Hearables Feature Set
Application Note

Application Note – Hearables Feature Set

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1. Hearables Feature set

This application note describes the hearable features for BMA456. The hearable firmware image supports the following features: Any-motion, No-motion, Step counter, Auto low power and Multi-tap detection.
For complete details regarding BMA456 specifications (e.g. pin-out, power modes, 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/accelerometers/bma456.html
https://github.com/BoschSensortec.

1.1. Interrupt Features

Global Configuration

The configuration of the interrupt feature engine 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 single bytes 0x00 to 0x3F described in FEATURES_IN.

Make sure sensor has been initialized properly before the feature configuration is performed (see description in chapter 1.)

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

Feature	Output Status
tap detection	INT_STATUS_0.tap_out
step detector / step counter	INT_STATUS_0.step_counter_out
activity recognition	INT_STATUS_0.activity_type_out
any-motion	INT_STATUS_0.any_motion_out
no-motion	INT_STATUS_0.no_motion_out
error interrupt	INT_STATUS_0.error_int_out

Table 1: Interrupt status register overview

Additionally, the step counter numeric value is stored in the registers: STEP_COUNTER_0, STEP_COUNTER_1, STEP_COUNTER_2 and STEP_COUNTER_3.

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 to run the sensor again properly.

The BMA456 supports features processing in both power modes: high performance and low power. In addition BMA456 supports automated power modes conditional power mode switching. The features have as input data the acceleration samples, which between 50Hz and 200Hz in low power mode.

Minimum Bandwidth Settings
If performance mode is enabled (ACC_CONF.acc_perf_mode is 0b1, so continuous mode is used), then the features are functioning correctly, regardless to the ODR and the Bandwidth that the Host would set.
If Performance Mode is disabled (ACC_CONF.acc_perf_mode is 0b0) (device in non-continuous mode), then the minimum ODR setting must comply with the following restrictions:

- The ODR must be set to minimum 50 Hz for the most features except tap detection feature
- The ODR must be set to minimum 200 Hz for the use of single/double/triple tap detection

If the minimum requirements are not met, the corresponding error flag from the register INTERNAL_STATUS is set.

Axes remapping for interrupt features

If the sensor orientation, when integrated into the customer devices, is different from described in chapter 'sensing axis orientation', the sensor axis/axes must be remapped to use the integrated features properly.
Axes 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 be also configured. For example x axis can be mapped to –x axis, +y axis, - y axis, +z axis or –z axis. Similarly other axes also have its own combination.

Note:
The axis remapping does apply only to the data fetched into the features. The DATA_0 to DATA_13 registers are not affected and should be accordingly remapped on the driver level if needed.

Configuration settings:

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

1.2. General Interrupt Pin configuration

Electrical Interrupt Pin Behavior

Both interrupt pins INT1 and INT2 can be configured to show the desired electrical behavior.
Interrupt pins can be enabled in INT1_IO_CTRL.output_en respectively INT2_IO_CTRL.output_en.
The characteristic of the output driver of the interrupt pins may be configured with bits INT1_IO_CTRL.od and INT2_IO_CTRL.od. By setting these bits to 0b1, the output driver shows open-drive characteristic, by setting the configuration bits to 0b0, the output driver shows push-pull characteristic.
The electrical behavior of the Interrupt pins, whenever an interrupt is triggered, can be configured as either “active-high” or “active-low” via INT1_IO_CTRL.lvl respectively INT2_IO_CTRL.lvl.

Both interrupt pins can be configured as input pins via INT1_IO_CTRL.input_en respectively INT2_IO_CTRL.input_en. BMA supports edge and level triggered interrupt inputs, this can be configured through INT1_IO_CTRL.edge_ctrl respectively INT2_IO_CTRL.edge_ctrl.

BMA supports non-latched and latched interrupts modes for data-ready, the configuration can be performed by setting the INT_LATCH.int_latch register. The feature interrupts described in chapter 1.1 support only latched mode described below.
In latched mode an asserted interrupt status in INT_STATUS_0 or INT_STATUS_1 and the selected pin are cleared if the corresponding status register is read. If more than one interrupt pin is used in latched mode, all interrupts in INT_STATUS_0 should be mapped to one pin and all interrupts in INT_STATUS_1 should be mapped to the other pin. If just one interrupt pin is used all interrupts may be mapped to this pin. If the activation condition still holds when it is cleared, the interrupt status is asserted again when the interrupt condition holds again.
In the non-latched mode (only for data-ready) the interrupt status bit and the selected pin are reset as soon as the activation condition is not valid anymore.

Interrupt Pin Mapping

In order, for the Host to react to the features output, they can be mapped to the external pin INT1 or pin INT2, by setting the corresponding bits from the registers INT1_MAP, respectively INT2_MAP.
To disconnect the features outputs to the external pins, the same corresponding bits must be reset, from the registers, INT1_MAP, respectively INT2_MAP.

Once a feature triggered the output pin, the Host can read out the corresponding bit from the register, INT_STATUS_0 (Feature Interrupts) or INT_STATUS_1 (data ready).

