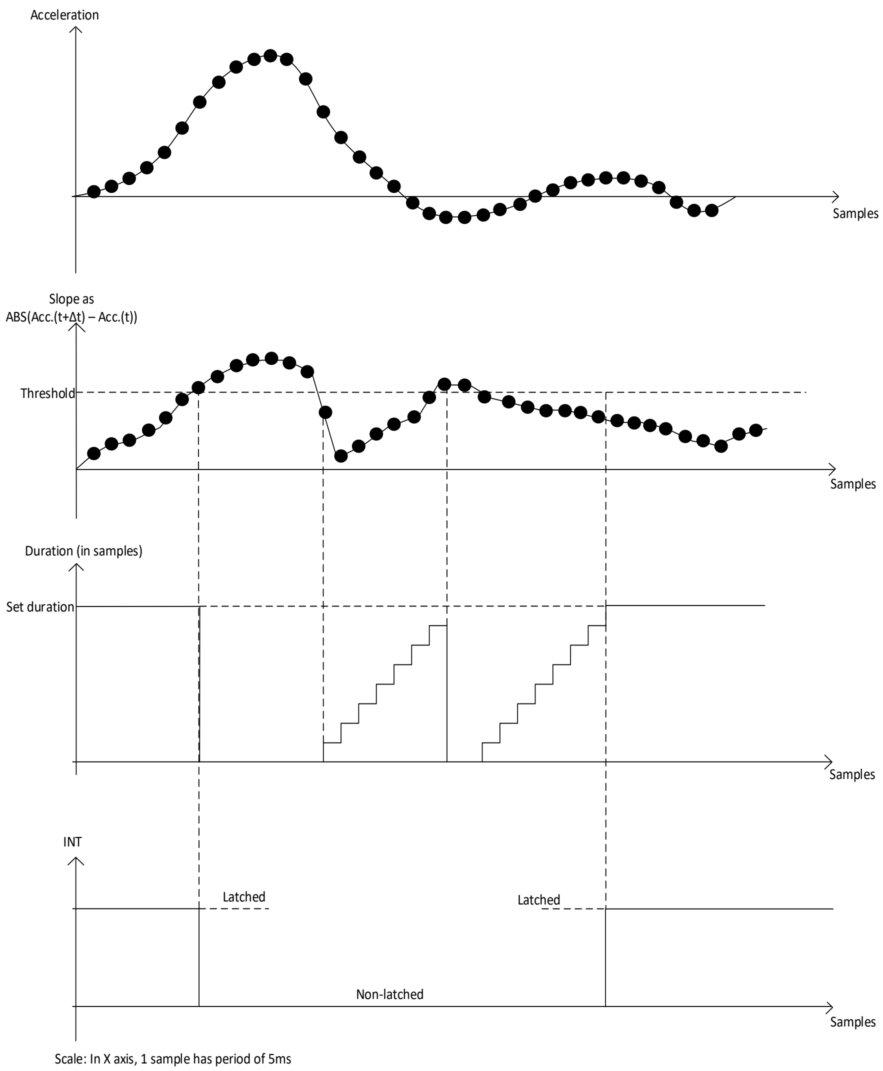
1. ACC_INT_STAT_0. any_motion_out – Set to 1 when any motion interrupt is generated by the device.

No motion detection:

No-motion detection uses the slope between two consecutive acceleration signal samples to detect static state of the device. The interrupt is configured by setting enable flag NOMO_1.enable along with at least one of the following flags: NOMO_2.x_en, NOMO_2.y_en and NOMO_2.z_en, respectively for each axis.

No-motion interrupt is triggered when the slope on all enabled sensing axis remains smaller than the configurable NOMO_1.threshold for the duration configured by NOMO_2.duration. No-motion interrupt is cleared as soon as the acceleration slope exceeds the set threshold. The signals and timings relevant to the no-motion interrupt functionality are depicted in the figure below.

Signal and timing diagram for no-motion interrupt detection



Register NOMO_2.duration defines the number of consecutive data points for which the slope of enabled axis must be smaller than the threshold for an interrupt to be asserted.

Configuration settings:

1. NOMO_1.enable – enable the feature.
2. NOMO_1.threshold – the slope threshold.
3. NOMO_2.duration – the number of consecutive data points for which the threshold condition must be respected, for interrupt assertion.

4. NOMO_2.x_en – indicates if this feature is enabled for x axis
5. NOMO_2.y_en – indicates if this feature is enabled for y axis
6. NOMO_2.z_en –indicates if this feature is enabled for z axis

Output details:

1. ACC_INT_STAT_0. no_motion_out – Set to 1 when no motion interrupt is generated by the device.

2.1.3. High_g/ low_g detection

High_g detection

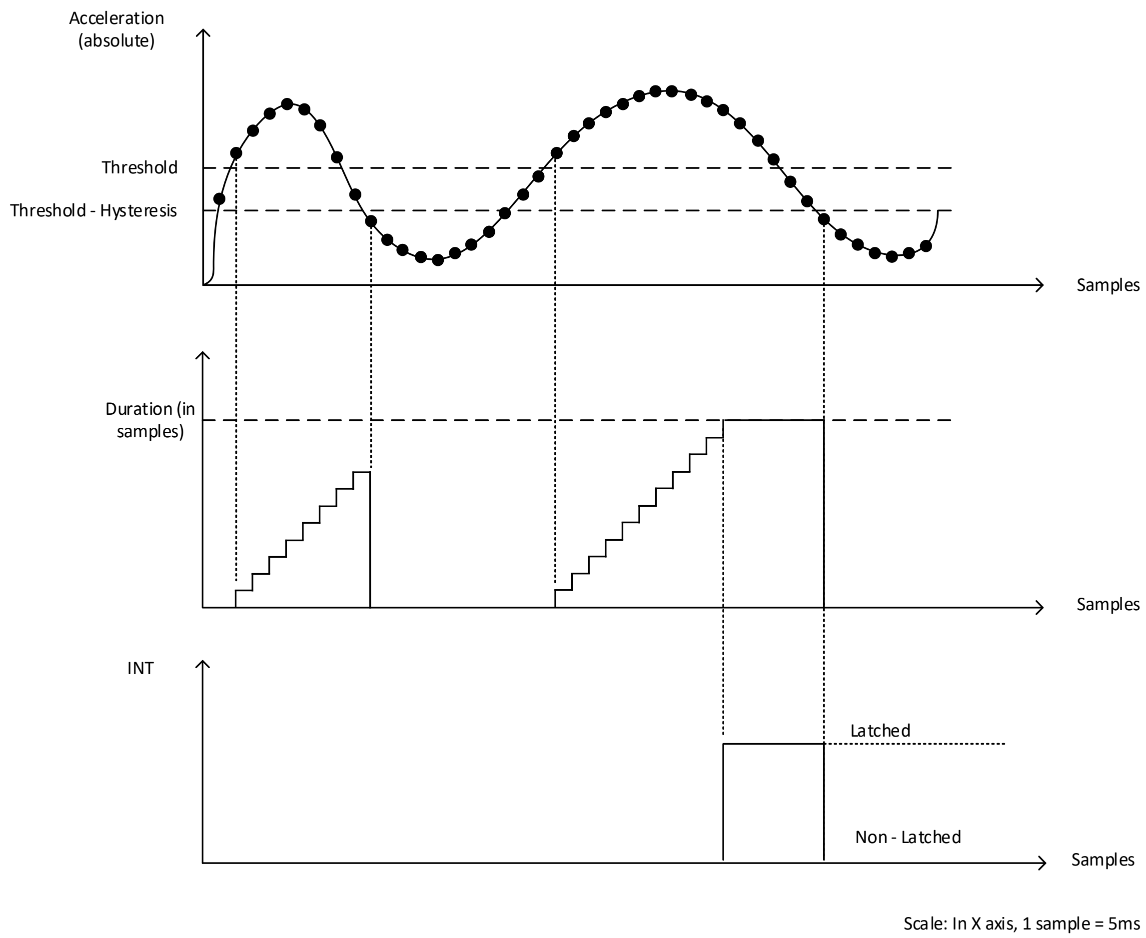
This interrupt is enabled by setting enable flag HI_G_2.enable along with at least one axis.

The interrupt is asserted if the absolute value of acceleration data of at least one enabled axis exceeds the programmed HI_G_1.threshold and the sign of the value does not change for a minimum HI_G_3.duration.

The interrupt condition is cleared when the absolute value of acceleration data of all selected axes falls below the HI_G_1.threshold minus HI_G_2.hysteresis or if the sign of the acceleration value changes.

If any device axis is parallel to the gravitational vector, then that axis will report ±1g as output. In this case, it is recommended to have (threshold - hysteresis) greater than 1g. If (threshold - hysteresis) is less than 1g then after high-g interrupt is triggered, the interrupt will not get cleared if anyone axis is parallel to the gravitational vector since that axis will already be at 1g.

The X, Y and Z axes are enabled with HI_G_2.en_x, HI_G_2.en_y, HI_G_2.en_z bits.



Signal and timing diagram for high-g detection

Configuration settings:

1. HI_G_3.duration – 12 bit unsigned integer (valid values 0...4095) holding the duration in 200 Hz samples (5 ms) for which the threshold has to be exceeded; default value 4 = 20 msec. Range is 0 to 20sec.
2. HI_G_2.hysteresis – 12 bit unsigned integer (valid values 0...4095) holding the hysteresis. Default value is 1000 = 0.49 g. Range is 0 to 2g.
3. HI_G_2.en_x – Selects the feature for x axis
4. HI_G_2.en_y – Selects the feature for y axis
5. HI_G_2.en_z – Selects the feature for z axis
6. HI_G_2.enable – Enables the feature
7. HI_G_1.threshold – The acceleration threshold above which the high_g motion is signaled. 15 bit un-signed integer (valid values 0...32767) holding the threshold. Default is 10000 = 4.9g. Range is 0 to 16g.

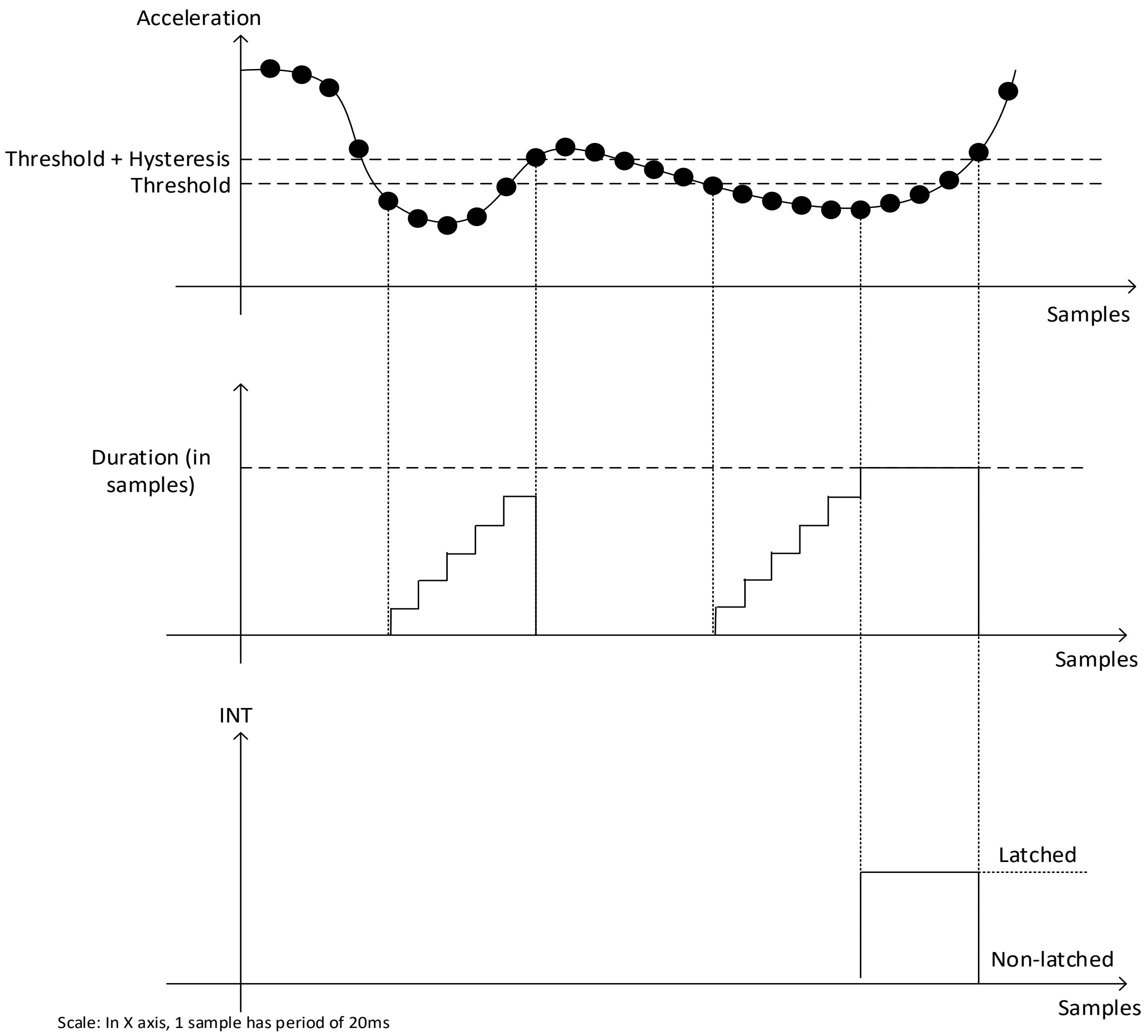
Output details:

1. Bit 3 (ORIENT_HIGHG_OUT.high_g_detect_x), this is set if high-g was detected on x axis.
2. Bit 4 (ORIENT_HIGHG_OUT.high_g_detect_y), this is set if high-g was detected on y axis.
3. Bit 5 (ORIENT_HIGHG_OUT.high_g_detect_z), this is set if high-g was detected on z axis.
4. Bit 6 (ORIENT_HIGHG_OUT.high_g_detect_sign), this reflects the sign of the acceleration for which the high-g was detected; 1 – negative, 0 – positive.
5. ACC_INT_STAT_0.high_g_out – Set to 1 when high-g interrupt is generated by the device.

Low_g detection

For low-g detection, the absolute values of the acceleration data of all axes are observed. The vector length of all accelerations, sqrt(acc_x^2 + acc_y^2 + acc_z^2), is compared with the LO_G_1.threshold.

The interrupt will be generated when the acceleration is smaller than threshold for minimum number of samples (LO_G_3.duration). The interrupt is reset when the acceleration is above the Threshold + Hysteresis value.



Signal and timing diagram for low-g detection

Configuration settings:

1. LO_G_1.threshold – 15 bit unsigned integer (valid values 0...32767) holding the threshold value. Default is 512 = 0.25 g. Range is 0 to 16g. Recommended range for customer: 0…1g
2. LO_G_2.hysteresis – 12 bit unsigned integer (valid values 0...4095) holding the hysteresis value. Default value is 256 = 0.125 g. Range is 0 to 2g. Recommended range for customer: 0…0.5g
3. LO_G_3.duration – 12 bit unsigned integer (valid values 0...4095) holding the duration in 50 Hz samples (20 ms) for which the threshold has to be exceeded; default: 0 = 0 ms. Range is 0 to 82 sec.
4. LO_G_2.enable – Enables the feature

Output details:

1. ACC_INT_STAT_0.low_g_out – Set to 1 when low-g interrupt is generated by the device.

2.1.4. Orientation detection

The orientation recognition feature informs on an orientation change of the sensor with respect to the gravitational field vector g. There are the orientations face up/face down and orthogonal to that portrait upright, landscape left, portrait downside, and landscape right. The interrupt for face up/face down may be enabled separately through ORIENT_1.ud_en.

The sensor orientation is defined by the angles phi and theta (phi φ is rotation around the stationary z axis, theta θ is rotation around the stationary y axis).

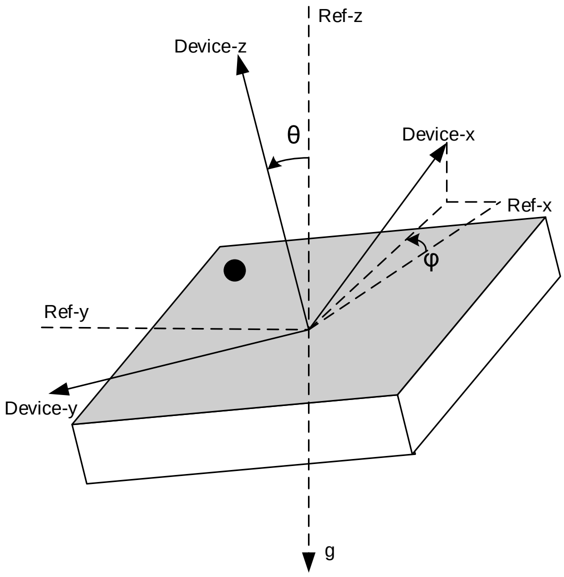


Figure: Definition of coordinate system with respect to pin 1 marker

This feature uses the earth's gravitational field for reference coordinates. The measured acceleration vector components look as follows:

$$acc\_x = 1g * \sin\theta * \cos\varphi \quad (1)$$
$$acc\_y = -1g * \sin\theta * \sin\varphi \quad (2)$$
$$acc\_z = 1g * \cos\theta \quad (3)$$
$$(2) / (1): acc\_y / acc\_x = -\tan\varphi$$

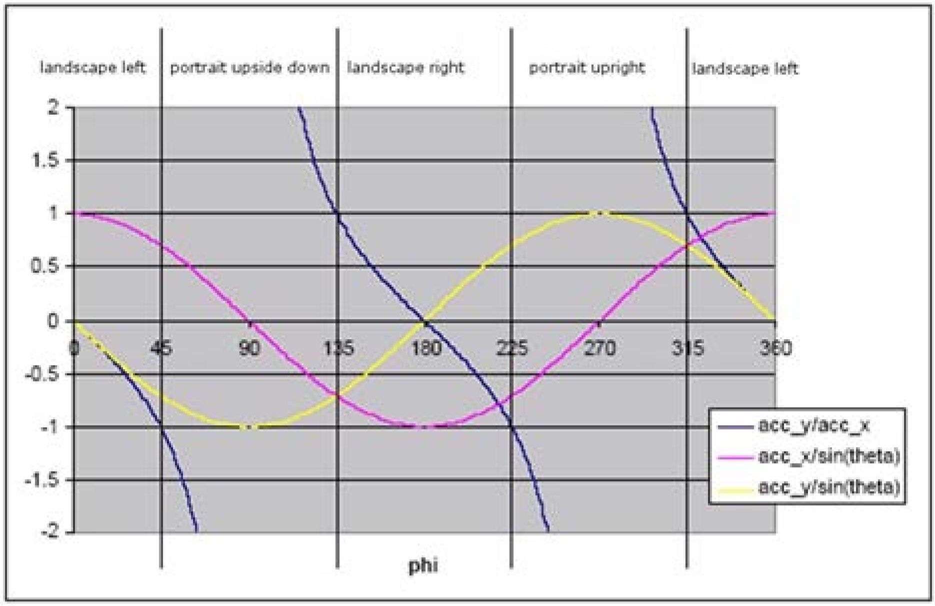


Figure: Angle-to-Orientation Mapping

Note that the sensor measures the direction of the force which needs to be applied to keep the sensor at rest (i.e. opposite direction than g itself).

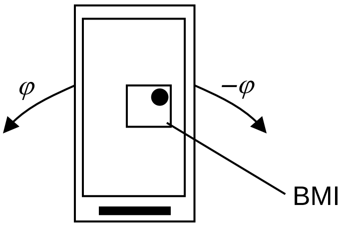


Figure: Looking at phone device from frontside/portrait upright (φ = 90°, θ =270°)

The orientation value is stored in the output register. There are three orientation calculation modes: symmetrical, high-asymmetrical and low-asymmetrical. The mode is selected by the register ORIENT_1.mode as follows:

ORIENT_1.mode	**Orientation mode**
00	Symmetrical
01	High asymmetrical
10	Low asymmetrical
11	Symmetrical

Orientation Mode: Symmetrical or Asymmetrical

The output has the following meanings depending on the switching mode:

Orient	Name	Angle	Condition
x01	landscape left	315°<phi<45°	|acc_y/acc_x|<1 && acc_x≥0
x11	landscape right	135°<phi<225°	|acc_y/acc_x|<1 && acc_x<0
x10	portrait upside down	45°<phi<135°	|acc_y/acc_x|≥1 && acc_y<0
x00	portrait upright	225°<phi<315°	|acc_y/acc_x|≥1 && acc_y≥0

Symmetrical mode

Orient	Name	Angle	Condition
x01	landscape left	297°<phi<63°	|acc_y/acc_x|<2 && acc_x≥0
x11	landscape right	117°<phi<243°	|acc_y/acc_x|<2 && acc_x<0
x10	portrait upside down	63°<phi<117°	|acc_y/acc_x|≥2 && acc_y<0
x00	portrait upright	243°<phi<297°	|acc_y/acc_x|≥2 && acc_y≥0

High asymmetrical mode

Orient	Name	Angle	Condition
x01	landscape left	333°<phi<27°	|acc_y/acc_x|<0.5 && acc_x≥0
x11	landscape right	153°<phi<207°	|acc_y/acc_x|<0.5 && acc_x<0
x10	portrait upside down	27°<phi<153°	|acc_y/acc_x|≥0.5 && acc_y<0
x00	portrait upright	207°<phi<333°	|acc_y/acc_x|≥0.5 && acc_y≥0

Low asymmetrical mode

For upside or downside orientation, the respective bit of output has the definition:

ORIENT_HIGHG_OUT.orientation_faceup_dow	**acc_z**
Value 0 = upside	(270° < θ < 90°) → *acc_z >= 0*
Value 1 = downside	(90° < θ < 270°) → *acc_z < 0*

Upside/Downside definition

Both portrait/landscape and upside/downside recognition use an ORIENT_2.hysteresis. The hysteresis for portrait/landscape detection is configurable and applies to all conditions as described in the tables below.

Orient	Name	Angle	Condition
x01	landscape left	315°+hy <phi< 45°-hy	|acc_y|<|acc_x|-hyst && acc_x≥0
x11	landscape right	135°+hy <phi< 225°-hy	|acc_y|<|acc_x|-hyst && acc_x<0
x10	portrait upside down	45°+hy <phi< 135°-hy	|acc_y|>|acc_x|+hyst && acc_y<0
x00	portrait upright	225°+hy <phi< 315°-hy	|acc_y|>|acc_x|+hyst && acc_y≥0

Symmetrical mode

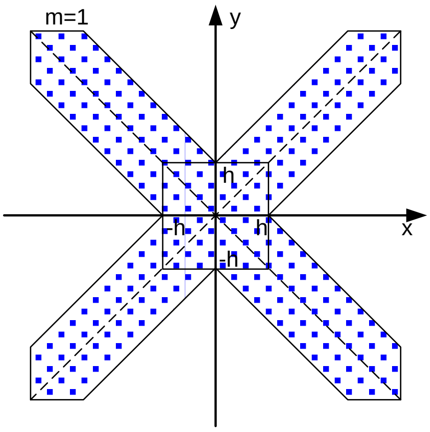


Figure: Hysteresis in symmetrical mode

orient	Name	Angle	Condition
x01	landscape left	297°+hy <phi<63°-hy	|acc_y|<2*(|acc_x|-hyst) && acc_x≥0
x11	landscape right	117°+hy <phi<243°-hy	|acc_y|<2*(|acc_x|-hyst) && acc_x<0
x10	portrait upside down	63°+hy <phi<117°-hy	|acc_y|>2*|acc_x|+hyst && acc_y<0
x00	portrait upright	243°+hy <phi<297°-hy	|acc_y|>2*|acc_x|+hyst && acc_y≥0

High asymmetrical mode

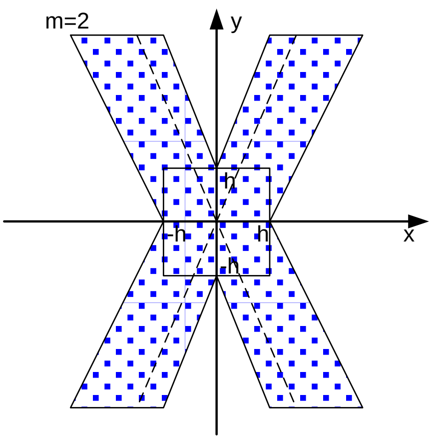


Figure: Hysteresis in high asymmetrical mode

orient	Name	Angle	Condition
x01	landscape left	333°+hy <phi<27°-hy	|acc_y|<(|acc_x|-hyst)/2 && acc_x≥0
x11	landscape right	153°+hy <phi<207°-hy	|acc_y|<(|acc_x|-hyst)/2 && acc_x<0
x10	portrait upside down	27°+hy <phi<153°-hy	|acc_y|>|acc_x|/2+hyst && acc_y<0
x00	portrait upright	207°+hy <phi<333°-hy	|acc_y|>|acc_x|/2+hyst && acc_y≥0

Low asymmetrical mode

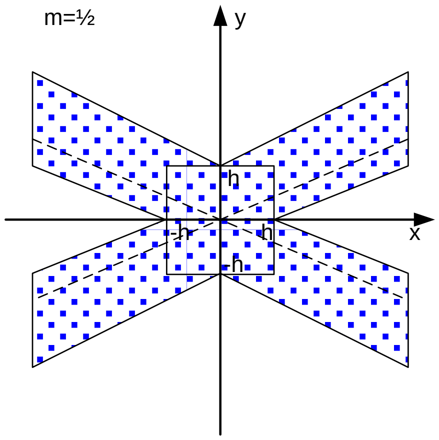


Figure: Hysteresis in low asymmetrical mode

The hysteresis for upside/downside detection is fixed to 11.5° which is ~200 mg.