2. Hearable Features

2.1. Any-motion detection

The any-motion detection uses the slope between two acceleration signals to detect changes in motion. The interrupt is configured by setting at least one of the following flags FEAT_EN_1.any_x_en, FEAT_EN_1.any_y_en, FEAT_EN_1.any_z_en, respectively for each axis.
It generates an interrupt when the absolute value of the slope (the difference between two accelerations) exceeds the preset FEATURES_IN.any_motion.settings_1.threshold for a certain number, FEATURES_IN.any_motion.settings_2.duration, of consecutive data points. If the same number of data points falls below the FEATURES_IN.any_motion.setings_1.threshold, the interrupt is reset.

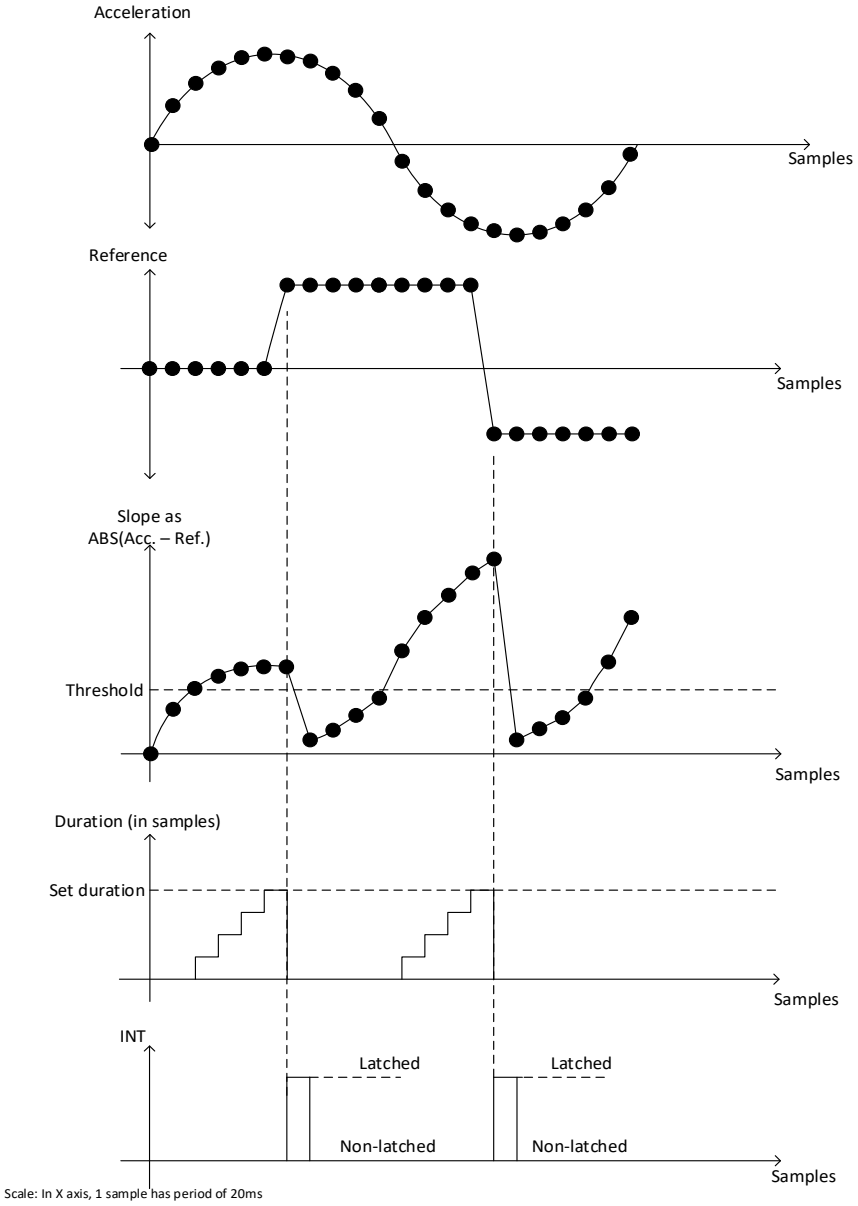

Figure 1: Signal and timing diagram for any motion Interrupt detection

Configuration settings

- FEATURES_IN.any_motion.settings_1.threshold – the slope threshold.
- FEATURES_IN.any_motion.settings_2.duration – the number of consecutive data points for which the threshold condition must be respected, for interrupt assertion.
- FEAT_EN_1.any_x_en – indicates if this feature is enabled for x axis
- FEAT_EN_1.any_y_en – indicates if this feature is enabled for y axis
- FEAT_EN_1.any_z_en –indicates if this feature is enabled for z axis

When FEATURES_IN.any_motion.settings_1.slope is set to 0b0, the slope (difference) is being computed between the current acceleration sample and the reference sample. The reference sample is updated while the any-motion is detected; basically this means the reference is the last state when sensor detected any-motion. When FEATURES_IN.any_motion.settings_1.slope is set to 0b1, the slope (difference) is being computed between the current acceleration sample and the previous acceleration sample.
If FEATURES_IN.any_motion.settings_1.int_bhvr is set to 0b0, multiple interrupt will be triggered as long as the any motion condition is valid. If FEATURES_IN.any_motion.settings_1.int_bhvr is set to 0b1, single interrupt will be triggered when the any motion condition is valid.
Register FEATURES_IN.any_motion.settings_2.duration defines the number of consecutive slope data points of the selected axis which must exceed the threshold for an interrupt to be asserted.