Orient	Name	Angle	Condition
0xx	upside	281.5°<Theta<78.5°	acc_z>200mg (|acc_z|>200mg and acc_z≥0)
1xx	downside	101.5°<phi<258°	acc_z<–200mg (|acc_z|>200mg and acc_z<0)

Upside/downside hysteresis

Blocking mode

The orientation blocking mode feature may be used to avoid undesired orientation change detection e.g. if the device is nearly flat or in motion. The configuration of the blocking mode is done via the ORIENT_1.blocking parameter:

Blocking	Conditions
00	Interrupt blocking is disabled
01	Interrupt blocked if device close to the horizontal position (theta_flat) OR acceleration of any axis > 1.5g
10	Interrupt blocked if device close to the horizontal position (theta_flat) OR acceleration of any axis > 1.5g OR slope>0.2g
11	Interrupt blocked if device close to the horizontal position (theta_flat) OR acceleration of any axis > 1.5g OR slope > 0.4g OR another change within 100ms

Table: Orientation blocking

If the 100 msec interrupt blocking is enabled (blocking mode ‘11’), to trigger the interrupt, the detected orientation has to remain the same (stable) until the timer for 100 msec expires. The timer starts to count when orientation changes between two consecutive samples. If the orientation changes while timer is still counting, the timer is restarted.

Configuration settings:

1. ORIENT_1.mode – Sets the mode: symmetrical (values 0 or 3), high asymmetrical (value 1) or low asymmetrical (value 2).
2. ORIENT_1.blocking – Sets the blocking mode. If blocking is set, no orientation interrupt will be triggered. Default value is 3 – the most restrictive blocking mode.
3. ORIENT_1.theta – Coded value of the threshold angle with horizontal used in Blocking modes; theta = 64 * (tan(angle)^2); default value is 40, equivalent to 38 degrees angle.
4. ORIENT_2.hysteresis - Acceleration hysteresis for orientation detection. Resolution of field is 4.8mg (Value 2048 = 1g). Default value is 128 = 0.0625g. Range is 0 to 1g.
5. ORIENT_1.enable – Enables the feature.
6. ORIENT_1.ud_en – Enables the upside/downside detection, in addition to landscape/portrait detection.

Output details:

There are 3 bits:

1. Bit 2 (ORIENT_HIGHG_OUT.orientation_faceup_down) reflects the face-up (value 0), respectively face-down (value 1), only if ud_en is enabled. If host disables this feature with ud_en=0, then the output bit is not valid until ud_en is set to 1 again.
2. Bit 0-1 (ORIENT_HIGHG_OUT.orientation_portrait_landscape) have the value:
    - portrait_upright = 0
    - landscape_left = 1
    - portrait_upside_down = 2
    - landscape_right = 3
3. ACC_INT_STAT_0.orientation_out – Set to 1 when change of orientation is detected by the device. Change of orientation means:
    - Output bit 2 is modified i.e. Face-up to face-down or vice versa
    - Output bits 0-1 are modified i.e. change in portrait/landscape orientation

2.1.5. Data Synchronization

The data synchronization feature supports for both BMI085 & BMI088 sensors. Synchronized data means that the acquisition of the gyroscope and accelerometer data is happening at the same time and the signals have same propagation time. The time between motion to register read-out depends on the physical propagation time mainly caused by signal processing path and analog-to-digital conversion and is sensor specific. The typical group delay of the gyroscope and accelerometer signals is disclosed in the tables below.

Accelerometer output data rate (Hz)	BMI085 group delay (ms)	BMI088 group delay (ms)
1600	typ. 0.625	typ. 1.1
800	typ. 1.25	typ. 1.8
400	typ. 2.5	typ. 3

Gyroscope output data rate (Hz)	BMI085 & BMI088 group delay (ms)
2000	typ. 1.5
1000	typ. 2.5
400	typ. 7

The synchronization between accelerometer and gyroscope data to a common point of time and a common group delay can be realized with the help of the internal processing unit of the accelerometer. The internal processing unit of accelerometer part measures the timestamp of the accelerometer analog-to-digital conversion data ready signal and the timestamp of the gyroscope data ready signal. Finally, the processing unit interpolates the acceleration data by using the timestamp difference, the known group delay of every signal path, stores the synchronized data in the general purpose register and sets the interrupt data ready pin to high. The synchronized sensor data can be read from accelerometer and gyroscope data registers by the host. The refresh rate of the registers is linked to gyroscope data rate (400 Hz, 1 kHz, 2 kHz).

The hardware interrupts pins (INT1 / INT3) of the BMI08x are used for data synchronization purposes. The interrupt pin INT2 can be used for data ready notification to the host by BMI08x.

Technical realization

The data synchronization feature requires physical interrupt pin's connection of the sensors on the pcb and a special configuration of the BMI08x. Requirements and the steps are described below.

Application Schematic

The typical application circuit diagram by using BMI08x synchronized data output is shown in the figure below. The interrupt pin INT1 and INT3 of BMI085 must be to be connected externally on pcb. For host notification pin (INT2) shall be used.

For latency-critical multisensory applications, it is recommended to use SPI interface for fastest sensor data read (recommended SPI clock speed is >2MHz).

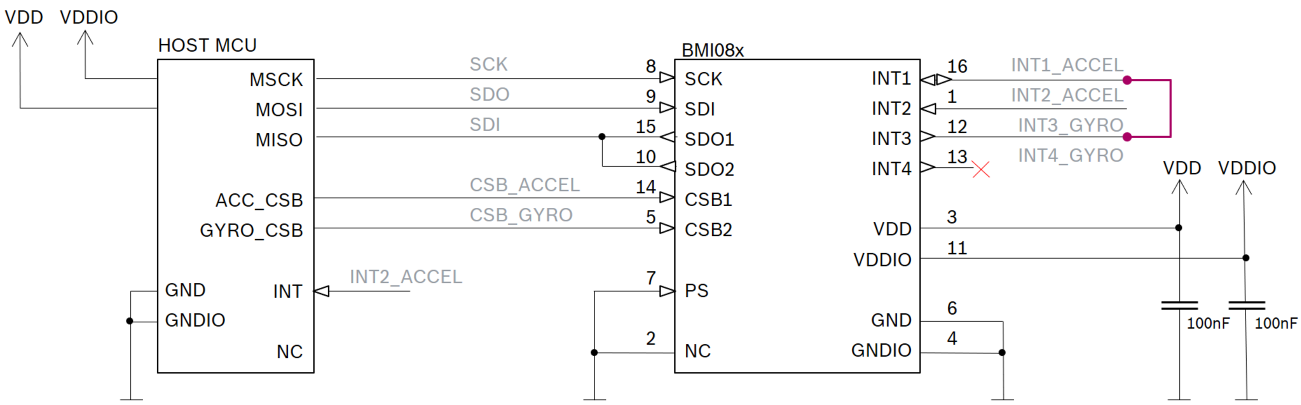
Additionally, it is recommended to use edge triggered interrupt configuration on the host mcu.

Software

In order to use the data synchronization feature of BMI08x, several sensors configuration steps are required and shall be applied after every power on reset (POR) or soft reset. Besides the sensor configuration, it is furthermore required to load binary code into the processing unit of the accelerometer part. It is highly recommended to use the Bosch Sensortec BMI08x sensor API (https://github.com/BoschSensortec/BMI08x-Sensor-API).

Sensor Initialization

The sensor API also contains a readme file (DataSync.md), were the user can find the API calls that need to be executed in order to set up the synchronization feature. It is highly recommended also to consider the delays, which are sometimes needed between the executions of the different API calls.



Read synchronized sensor data

As soon as the host will be notified by BMI08x data ready interrupt (INT2), the synchronized IMU data can be read from data registers. The angular rate data can be read from data registers (*0x02 – 0x07*) of the gyroscope part, while the synchronized acceleration data can be found in the general purpose data registers (*0x1E and 0x27*) of accelerometer part. In addition to the synchronized data, the raw acceleration data and if required the sensor time can be read from the appropriate registers.

The acceleration data are stored in following data registers of accelerometer part:

1) Raw sensor data at *0x12* (length = 6 bytes: *ax, ay, az*)
2) Synchronized accelerometer data ax, ay at *0x1E* (length = 4 bytes: *ax_sync, ay_sync*)
3) Synchronized accelerometer data az at *0x27* (length = 2 bytes: *az_sync*)
4) Sensor time can be read out at *0x18* (length = 3 bytes)

Sample code

A piece of sample code showing the required steps to be undertaken in order to receive synchronized data can be found as part of the COINES tool on Bosch Sensortec's web page: https://www.bosch-sensortec.com/software-tools/tools/coines/

Synchronization feature timings:

Parameter	Time	Notes
gyroscope sampling time	typ. 500us	
accelerometer internal sampling time	typ. 625us	
accelerometer synchronized data sampling time	typ. 500us	synchronized to gyroscope data ready interrupt
accelerometer data ready latency	typ. 25us	latency between gyroscope data ready interrupt and accelerometer data ready interrupt
synchronization accuracy	typ. <100us	
latency / group delay of synchronized data (motion-to-data ready)	typ. 1.5ms @ 2kHz ODR typ. 2.5ms @ 1kHz ODR typ. 7ms @ 400Hz ODR	

Snapshot of logic analyzer, showing the gyro data ready signal (marker A, C) and the time delay until the accelerometer's internal signal processor as processed the data and sends a data ready signal to the host (marker B).

3. Power Mode

The power state of the accelerometer in the BMI088 is controlled through the registers ACC_PWR_CONF and ACC_PWR_CTRL. Whereas the power state of the gyroscope in the BMI088 is controlled through the register GYR_LPM1.
The register ACC_PWR_CTRL enables and disables the accelerometer. The register ACC_PWR_CONF controls which power state the sensors enter if they are enabled or disabled in the register ACC_PWR_CTRL. The power state impacts the behavior of the sensor with respect to start-up time, available functions, etc. but not the sensor data quality. The sensor data quality is controlled in registers ACC_PWR_CONF.
In all global power configurations both register contents and FIFO contents are retained.

Low Power MODE:
This power configuration aggressively reduces power of the device as much as possible. The low power mode configuration is activated by setting ACC_PWR_CONF.acc_pwr_save = 0x01 and disabling ACC_CONF.acc_perf_mode=0b0.
In this configuration these extremely user visible features may not be available.:

- Register writes need an inter-write delay of at least 450 µs.

Accelerometer data processing for low power mode

Low power mode can be enabled by ACC_PWR_CONF.acc_pwr_save =0x01 and ACC_CONF.acc_perf_mode =0b0. In this power mode, the accelerometer regularly changes between a suspend power mode phase where no measurement is performed and a performance power mode phase, where data is acquired. The period of the duty cycle for changing between suspend and performance mode will be determined by the output data rate (ACC_CONF.acc_odr). The output data rate can be configured in one of 10 different valid ODR configurations going from 0.78Hz up to 400Hz. The samples acquired during the normal mode phase will be averaged and the result will be the output data. The number of averaged samples can be determined by the parameter ACC_CONF.acc_bwp through the following formula:

$$\text{averaged samples} = 2^{(Val(acc\_bwp))}$$
$$\text{skipped samples} = (1600/ODR)\text{-averaged samples}$$

A higher number of averaged samples will result in a lower noise level of the signal, but since the performance power mode phase is increased, the power consumption will also rise.

Note: In case of only accelerometer data is needed, the register GYR_LPM1 need to be set to deep suspend mode.

4. Register Description

4.1. Register Map

4.1.1. **Communication with the sensor**

The entire communication with the device is performed by reading from and writing to registers. Registers have a width of 8 bits; they are mapped to an 8-bit address space. Accelerometer and gyroscope have individual register maps. The selection of the appropriate register map is done on digital interface level by either selecting the corresponding chip select pin (SPI mode) or I^{2}C address (I^{2}C mode). For details regarding the digital interface, see chapter 6.

The functional registers and the register addresses containing functional bits are marked in the following register maps. All non-functional registers are marked as reserved and should be completely ignored by the user.

It is recommended to mask out (logical *and* with zero) non-functional bits (marked with '-') of registers which partially contain functional bits (i.e. read the register content first, changing bit by means of bit-wise operations, and write the modified byte back to the register).

4.2. Register map: accelerometer

read/write	read only	write only	reserved

Corresponding to bmi088_mm_image.tbin, version 1.0, register map version 1.0

Addr	Name	Reset value	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
0x7E	ACC_SOFTRESET	0x00	softreset_cmd (0xb6)							
0x7D	ACC_PWR_CTRL	0x00	reserved					acc_en	reserved	
0x7C	ACC_PWR_CONF	0x03	reserved							pwr_save_mode
0x7B	-	-	reserved							
...	-	-	reserved							
0x74	-	-	reserved							
0x73	OFFSET_2	0x00	off_acc_z							
0x72	OFFSET_1	0x00	off_acc_y							
0x71	OFFSET_0	0x00	off_acc_x							
0x70	NV_CONF	0x00	reserved				acc_off_en	i2c_wdt_en	i2c_wdt_sel	spi_en
0x6F	-	-	reserved							
0x6E	-	-	reserved							
0x6D	ACC_SELF_TEST	0x00	reserved				acc_self_test_amp	acc_self_test_sign	reserved	acc_self_test_en
0x6C	-	-	reserved							
0x6B	IF_CONF	0x00	reserved			if_mode	reserved			spi3
0x6A	NVM_CONF	0x00	reserved						nvm_prog_en	reserved
0x69	-	-	reserved							
...	-	-	reserved							
0x60	-	-	reserved							
0x5F	INTERNAL_ERROR	0x00	reserved					int_err_2	int_err_1	reserved
0x5E	FEATURES_IN	0x00	features_in							
0x5D	-	-	reserved							
...	-	-	reserved							
0x5A	-	-	reserved							

0x59	INIT_CTRL	0x90	init_ctrl							
0x58	INT_MAP_DATA	0x00	reserved	int2_drdy	int2_fwm	int2_ffull	reserved	int1_drdy	int1_fwm	int1_ffull
0x57	INT2_MAP	0x00	error_int_out	reserved	no_motion_out	orientation_out	low_g_out	high_g_out	any_motion_out	Data_sync_out
0x56	INT1_MAP	0x00	error_int_out	reserved	no_motion_out	orientation_out	low_g_out	high_g_out	any_motion_out	Data_sync_out
0x55	INT_LATCH	0x00	reserved							int_latch
0x54	INT2_IO_CTRL	0x00	reserved			input_en	output_en	od	lvl	edge_ctrl
0x53	INT1_IO_CTRL	0x00	reserved			input_en	output_en	od	lvl	edge_ctrl
0x52	-	-	reserved							
...	-	-	reserved							
0x50	-	-	reserved							
0x4F	AUX_WR_DATA	0x02	write_data							
0x4E	AUX_WR_ADDR	0x4C	write_addr							
0x4D	AUX_RD_ADDR	0x42	read_addr							
0x4C	AUX_IF_CONF	0x83	aux_manual_en	reserved					aux_rd_burst	
0x4B	AUX_DEV_ID	0x20	i2c_device_addr							reserved
0x4A	-	-	reserved							
0x49	FIFO_CONFIG_1	0x10	reserved	fifo_acc_en	fifo_aux_en	fifo_header_en	fifo_tag_int1_en	fifo_tag_int2_en	reserved	
0x48	FIFO_CONFIG_0	0x02	reserved						fifo_time_en	fifo_stop_on_full
0x47	FIFO_WTM_1	0x02	reserved			fifo_water_mark_12_8				
0x46	FIFO_WTM_0	0x00	fifo_water_mark_7_0							
0x45	FIFO_DOWNS	0x80	acc_fifo_filt_data	acc_fifo_downs			reserved			
0x44	AUX_CONF	0x46	aux_offset				aux_odr			
0x43	-	-	reserved							
0x42	-	-	reserved							
0x41	ACC_RANGE	0x01	reserved						acc_range	
0x40	ACC_CONF	0xA8	acc_perf_mode	acc_bwp			acc_odr			
0x3F	-	-	reserved							

<table>
<tr><td>...</td><td>-</td><td>-</td><td colspan="8">reserved</td></tr>
<tr><td>0x2B</td><td>-</td><td>-</td><td colspan="8">reserved</td></tr>
<tr><td>0x2A</td><td>INTERNAL_STATUS</td><td>0x00</td><td colspan="2">reserved</td><td>axes_remap_error</td><td colspan="5">message</td></tr>
<tr><td>0x29</td><td>ORIENT_HIGHG_OUT</td><td>0x00</td><td>reserved</td><td>high_g_detect_sign</td><td>high_g_detect_z</td><td>high_g_detect_y</td><td>high_g_detect_x</td><td>orientation_faceup_down</td><td colspan="2">orientation_portrait_landscape</td></tr>
<tr><td>0x28</td><td>-</td><td>-</td><td colspan="8">reserved</td></tr>
<tr><td>0x27</td><td>-</td><td>-</td><td colspan="8">reserved</td></tr>
<tr><td>0x26</td><td>FIFO_DATA</td><td>0x00</td><td colspan="8">fifo_data</td></tr>
<tr><td>0x25</td><td>FIFO_LENGTH_1</td><td>0x00</td><td colspan="2">reserved</td><td colspan="6">fifo_byte_counter_13_8</td></tr>
<tr><td>0x24</td><td>FIFO_LENGTH_0</td><td>0x00</td><td colspan="8">fifo_byte_counter_7_0</td></tr>
<tr><td>0x23</td><td>-</td><td>-</td><td colspan="8">reserved</td></tr>
<tr><td>0x22</td><td>TEMPERATURE</td><td>0x00</td><td colspan="8">temperature</td></tr>
<tr><td>0x21</td><td>-</td><td>-</td><td colspan="8">reserved</td></tr>
<tr><td>...</td><td>-</td><td>-</td><td colspan="8">reserved</td></tr>
<tr><td>0x1E</td><td>-</td><td>-</td><td colspan="8">reserved</td></tr>
<tr><td>0x1D</td><td>ACC_INT_STAT_1</td><td>0x00</td><td>acc_drdy_int</td><td colspan="5">reserved</td><td>fwm_int</td><td>ffull_int</td></tr>
<tr><td>0x1C</td><td>ACC_INT_STAT_0</td><td>0x00</td><td>error_int_out</td><td>reserved</td><td>no_motion_out</td><td>orientation_out</td><td>low_g_out</td><td>high_g_out</td><td>any_motion_out</td><td>Data_sync_out</td></tr>
<tr><td>0x1B</td><td>EVENT</td><td>0x01</td><td colspan="7">reserved</td><td>por_detected</td></tr>
<tr><td>0x1A</td><td>SENSOR_TIME_2</td><td>0x00</td><td colspan="8">sensor_time_23_16</td></tr>
<tr><td>0x19</td><td>SENSOR_TIME_1</td><td>0x00</td><td colspan="8">sensor_time_15_8</td></tr>
<tr><td>0x18</td><td>SENSOR_TIME_0</td><td>0x00</td><td colspan="8">sensor_time_7_0</td></tr>
<tr><td>0x17</td><td>ACC_Z_MSB</td><td>0x00</td><td colspan="8">acc_z_11_4</td></tr>
<tr><td>0x16</td><td>ACC_Z_LSB</td><td>0x00</td><td colspan="4">acc_z_3_0</td><td colspan="4">reserved</td></tr>
<tr><td>0x15</td><td>ACC_Y_MSB</td><td>0x00</td><td colspan="8">acc_y_11_4</td></tr>
<tr><td>0x14</td><td>ACC_Y_LSB</td><td>0x00</td><td colspan="4">acc_y_3_0</td><td colspan="4">reserved</td></tr>
<tr><td>0x13</td><td>ACC_X_MSB</td><td>0x00</td><td colspan="8">acc_x_11_4</td></tr>
<tr><td>0x12</td><td>ACC_X_LSB</td><td>0x00</td><td colspan="4">acc_x_3_0</td><td colspan="4">reserved</td></tr>
<tr><td>0x11</td><td>DATA_7</td><td>0x00</td><td colspan="8">aux_r_11_4</td></tr>
</table>

0x10	DATA_6	0x00	aux_r_3_0				reserved			
0x0F	DATA_5	0x00	aux_z_11_4							
0x0E	DATA_4	0x00	aux_z_3_0				reserved			
0x0D	DATA_3	0x00	aux_y_11_4							
0x0C	DATA_2	0x00	aux_y_3_0				reserved			
0x0B	DATA_1	0x00	aux_x_11_4							
0x0A	DATA_0	0x00	aux_x_3_0				reserved			
0x09	-	-	reserved							
...	-	-	reserved							
0x04	-	-	reserved							
0x03	ACC_STATUS	0x10	drdy_acc	reserved	drdy_aux	cmd_rdy	reserved	aux_man_op	reserved	
0x02	ACC_ERR_REG	0x00	aux_err	fifo_err	reserved	error_code			cmd_err	fatal_err
0x01	-	-	reserved							
0x00	ACC_CHIP_ID	0x1E	chip_id							

FEATURES_IN

Register Address	Register Name	Default Value	7		6	5	4	3	2	1	0
0x5E: 0x1D	general_settings.AXIS_REMAP_1[1]	0x00		reserved							map_z_axis_sign
0x5E: 0x1C	general_settings.AXIS_REMAP_1[0]	0x88		map_z_axis		map_y_axis_sign	map_y_axis		map_x_axis_sign	map_x_axis	
0x5E: 0x1B	general_settings.Reserved[1]	0x00		Reserved							
0x5E: 0x1A	general_settings.Reserved[0]	0x00		Reserved							
0x5E: 0x19	no_motion.NOMO_2[1]	0xE0	z_en		y_en	x_en	duration				
0x5E: 0x18	no_motion.NOMO_2[0]	0x05		duration							
0x5E: 0x17	no_motion.NOMO_1[1]	0x00		reserved				enable	threshold		

0x5E: 0x16	no_motion.NOMO_1[0]	0xAA		threshold						
0x5E: 0x15	orientation.ORIENT_2[1]	0x00		reserved					hysteresis	
0x5E: 0x14	orientation.ORIENT_2[0]	0x80		hysteresis						
0x5E: 0x13	orientation.ORIENT_1[1]	0x0A		reserved				theta		
0x5E: 0x12	orientation.ORIENT_1[0]	0x30		theta		blocking		mode	ud_en	enable
0x5E: 0x11	low_g.LO_G_3[1]	0x00		reserved				duration		
0x5E: 0x10	low_g.LO_G_3[0]	0x00		duration						
0x5E: 0x0F	low_g.LO_G_2[1]	0x01		reserved			enable	hysteresis		
0x5E: 0x0E	low_g.LO_G_2[0]	0x00		hysteresis						
0x5E: 0x0D	low_g.LO_G_1[1]	0x02	reserved		threshold					
0x5E: 0x0C	low_g.LO_G_1[0]	0x00		threshold						
0x5E: 0x0B	high_g.HI_G_3[1]	0x00		reserved				duration		
0x5E: 0x0A	high_g.HI_G_3[0]	0x04		duration						
0x5E: 0x09	high_g.HI_G_2[1]	0x73	enable		en_z	en_y	en_x	hysteresis		
0x5E: 0x08	high_g.HI_G_2[0]	0xE8		hysteresis						

0x5E: 0x07	high_g.HI_G_1[1]	0x0C	reserved		threshold						
0x5E: 0x06	high_g.HI_G_1[0]	0x00		threshold							
0x5E: 0x05	-	-		reserved							
0x5E: 0x04	-	-		reserved							
0x5E: 0x03	any_motion.ANYMO_2[1]	0xE0	z_en		y_en	x_en	duration				
0x5E: 0x02	any_motion.ANYMO_2[0]	0x05		duration							
0x5E: 0x01	any_motion.ANYMO_1[1]	0x00		reserved				enable	threshold		
0x5E: 0x00	any_motion.ANYMO_1[0]	0xAA		threshold							

4.3. Register description: accelerometer

4.3.1. Register (0x00) ACC_CHIP_ID

DESCRIPTION: Chip identification code
RESET: 0x1E
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x00		ACC_CHIP_ID		0x1E	
	7...0	chip_id	Chip identification code for BMI088MM	0x1E	R

4.3.2. Register (0x02) ACC_ERR_REG

DESCRIPTION: Reports sensor error conditions
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x02		ACC_ERR_REG		0x00	
	0	fatal_err	Fatal Error, chip is not in operational state (Boot-, power-system). This flag will be reset only by power-on-reset or softreset.	0x0	R
	1	cmd_err	Command execution failed.	0x0	R
	4...2	error_code	Error codes for persistent errors **Value** **Name** **Description** 0x00 no_error no error is reported 0x01 acc_err error in Register ACC_CONF	0x0	R
	6	fifo_err	Error in FIFO detected: Input data was discarded in stream mode. This flag will be reset when read.	0x0	R
	7	aux_err	Error in I2C-Master detected. This flag will be reset when read.	0x0	R

4.3.3. Register (0x03) ACC_STATUS

DESCRIPTION: Sensor status flags
RESET: 0x10
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x03		ACC_STATUS		0x10	
	2	aux_man_op	‘1’(‘0’) indicate a (no) manual auxiliary interface operation is ongoing.	0x0	R
	4	cmd_rdy	CMD decoder status. \`0´ -> Command in progress \`1´ -> Command decoder is ready to accept a new command	0x1	R
	5	drdy_aux	Data ready for auxiliary sensor. It gets reset when one auxiliary DATA register is read out	0x0	R

	7	drdy_acc	Data ready for accelerometer. It gets reset when one accelerometer DATA register is read out	0x0	R

4.3.4. **Register (0x0A) DATA_0**

DESCRIPTION: AUX_X(LSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x0A		DATA_0		0x00	
	7...4	aux_x_3_0		0x0	R

4.3.5. **Register (0x0B) DATA_1**

DESCRIPTION: AUX_X(MSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x0B		DATA_1		0x00	
	7...0	aux_x_11_4		0x0	R

4.3.6. **Register (0x0C) DATA_2**

DESCRIPTION: AUX_Y(LSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x0C		DATA_2		0x00	
	7...4	aux_y_3_0		0x0	R

4.3.7. **Register (0x0D) DATA_3**

DESCRIPTION: AUX_Y(MSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x0D		DATA_3		0x00	
	7...0	aux_y_11_4		0x0	R

4.3.8. Register (0x0E) DATA_4

DESCRIPTION: AUX_Z(LSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x0E		DATA_4		0x00	
	7...4	aux_z_3_0		0x0	R

4.3.9. Register (0x0F) DATA_5

DESCRIPTION: AUX_Z(MSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x0F		DATA_5		0x00	
	7...0	aux_z_11_4		0x0	R

4.3.10. Register (0x10) DATA_6

DESCRIPTION: AUX_R(LSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x10		DATA_6		0x00	
	7...4	aux_r_3_0		0x0	R

4.3.11. Register (0x11) DATA_7

DESCRIPTION: AUX_R(MSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x11		DATA_7		0x00	
	7...0	aux_r_11_4		0x0	R

4.3.12. Register (0x12) ACC_X_LSB

DESCRIPTION: ACC_X(LSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x12		ACC_X_LSB		0x00	
	7...4	acc_x_3_0		0x0	R

4.3.13. **Register (0x13) ACC_X_MSB**

DESCRIPTION: ACC_X(MSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x13		ACC_X_MSB		0x00	
	7...0	acc_x_11_4		0x0	R

4.3.14. **Register (0x14) ACC_Y_LSB**

DESCRIPTION: ACC_Y(LSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x14		ACC_Y_LSB		0x00	
	7...4	acc_y_3_0		0x0	R

4.3.15. **Register (0x15) ACC_Y_MSB**

DESCRIPTION: ACC_Y(MSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x15		ACC_Y_MSB		0x00	
	7...0	acc_y_11_4		0x0	R

4.3.16. **Register (0x16) ACC_Z_LSB**

DESCRIPTION: ACC_Z(LSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x16		ACC_Z_LSB		0x00	
	7...4	acc_z_3_0		0x0	R

4.3.17. **Register (0x17) ACC_Z_MSB**

DESCRIPTION: ACC_Z(MSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x17		ACC_Z_MSB		0x00	
	7...0	acc_z_11_4		0x0	R

4.3.18. Register (0x18) SENSORTIME_0

DESCRIPTION: Sensor time <7:0>
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x18		SENSORTIME_0		0x00	
	7...0	sensor_time_7_0	Sensor time <7:0> in units of 39.0625 us.	0x0	R

4.3.19. Register (0x19) SENSORTIME_1

DESCRIPTION: Sensor time <15:8>
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x19		SENSORTIME_1		0x00	
	7...0	sensor_time_15_8	Sensor time <15:8> in units of 10 ms.	0x0	R

4.3.20. Register (0x1A) SENSORTIME_2

DESCRIPTION: Sensor time <23:16>
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x1A		SENSORTIME_2		0x00	
	7...0	sensor_time_23_16	Sensor time <23:16> in units of 2.56 s.	0x0	R

4.3.21. Register (0x1B) EVENT

DESCRIPTION: Sensor status flags
RESET: 0x01
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x1B		EVENT		0x01	
	0	por_detected	'1' after device power up or softreset. Clear-on-read	0x1	R

4.3.22. Register (0x1C) ACC_INT_STAT_0

DESCRIPTION: Interrupt/Feature status.This register will be cleared on read.
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x1C		ACC_INT_STAT_0		0x00	
	0	Data_sync_out	Data Synchronization out	0x0	R
	1	any_motion_out	Any-motion detection output	0x0	R
	2	high_g_out	High_g detection out	0x0	R
	3	low_g_out	Low_g detection out	0x0	R

	4	orientation_out	orientation detection out	0x0	R
	5	no_motion_out	No-motion detection out	0x0	R
	7	error_int_out	Error interrupt output	0x0	R

4.3.23. **Register (0x1D) ACC_INT_STAT_1**

DESCRIPTION: Interrupt Status. This register will be cleared on read.
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x1D		ACC_INT_STAT_1		0x00	
	0	ffull_int	FIFO Full Interrupt	0x0	R
	1	fwm_int	FIFO Watermark Interrupt	0x0	R
	7	acc_drdy_int	Accelerometer data ready interrupt	0x0	R

4.3.24. **Register (0x22) TEMPERATURE**

DESCRIPTION: Contains the temperature value of the sensor
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x22		TEMPERATURE		0x00	
	7...0	temperature	Temperature value in two's complement representation in units of 1 Kelvin: 0x00 corresponds to 23 degree Celsius.	0x0	R

4.3.25. **Register (0x24) FIFO_LENGTH_0**

DESCRIPTION: FIFO byte count register (LSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x24		FIFO_LENGTH_0		0x00	
	7...0	fifo_byte_counter_7_0	Current fill level of FIFO buffer.	0x0	R

4.3.26. **Register (0x25) FIFO_LENGTH_1**

DESCRIPTION: FIFO byte count register (MSB)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x25		FIFO_LENGTH_1		0x00	
	5...0	fifo_byte_counter_13_8	FIFO byte counter bits 13..8	0x0	R

4.3.27. **Register (0x26) FIFO_DATA**

DESCRIPTION: FIFO data output register

RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x26		FIFO_DATA		0x00	
	7...0	fifo_data	FIFO read data.	0x0	R

4.3.28. **Register (0x29) ORIENT_HIGHG_OUT**

DESCRIPTION: Describes orientation and highg output
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x29		ORIENT_HIGHG_OUT		0x00	
	1...0	orientation_portrait_landscape	Output value of the orientation detection feature. Value after device initialization is 0b00 i.e. portrait upright **Value** / **Name** / **Description** 0x00 / portrait_upright / Portrait upright orientation 0x01 / landscape_left / Landscape left orientation 0x02 / portrait_upside_down / Portrait upside down orientation 0x03 / landscape_right / Landscape right orientation	0x0	R
	2	orientation_faceup_down	Output value of face down face up orientation (only if ud_en is enabled). Value after device initialization is 0b0 i.e. face up **Value** / **Name** / **Description** 0x00 / face_up / Face up orientation 0x01 / face_down / Face down orientation	0x0	R
	3	high_g_detect_x	High-g was detected on X-axis	0x0	R
	4	high_g_detect_y	High-g was detected on Y-axis	0x0	R
	5	high_g_detect_z	High-g was detected on Z-axis	0x0	R
	6	high_g_detect_sign	Axis direction for which the high-g was detected. 1 for negative axis, 0 for positive axis.	0x0	R

4.3.29. Register (0x2A) INTERNAL_STATUS

DESCRIPTION:
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x2A		INTERNAL_STATUS		0x00	
	4...0	message	Internal Status Message **Value Name Description** 0x00 not_init ASIC is not initialized 0x01 init_ok ASIC initialized 0x02 init_err Initialization error 0x03 dvr_err Invalid driver 0x04 sns_stop Sensor stopped	0x0	R
	5	axes_remap_error	Axes remapped wrongly because a source axis is not assigned to more than one target axis.	0x0	R

4.3.30. Register (0x40) ACC_CONF

DESCRIPTION: Sets the output data rate, the bandwidth, and the read mode of the acceleration sensor
RESET: 0xA8
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x40		ACC_CONF		0xA8	
	3...0	acc_odr	ODR in Hz. The output data rate is independent of the power mode setting for the sensor, but not all settings are supported in all power modes. **Value Name Description** 0x00 reserved Reserved 0x01 odr_0p78 25/32 0x02 odr_1p5 25/16 0x03 odr_3p1 25/8 0x04 odr_6p25 25/4 0x05 odr_12p5 25/2 0x06 odr_25 25 0x07 odr_50 50 0x08 odr_100 100 0x09 odr_200 200 0x0a odr_400 400 0x0b odr_800 800 0x0c odr_1k6 1600 0x0d odr_3k2 Reserved 0x0e odr_6k4 Reserved 0x0f odr_12k8 Reserved	0x8	RW

	6...4	acc_bwp	Bandwidth parameter, determines filter configuration (acc_perf_mode=1) and averaging for undersampling mode (acc_perf_mode=0) **Value** **Name** **Description** 0x00 osr4_avg1 acc_perf_mode = 1 -> OSR4 mode; acc_perf_mode = 0 -> no averaging 0x01 osr2_avg2 acc_perf_mode = 1 -> OSR2 mode; acc_perf_mode = 0 -> average 2 samples 0x02 norm_avg4 acc_perf_mode = 1 -> normal mode; acc_perf_mode = 0 -> average 4 samples 0x03 cic_avg8 acc_perf_mode = 1 -> Reserved; acc_perf_mode = 0 -> average 8 samples 0x04 res_avg16 acc_perf_mode = 1 -> Reserved; acc_perf_mode = 0 -> average 16 samples 0x05 res_avg32 acc_perf_mode = 1 -> Reserved; acc_perf_mode = 0 -> average 32 samples 0x06 res_avg64 acc_perf_mode = 1 -> Reserved; acc_perf_mode = 0 -> average 64 samples 0x07 res_avg128 acc_perf_mode = 1 -> Reserved; acc_perf_mode = 0 -> average 128 samples	0x2	RW
	7	acc_perf_mode	Select accelerometer filter performance mode: **Value** **Name** **Description** 0x00 cic_avg averaging mode. 0x01 cont continuous filter function.	0x1	RW

4.3.31. **Register (0x41) ACC_RANGE**

DESCRIPTION: Selection of the Accelerometer g-range
RESET: 0x01

DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x41		ACC_RANGE		0x01	
	1...0	acc_range	Accelerometer g-range **Value Name Description** 0x00 range_2g +/-2g 0x01 range_4g +/-4g 0x02 range_8g +/-8g 0x03 range_16g +/-16g	0x1	RW

4.3.32. Register (0x44) AUX_CONF

DESCRIPTION: Sets the output data rate of the Auxiliary interface
RESET: 0x46
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x44		AUX_CONF		0x46	
	3...0	aux_odr	Select the poll rate for the sensor attached to the Auxiliary interface. **Value Name Description** 0x00 reserved Reserved 0x01 odr_0p78 25/32 0x02 odr_1p5 25/16 0x03 odr_3p1 25/8 0x04 odr_6p25 25/4 0x05 odr_12p5 25/2 0x06 odr_25 25 0x07 odr_50 50 0x08 odr_100 100 0x09 odr_200 200 0x0a odr_400 400 0x0b odr_800 800 0x0c odr_1k6 Reserved 0x0d odr_3k2 Reserved 0x0e odr_6k4 Reserved 0x0f odr_12k8 Reserved	0x6	RW
	7...4	aux_offset	trigger-readout offset in units of 2.5 ms. If set to zero, the offset is maximum, i.e. after readout a trigger is issued immediately.	0x4	RW

4.3.33. **Register (0x45) FIFO_DOWNS**

DESCRIPTION: Configure Accelerometer downsampling rates for FIFO
RESET: 0x80
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x45		FIFO_DOWNS		0x80	
	6...4	acc_fifo_downs	Downsampling for accelerometer data (2**acc_fifo_downs)	0x0	RW
	7	acc_fifo_filt_data	selects filtered or unfiltered Accelerometer data for fifo **Value** **Name** **Description** 0x00 unfiltered Unfiltered data 0x01 filtered Filtered data	0x1	RW

4.3.34. **Register (0x46) FIFO_WTM_0**

DESCRIPTION: FIFO Watermark level LSB
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x46		FIFO_WTM_0		0x00	
	7...0	fifo_water_mark_7_0		0x0	RW

4.3.35. **Register (0x47) FIFO_WTM_1**

DESCRIPTION: FIFO Watermark level MSB
RESET: 0x02
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x47		FIFO_WTM_1		0x02	
	4...0	fifo_water_mark_12_8		0x2	RW

4.3.36. **Register (0x48) FIFO_CONFIG_0**

DESCRIPTION: FIFO frame content configuration
RESET: 0x02
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x48		FIFO_CONFIG_0		0x02	
	0	fifo_stop_on_full	Stop writing samples into FIFO when FIFO is full. **Value** **Name** **Description** 0x00 disable do not stop writing to FIFO when full	0x0	RW

			0x01 enable Stop writing into FIFO when full.		
	1	fifo_time_en	Return sensortime frame after the last valid data frame. **Value Name Description** 0x00 disable do not return sensortime frame 0x01 enable return sensortime frame	0x1	RW

4.3.37. **Register (0x49) FIFO_CONFIG_1**

DESCRIPTION: FIFO frame content configuration
RESET: 0x10
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x49		FIFO_CONFIG_1		0x10	
	2	fifo_tag_int2_en	FIFO interrupt 2 tag enable **Value Name Description** 0x00 disable disable tag 0x01 enable enable tag	0x0	RW
	3	fifo_tag_int1_en	FIFO interrupt 1 tag enable **Value Name Description** 0x00 disable disable tag 0x01 enable enable tag	0x0	RW
	4	fifo_header_en	FIFO frame header enable **Value Name Description** 0x00 disable no header is stored (output data rate of all enabled sensors need to be identical) 0x01 enable header is stored	0x1	RW
	5	fifo_aux_en	Store Auxiliary data in FIFO (all 3 axes) **Value Name Description** 0x00 disable no Auxiliary data is stored 0x01 enable Auxiliary data is stored	0x0	RW
	6	fifo_acc_en	Store Accelerometer data in FIFO (all 3 axes) **Value Name Description** 0x00 disable no Accelerometer data is stored 0x01 enable Accelerometer data is stored	0x0	RW

4.3.38. **Register (0x4B) AUX_DEV_ID**

DESCRIPTION: Auxiliary interface slave device id
RESET: 0x20
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x4B		AUX_DEV_ID		0x20	
	7...1	i2c_device_addr	I2C device address of Auxiliary slave	0x10	RW

4.3.39. **Register (0x4C) AUX_IF_CONF**

DESCRIPTION: Auxiliary interface configuration
RESET: 0x83
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x4C		AUX_IF_CONF		0x83	
	1...0	aux_rd_burst	Burst data length (1,2,6,8 byte) **Value** **Name** **Description** 0x00 BL1 Burst length 1 0x01 BL2 Burst length 2 0x02 BL6 Burst length 6 0x03 BL8 Burst length 8	0x3	RW
	7	aux_manual_en	Enable auxiliary interface manual mode. **Value** **Name** **Description** 0x00 disable Data mode 0x01 enable Setup mode	0x1	RW

4.3.40. **Register (0x4D) AUX_RD_ADDR**

DESCRIPTION: Auxiliary interface read register address
RESET: 0x42
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x4D		AUX_RD_ADDR		0x42	
	7...0	read_addr	Address to read	0x42	RW

4.3.41. **Register (0x4E) AUX_WR_ADDR**

DESCRIPTION: Auxiliary interface write register address
RESET: 0x4C
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x4E		AUX_WR_ADDR		0x4C	
	7...0	write_addr	Address to write	0x4C	RW

4.3.42. **Register (0x4F) AUX_WR_DATA**

DESCRIPTION: Auxiliary interface write data
RESET: 0x02
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x4F		AUX_WR_DATA		0x02	
	7...0	write_data	Data to write	0x2	RW

4.3.43. **Register (0x53) INT1_IO_CTRL**

DESCRIPTION: Configure the electrical behaviour of the interrupt pins
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x53		INT1_IO_CTRL		0x00	
	0	edge_ctrl	Configure trigger condition of INT1 pin (input) **Value Name Description** 0x00 level_tr Level 0x01 edge_tr Edge	0x0	RW
	1	lvl	Configure level of INT1 pin **Value Name Description** 0x00 active_low active low 0x01 active_high active high	0x0	RW
	2	od	Configure behaviour of INT1 pin to open drain. **Value Name Description** 0x00 push_pull push-pull 0x01 open_drain open drain	0x0	RW
	3	output_en	Output enable for INT1 pin **Value Name Description** 0x00 off Output disabled 0x01 on Output enabled	0x0	RW
	4	input_en	Input enable for INT1 pin **Value Name Description** 0x00 off Input disabled 0x01 on Input enabled	0x0	RW

4.3.44. **Register (0x54) INT2_IO_CTRL**

DESCRIPTION: Configure the electrical behaviour of the interrupt pins
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x54		INT2_IO_CTRL		0x00	
	0	edge_ctrl	Configure trigger condition of INT2 pin (input) **Value Name Description**	0x0	RW

			0x00 level_tr Level 0x01 edge_tr Edge		
	1	lvl	Configure level of INT2 pin **Value** **Name** **Description** 0x00 active_low active low 0x01 active_high active high	0x0	RW
	2	od	Configure behaviour of INT2 pin to open drain. **Value** **Name** **Description** 0x00 push_pull push-pull 0x01 open_drain open drain	0x0	RW
	3	output_en	Output enable for INT2 pin **Value** **Name** **Description** 0x00 off Output disabled 0x01 on Output enabled	0x0	RW
	4	input_en	Input enable for INT2 pin **Value** **Name** **Description** 0x00 off Input disabled 0x01 on Input enabled	0x0	RW

4.3.45. **Register (0x55) INT_LATCH**

DESCRIPTION: Configure interrupt modes
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x55		INT_LATCH		0x00	
	0	int_latch	Latched/non-latched/temporary interrupt modes **Value** **Name** **Description** 0x00 none non latched 0x01 permanent latched	0x0	RW

4.3.46. **Register (0x56) INT1_MAP**

DESCRIPTION: Interrupt/Feature mapping on INT1
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x56		INT1_MAP		0x00	
	0	Data_sync_out	Data Synchronization out	0x0	RW
	1	any_motion_out	Any-motion detection output	0x0	RW
	2	high_g_out	High_g detection out	0x0	RW
	3	low_g_out	Low_g detection out	0x0	RW
	4	orientation_out	orientation detection out	0x0	RW
	5	no_motion_out	No-motion detection out	0x0	RW
	7	error_int_out	Error interrupt output	0x0	RW

4.3.47. **Register (0x57) INT2_MAP**

DESCRIPTION: Interrupt/Feature mapping on INT2
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x57		INT2_MAP		0x00	
	0	Data_sync_out	Data Synchronization out	0x0	RW
	1	any_motion_out	Any-motion detection output	0x0	RW
	2	high_g_out	High_g detection out	0x0	RW
	3	low_g_out	Low_g detection out	0x0	RW
	4	orientation_out	orientation detection out	0x0	RW
	5	no_motion_out	No-motion detection out	0x0	RW
	7	error_int_out	Error interrupt output	0x0	RW

4.3.48. **Register (0x58) INT_MAP_DATA**

DESCRIPTION: Interrupt mapping hardware interrupts
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x58		INT_MAP_DATA		0x00	
	0	int1_ffull	FIFO Full interrupt mapped to INT1	0x0	RW
	1	int1_fwm	FIFO Watermark interrupt mapped to INT1	0x0	RW
	2	int1_drdy	Data Ready interrupt mapped to INT1	0x0	RW
	4	int2_ffull	FIFO Full interrupt mapped to INT2	0x0	RW
	5	int2_fwm	FIFO Watermark interrupt mapped to INT2	0x0	RW
	6	int2_drdy	Data Ready interrupt mapped to INT2	0x0	RW

4.3.49. **Register (0x59) INIT_CTRL**

DESCRIPTION: Start initialization
RESET: 0x90
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x59		INIT_CTRL		0x90	
	7...0	init_ctrl	Start initialization	0x90	RW

4.3.50. **Register (0x5E) FEATURES_IN**

DESCRIPTION: Feature configuration read/write port
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x5E		FEATURES_IN		0x00	

	7...0	features_in	Feature configuration read/write data	0x0	RW
Address	Bit	Name	Description	Reset	Access
any_motion					
0x5E: 0x00		ANYMO_1	Any-motion detection general configuration flags - part 1	0x00AA	
	10...0	threshold	Slope threshold value for any-motion detection. Range is 0 to 1.5g. Default value is 0xAA = 124mg.	0xAA	RW
	11	enable	Enables the feature	0x0	RW
0x5E: 0x02		ANYMO_2	Any-motion detection general configuration flags - part 2	0xE005	
	12...0	duration	Defines the number of consecutive data points for which the threshold condition must be respected for interrupt assertion. It is expressed in 50 Hz samples (20 ms). Range is 0 to 163sec. Default value is 5=100ms.	0x5	RW
	13	x_en	Enables the feature on a per-axis basis	0x1	RW
	14	y_en	Enables the feature on a per-axis basis	0x1	RW
	15	z_en	Enables the feature on a per-axis basis	0x1	RW
high_g					
0x5E: 0x06		HI_G_1	The acceleration threshold above which the high_g motion is signaled.	0x0C00	
	14...0	threshold	The acceleration threshold above which the high_g motion is signaled15 bit, signed integer (valid values 0...32767) holding the threshold in 5.11 g format. Default is 3072 = 2.25 g. Range is 0 to 24g.	0xC00	RW
0x5E: 0x08		HI_G_2	Enable flags and hysteresis configuration	0x73E8	
	11...0	hysteresis	Hysteresis value for high_g feature. Range is 0 to 3g. Default value is 1000 = 0.74g.	0x3E8	RW
	12	en_x	Enables the feature on a per-axis basis	0x1	RW
	13	en_y	Enables the feature on a per-axis basis	0x1	RW
	14	en_z	Enables the feature on a per-axis basis	0x1	RW
	15	enable	Enables the feature	0x0	RW
0x5E: 0x0A		HI_G_3	Duration interval	0x0004	
	11...0	duration	12 bit signed character (valid values 0...4095) holding the duration in 200 Hz samples (5 ms) for which the threshold has to be exceeded; default value 4 = 20 msec. Range is 0 to 20sec.	0x4	RW
low_g					

0x5E: 0x0C		LO_G_1	The acceleration threshold below which the low_g motion is signaled.	0x0200	
	14...0	threshold	Threshold value for low-g feature. Range is 0 to 1.5g. Default value is 512 = 0.375g.	0x200	RW
0x5E: 0x0E		LO_G_2	Enable flag and hysteresis configuration	0x0100	
	11...0	hysteresis	Hysteresis value for low_g feature. Range is 0 to 0.75g. Default value is 256 = 0.187g.	0x100	RW
	12	enable	Enables the feature	0x0	RW
0x5E: 0x10		LO_G_3	Duration interval	0x0000	
	11...0	duration	Duration in 50 Hz samples (20 msec) for which the threshold has to be exceeded. Range is 0 to 82 sec. Default value is 0 = 0 ms.	0x0	RW
orientation					
0x5E: 0x12		ORIENT_1	Orientation general configuration flags	0x0A30	
	0	enable	Enables the feature	0x0	RW
	1	ud_en	Enables upside/down detection, if set to 1	0x0	RW
	3...2	mode	Sets the mode: symmetrical (values 0 or 3), high asymmetrical (value 1) or low asymmetrical (value 2).	0x0	RW
	5...4	blocking	Sets the blocking mode. If blocking is set, no Orientation interrupt will be triggered. Default value is 3 – the most restrictive blocking mode.	0x3	RW
	11...6	theta	Coded value of the threshold angle with horizontal used in Blocking modes; theta = 64 * (tan(angle)^2); default value is 40, equivalent to 38 degrees angle.	0x28	RW
0x5E: 0x14		ORIENT_2	Acceleration hysteresis	0x0080	
	10...0	hysteresis	Acceleration hysteresis for orientation detection. Default value is 128 = 0.09375g. Range is 0 to 1.5g.	0x80	RW
no_motion					
0x5E: 0x16		NOMO_1	No-motion detection general configuration flags - part 1	0x00AA	
	10...0	threshold	Slope threshold value for no-motion detection. Range is 0 to 1.5g. Default value is 0xAA = 124mg.	0xAA	RW
	11	enable	Enables the feature	0x0	RW
0x5E: 0x18		NOMO_2	No-motion detection general configuration flags - part 2	0xE005	

	12...0	duration	Defines the number of consecutive data points for which the threshold condition must be respected for interrupt assertion. It is expressed in 50 Hz samples (20 ms). Range is 0 to 163sec. Default value is 5=100ms.	0x5	RW
	13	x_en	Enables the feature on a per-axis basis	0x1	RW
	14	y_en	Enables the feature on a per-axis basis	0x1	RW
	15	z_en	Enables the feature on a per-axis basis	0x1	RW
general_settings					
0x5E: 0x1A		Reserved	Reserved	0x0000	
	15...0	Reserved	Reserved	0x0	R
0x5E: 0x1C		AXIS_REMAP_1	Describes axes remapping	0x0088	
	1...0	map_x_axis	Map the x axis to desired axis **Value Name Description** 0x00 x_axis Map to x-axis 0x01 y_axis Map to y-axis 0x02 z_axis Map to z-axis 0x03 reserved Map to x-axis	0x0	RW
	2	map_x_axis_sign	Map the x axis sign to the desired one **Value Name Description** 0x00 not_invert Clear this bit to not invert the x axis 0x01 inverted Set this bit to invert the x axis	0x0	RW
	4...3	map_y_axis	Map the y axis to desired axis **Value Name Description** 0x00 x_axis Map to x-axis 0x01 y_axis Map to y-axis 0x02 z_axis Map to z-axis 0x03 reserved Map to y-axis	0x1	RW
	5	map_y_axis_sign	Map the y axis sign to the desired one **Value Name Description** 0x00 not_invert Clear this bit to not invert the y axis 0x01 inverted Set this bit to invert the y axis	0x0	RW
	7...6	map_z_axis	Map the z axis to desired axis **Value Name Description** 0x00 x_axis Map to x-axis 0x01 y_axis Map to y-axis 0x02 z_axis Map to z-axis 0x03 reserved Map to z-axis	0x2	RW
	8	map_z_axis_sign	Map the z axis sign to the desired one **Value Name Description**	0x0	RW

			0x00 not_invert Clear this bit to not invert the z axis 0x01 inverted Set this bit to invert the z axis		

4.3.51. **Register (0x5F) INTERNAL_ERROR**

DESCRIPTION: Internal error flags.
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x5F		INTERNAL_ERROR		0x00	
	1	int_err_1	Internal error flag - long processing time, processing halted	0x0	R
	2	int_err_2	Internal error flag - fatal error, processing halted	0x0	R

4.3.52. **Register (0x6A) NVM_CONF**

DESCRIPTION: NVM controller mode (Prog/Erase or Read only)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x6A		NVM_CONF		0x00	
	1	nvm_prog_en	Enable NVM programming **Value** **Name** **Description** 0x00 disable disable 0x01 enable enable	0x0	RW

4.3.53. **Register (0x6B) IF_CONF**

DESCRIPTION: Serial interface settings
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x6B		IF_CONF		0x00	
	0	spi3	Configure SPI Interface Mode for primary interface **Value** **Name** **Description** 0x00 spi4 SPI 4-wire mode 0x01 spi3 SPI 3-wire mode	0x0	RW
	4	if_mode	Auxiliary interface configuration **Value** **Name** **Description** 0x00 p_auto_s_off Auxiliary interface:off	0x0	RW

			0x01 p_auto_s_mag Auxilary interface:Magnetometer		

4.3.54. **Register (0x6D) ACC_SELF_TEST**

DESCRIPTION: Settings for the sensor self-test configuration and trigger
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x6D		ACC_SELF_TEST		0x00	
	0	acc_self_test_en	Enable accelerometer self-test **Value Name Description** 0x00 disabled disabled 0x01 enabled enabled	0x0	RW
	2	acc_self_test_sign	select sign of self-test excitation as **Value Name Description** 0x00 negative negative 0x01 positive positive	0x0	RW
	3	acc_self_test_amp	select amplitude of the selftest deflection: **Value Name Description** 0x00 low low 0x01 high high	0x0	RW

4.3.55. **Register (0x70) NV_CONF**

DESCRIPTION: NVM backed configuration bits.
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x70		NV_CONF		0x00	
	0	spi_en	disable the I2C and enable SPI for the primary interface, when it is in autoconfig mode **Value Name Description** 0x00 disabled I2C enabled 0x01 enabled I2C disabled	0x0	RW
	1	i2c_wdt_sel	Select timer period for I2C Watchdog **Value Name Description** 0x00 wdt_short I2C watchdog timeout after 1.25 ms 0x01 wdt_long I2C watchdog timeout after 40 ms	0x0	RW
	2	i2c_wdt_en	I2C Watchdog at the SDI pin in I2C interface mode **Value Name Description** 0x00 Disable Disable I2C watchdog 0x01 Enable Enable I2C watchdog	0x0	RW

	3	acc_off_en	Add the offset defined in the off_acc_[xyz] OFFSET register to filtered and unfiltered Accelerometer data **Value** **Name** **Description** 0x00 disabled Disabled 0x01 enabled Enabled	0x0	RW

4.3.56. Register (0x71) OFFSET_0

DESCRIPTION: Offset compensation for Accelerometer X-axis (NVM backed)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x71		OFFSET_0		0x00	
	7...0	off_acc_x	Accelerometer offset compensation (X-axis).	0x0	RW

4.3.57. Register (0x72) OFFSET_1

DESCRIPTION: Offset compensation for Accelerometer Y-axis (NVM backed)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x72		OFFSET_1		0x00	
	7...0	off_acc_y	Accelerometer offset compensation (Y-axis).	0x0	RW

4.3.58. Register (0x73) OFFSET_2

DESCRIPTION: Offset compensation for Accelerometer Z-axis (NVM backed)
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x73		OFFSET_2		0x00	
	7...0	off_acc_z	Accelerometer offset compensation (Z-axis).	0x0	RW

4.3.59. Register (0x7C) ACC_PWR_CONF

DESCRIPTION: Power mode configuration register
RESET: 0x03
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x7C		ACC_PWR_CONF	Suspend Mode	0x3	RW
	7..0	pwr_save_mode	**Value** **Name** **Description** 0x00 aps_off advanced power save disabled (fast clk always enabled). 0x01 aps_on advanced power mode enabled (slow clk is active when no	0x1	RW

			measurement is ongoing.)		

4.3.60. **Register (0x7D) ACC_PWR_CTRL**

DESCRIPTION: Sensor enable register
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x7D		ACC_PWR_CTRL		0x00	
	2	acc_en	**Value** **Name** **Description** 0x00 acc_off Disables the Accelerometer. 0x01 acc_on Enables the Accelerometer.	0x0	RW

4.3.61. **Register (0x7E) ACC_SOFTRESET**

DESCRIPTION: Command Register
RESET: 0x00
DEFINITION (Go to register map):

Address	Bit	Name	Description	Reset	Access
0x7E		ACC_SOFTRESET		0x00	
	7...0	softreset_cmd (0xb6)	Writing a value of 0xB6 to this register resets the sensor. Do not write any other content to this register. Following a delay of 1 ms, all configuration settings are overwritten with their reset value. The soft-reset can be triggered from any operation mode.	0x0	RW

4.4. Register map: gyroscope

read/write	read only	write only	reserved

Reg. Addr.	Register name	Reset value	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
0x3F	FIFO_DATA	N/A	fifo_data_output_register							
0x3E	FIFO_CONFIG_1	0x00	fifo_mode							
0x3D	FIFO_CONFIG_0	0x00		fifo_water_mark_level_trigger_retain						
0x3C	GYRO_SELF_TEST	N/A	-			rate_ok	-	bist_fail	bist_rdy	trig_bst
0x3B - 0x35: reserved										
0x34	FIFO_EXT_INT_S	0x00			ext_fifo_s_en	ext_fifo_s_sel				
0x33 - 0x1F: reserved										
0x1E	FIFO_WM_EN	0x00	fifo_watermark_enable							
0x1D - 0x19: reserved			-							
0x18	INT3_INT4_IO_MAP	0x00	Int4_data	-	Int4_fifo	-		Int3_fifo	-	Int3_data
0x17: reserved			-							
0x16	INT3_INT4_IO_CONF	0x0F	-				Int4_od	Int4_lvl	Int3_od	Int3_lvl
0x15	GYRO_INT_CTRL	0x00	data_en	fifo_en	-					
0x14	GYRO_SOFTRESET	N/A	softreset							
0x13 - 0x12: reserved			-							
0x11	GYRO_LPM1	0x00	gyro_pm							
0x10	GYRO_BANDWIDTH	0x80	gyro_bw							
0x0F	GYRO_RANGE	0x00	gyro_range							
0x0E	FIFO_STATUS	N/A	fifo_overrun	fifo_frame_counter						
0x0D - 0x0B: reserved			-							
0x0A	GYRO_INT_STAT_1	N/A	gyro_drdy	-		fifo_int	-			
0x09 - 0x08: reserved			-							
0x07	RATE_Z_MSB	N/A	rate_z[15:8]							
0x06	RATE_Z_LSB	N/A	rate_z[7:0]							
0x05	RATE_Y_MSB	N/A	rate_y[15:8]							
0x04	RATE_Y_LSB	N/A	rate_y[7:0]							
0x03	RATE_X_MSB	N/A	rate_x[15:8]							
0x02	RATE_X_LSB	N/A	rate_x[7:0]							
0x01	*Reserved*	N/A	-							
0x00	GYRO_CHIP_ID	0x0F	gyro_chip_id							

4.5. Register description: gyroscope

4.5.1. Register 0x00: GYRO_CHIP_ID

Bit	Access	Reset value	Description
[7:0]	RO	0x0F	Contains identifier code of gyroscope.

4.5.2. Register 0x02 – 0x07: Rate data

Registers containing the angular velocity sensor output. The sensor output is stored as signed 16-bit number in 2's complement format in each 2 registers. From the registers, the gyro values can be calculated as follows:

Rate_X: RATE_X_MSB * 256 + RATE_X_LSB
Rate_Y: RATE_Y_MSB * 256 + RATE_Y_LSB
Rate_Z: RATE_Z_MSB * 256 + RATE_Z_LSB

When a register is read containing the LSB value of a rate value, the corresponding MSB register is locked internally, until it is read. By this mechanism, it is ensured that both LSB and MSB values belong to the same rate range value and are not updated between the readouts of the individual registers.

The unit is in LSB. The conversion from LSB to angular velocity (degree per second) is based on the range settings (see 5.5.5). For example, for the default range setting of 0x00 in register 0x0F, the following conversion table applies:

Sensor output [LSB]	Angular rate (in 2000°/s range mode)
+32767	+ 2000°/s
…	…
0	0°/s
…	…
-32767	- 2000°/s

4.5.3. **Register 0x0A: GYRO_INT_STAT_1**

Bit	Name	Access	Reset value	Description
[7]	gyro_drdy	RO	N/A	Data ready interrupt status. The interrupt is cleared automatically after 280-400 µs.
[6:5]	*reserved*			
[4]	fifo_int	RO	N/A	FIFO interrupt status
[3:0]	*reserved*			

4.5.4. **Register 0x0E: FIFO_STATUS**

The register contains FIFO status information.

Bit	Name	Access	Reset value	Description
[7]	Fifo_overrun	RO	N/A	If set, FIFO overrun condition has occurred. Note: flag can only be cleared by writing to the FIFO configuration register FIFO_CONFIG_1
[6:0]	Fifo_frame_counter	RO	N/A	Current fill level of FIFO buffer. An empty FIFO corresponds to 0x00. The frame counter can be cleared by reading out all frames from the FIFO buffer or writing to the FIFO configuration register FIFO_CONFIG_1.

4.5.5. **Register 0x0F: GYRO_RANGE**

<table>
<tr><th>Bit</th><th>Access</th><th>Reset value</th><th colspan="3">Description</th></tr>
<tr><td rowspan="7">[7:0]</td><td rowspan="7">RW</td><td rowspan="7">0x00</td><td colspan="3">Angular rate range and resolution. Possible values:</td></tr>
<tr><th>gyro_range</th><th>Full scale [°/s]</th><th>Resolution</th></tr>
<tr><td>0x00</td><td>±2000</td><td>16.384 LSB/°/s ⇔ 61.0 m°/s / LSB</td></tr>
<tr><td>0x01</td><td>±1000</td><td>32.768 LSB/°/s ⇔ 30.5 m°/s / LSB</td></tr>
<tr><td>0x02</td><td>±500</td><td>65.536 LSB/°/s ⇔ 15.3 m°/s / LSB</td></tr>
<tr><td>0x03</td><td>±250</td><td>131.072 LSB/°/s ⇔ 7.6 m°/s / LSB</td></tr>
<tr><td>0x04</td><td>±125</td><td>262.144 LSB/°/s ⇔ 3.8m°/s / LSB</td></tr>
</table>

4.5.6. Register 0x10: GYRO_BANDWIDTH

<table>
<tr><th>Bit</th><th>Access</th><th>Reset value</th><th>Description</th></tr>
<tr><td>[7:0]</td><td>RW</td><td>0x80[1]</td><td>The register allows the selection of the rate data filter bandwidth and output data rate (ODR). Possible values:
<table>
<tr><th>gyro_bw</th><th>ODR [Hz]</th><th>Filter bandwidth [Hz]</th></tr>
<tr><td>0x00</td><td>2000</td><td>532</td></tr>
<tr><td>0x01</td><td>2000</td><td>230</td></tr>
<tr><td>0x02</td><td>1000</td><td>116</td></tr>
<tr><td>0x03</td><td>400</td><td>47</td></tr>
<tr><td>0x04</td><td>200</td><td>23</td></tr>
<tr><td>0x05</td><td>100</td><td>12</td></tr>
<tr><td>0x06</td><td>200</td><td>64</td></tr>
<tr><td>0x07</td><td>100</td><td>32</td></tr>
</table></td></tr>
</table>

4.5.7. Register 0x11: GYRO_LPM1

Selection of the main power modes. Please note that only switching between normal mode and the suspend modes is allowed, it is not possible to switch between suspend and deep suspend and vice versa.

<table>
<tr><th>Bit</th><th>Access</th><th>Reset value</th><th>Description</th></tr>
<tr><td>[7:0]</td><td>RW</td><td>0x00</td><td>Switch to the main power modes.
<table>
<tr><th>gyro_pm</th><th>Power mode</th></tr>
<tr><td>0x00</td><td>normal</td></tr>
<tr><td>0x80</td><td>suspend</td></tr>
<tr><td>0x20</td><td>deep suspend</td></tr>
</table></td></tr>
</table>

4.5.8. Register 0x14: GYRO_SOFTRESET

Bit	Access	Reset value	Description
[7:0]	W	N/A	Writing a value of **0xB6** to this register resets the sensor. (Other values are ignored.) Following a delay of 30 ms, all configuration settings are overwritten with their reset value. The soft reset can be triggered from any operation mode.

[1] Note: bit #7 is read-only and always ‚1‘, but has no function and can safely be ignored.

4.5.9. Register 0x15: GYRO_INT_CTRL

Bit	Access	Reset value	Description
[7]	RW	0x0	Enables the new data interrupt to be triggered on new data.
[6]	RW	0x0	Enables the FIFO interrupt.
[5:0]	*reserved*		

4.5.10. Register 0x16: INT3_INT4_IO_CONF

Sets electrical and logical properties of the interrupt pins.

<table>
<tr><th>Bit</th><th>Name</th><th>Access</th><th>Reset value</th><th>Description</th></tr>
<tr><td>[3]</td><td>Int4_od</td><td>RW</td><td>‘1’</td><td><table><tr><th>Int4_od</th><th>Pin INT4 output configuration</th></tr><tr><td>‘0’</td><td>Push-pull</td></tr><tr><td>‘1’</td><td>Open-drain</td></tr></table></td></tr>
<tr><td>[2]</td><td>Int4_lvl</td><td>RW</td><td>‘1’</td><td><table><tr><th>Int4_lvl</th><th>Pin INT4 active state</th></tr><tr><td>‘0’</td><td>Active low</td></tr><tr><td>‘1’</td><td>Active high</td></tr></table></td></tr>
<tr><td>[1]</td><td>Int3_od</td><td>RW</td><td>‘1’</td><td><table><tr><th>Int3_od</th><th>Pin INT3 output configuration</th></tr><tr><td>‘0’</td><td>Push-pull</td></tr><tr><td>‘1’</td><td>Open-drain</td></tr></table></td></tr>
<tr><td>[0]</td><td>Int3_lvl</td><td>RW</td><td>‘1’</td><td><table><tr><th>Int3_lvl</th><th>Pin INT3 active state</th></tr><tr><td>‘0’</td><td>Active low</td></tr><tr><td>‘1’</td><td>Active high</td></tr></table></td></tr>
</table>

4.5.11. Register 0x18: INT3_INT4_IO_MAP

Map the data ready interrupt pin to one of the interrupt pins INT3 and/or INT4.

Bit	Access	Reset value	Description
[7]	RW	0x0	Data ready interrupt is mapped to INT4 pin.
[6]	*reserved*		
[5]	RW	0x0	FIFO interrupt is mapped to INT4.
[4:3]	*reserved*		
[2]	RW	0x0	FIFO interrupt is mapped to INT3.
[1]	*reserved*		
[0]	RW	0x0	Data ready interrupt is mapped to INT3 pin.

4.5.12. Register 0x1E: FIFO_WM_ENABLE

Enables FIFO watermark level interrupt.

<table>
<tr><th>Bit</th><th>Access</th><th>Reset value</th><th>Description</th></tr>
<tr><td>[7:0]</td><td>RW</td><td>0x08</td><td><table><tr><th>Value</th><th>Description</th></tr><tr><td>0x08</td><td>FIFO watermark level interrupt disabled</td></tr><tr><td>0x88</td><td>FIFO watermark level interrupt enabled</td></tr></table></td></tr>
</table>

4.5.13. Register 0x34: FIFO_EXT_INT_S

<table>
<tr><th>Bit</th><th>Access</th><th>Reset value</th><th>Description</th></tr>
<tr><td>[7:6]</td><td colspan="3">reserved</td></tr>
<tr><td>[5]</td><td>RW</td><td>0x00</td><td>If set, enables external FIFO synchronization mode</td></tr>
<tr><td>[4]</td><td>RW</td><td>0x00</td><td>Selects source for external FIFO synchronization<table><tr><th>ext_fifo_s_sel</th><th>Behavior</th></tr><tr><td>0x0</td><td>Source is pin INT3</td></tr><tr><td>0x1</td><td>Source is pin INT4</td></tr></table></td></tr>
<tr><td>[3:0]</td><td colspan="3">reserved</td></tr>
</table>

4.5.14. Register 0x3C: GYRO_SELF_TEST

Built-in self-test of gyroscope.

Bit	Access	Name	Reset value	Description
[4]	R	rate_ok	‘0’	A value of ‘1’ indicates proper sensor function.
[2]	R	bist_fail	‘0’	If ‘0’ and bist_rdy = ‘1’: built-in self-test is ok, sensor is ok If ‘1’ and bist_rdy = ‘1’: built-in self-test is not ok, sensor values may not be in expected range
[1]	R	bist_rdy	‘0’	If bit is ‘1’, built-in self-test has been performed and finished
[0]	W	trig_bist	N/A	Setting this bit to ‘1’ (i.e. writing 0x01 to this register) starts the built-in self-test.

4.5.15. **Register 0x3D: GYR_FIFO_CONFIG_0**

Bit	Access	Reset value	Description
[7]	*Reserved*		
[6:0]	RW	0x00	fifo_water_mark_level_trigger_retain<6:0> defines the FIFO watermark level. An interrupt will be generated, when the number of entries in the FIFO exceeds fifo_water_mark_level_trigger_retain<6:0>. Writing to this register clears the FIFO buffer.

4.5.16. **Register 0x3E: GYR_FIFO_CONFIG_1**

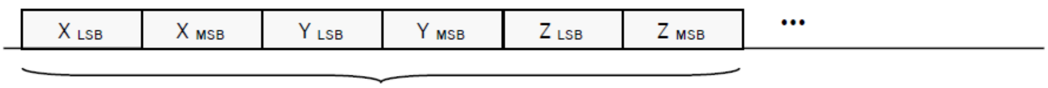
Contains FIFO configuration settings. The FIFO buffer memory is cleared and the fifo-full flag is cleared when writing to FIFO_CONFIG_1 register. In addition, the FIFO overrun flag (see the respective register) is cleared (it overrun occurred before).

<table>
<tr><th>Bit</th><th>Access</th><th>Reset value</th><th>Description</th></tr>
<tr><td>[7:0]</td><td>RW</td><td>0x08</td><td>
<table>
<tr><th>fifo_ mode</th><th>mode</th><th>description</th></tr>
<tr><td>0x40</td><td>FIFO</td><td>data collection stops once buffer is full (i.e. filled with 100 frames)</td></tr>
<tr><td>0x80</td><td>STREAM</td><td>sampling continues when buffer is full (i.e. filled with 99 frames); old is discarded</td></tr>
<tr><td>else</td><td colspan="2">reserved</td></tr>
</table>
</td></tr>
</table>

4.5.17. **Register 0x3F: FIFO_DATA**

FIFO data readout register. The format of the LSB and MSB components corresponds to that of the angular rate data readout registers. Read burst access may be used since the address counter will not increment when the read burst is started at the address of FIFO_DATA. The entire frame is discarded when a fame is only partially read out.

The format of the data read-out from register 0x3F is as follows:



Frame 1 (= 6 Bytes)

4. Document history and modification

Rev. No	Chapter	Description of modification/changes	Date
0.1		Document creation	April 2022
0.2	3	Included Low power mode	November 2022

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