2.2. **No-motion detection**

No-motion interrupt is generated when the slope on all selected axis remains smaller than a programmable FEATURES_IN.no_motion.settings_1.threshold for a programmable time. The interrupt is configured by setting at least one of the following flags: FEAT_EN_1.nomo_x_en, FEAT_EN_1.nomo_y_en and FEAT_EN_1.nomo_z_en, respectively for each axis.

The signals and timings relevant to the no-motion interrupt functionality are depicted in the figure below.

Configuration settings

- FEATURES_IN.no_motion.settings_1.threshold – the slope threshold.
- FEATURES_IN.no_motion.settings_2.duration – the number of consecutive data points for which the threshold condition must be respected, for interrupt assertion.
- FEAT_EN_1.nomo_x_en – indicates if this feature is enabled for x axis
- FEAT_EN_1.nomo_y_en – indicates if this feature is enabled for y axis
- FEAT_EN_1.nomo_z_en – indicates if this feature is enabled for z axis

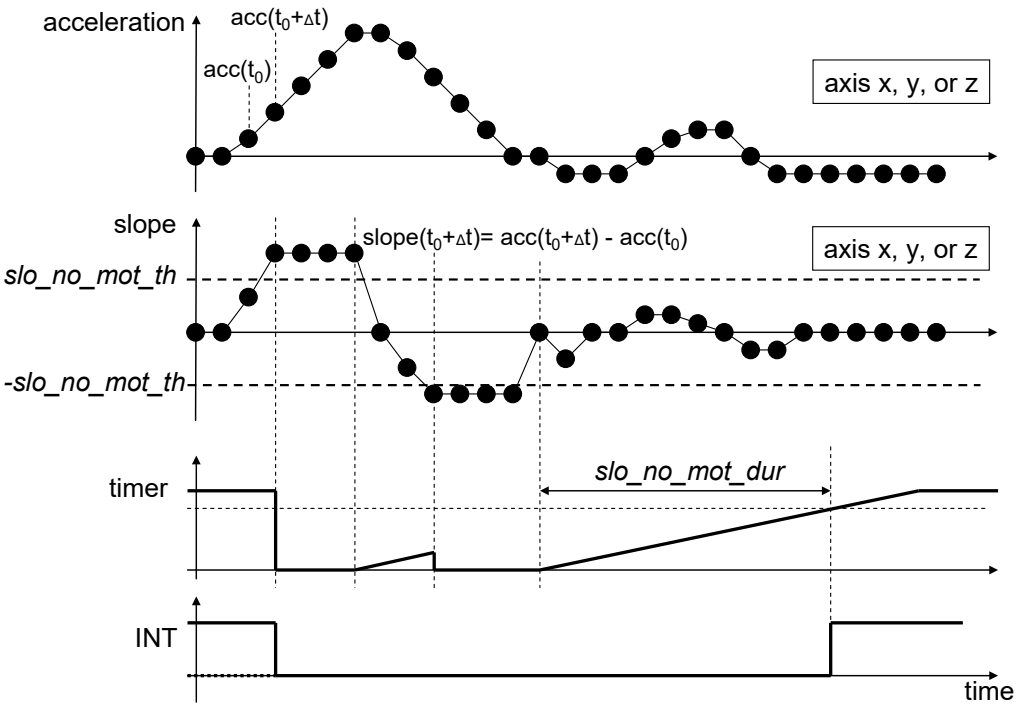

Figure 1: Signal timings no-motion interrupt

The register FEATURES_IN.no_motion.settings_2.duration defines the number of consecutive slope data points of the selected axis which must not exceed the threshold for an interrupt to be asserted. FEATURES_IN.no_motion.settings_1.int_bhvr selects the behaviour of no-motion interrupt. If FEATURES_IN.no_motion.settings_1.int_bhvr is set to 0b0, multiple interrupt will be triggered as long as the no motion condition is valid. If FEATURES_IN.no_motion.settings_1.int_bhvr is set to 0b1, single interrupt will be triggered for a valid condition.

2.3. **Step counter, step detector and activity recognition**

The step counter algorithm is optimized on high accuracy, while step detector is optimized on low latency. Both are running in parallel, once enabled, but the step detector interrupt output is mutually exclusive with the step counter watermark interrupt. The step counter is optimized for hearable devices and for head mounted use case.
The step counter implements the function required for step counting in Android 4.4 and higher: https://source.android.com/devices/sensors/sensor-types.html#step_counter. The step detector implements the function required for step detecting in Android 4.4 and higher: https://source.android.com/devices/sensors/sensor-types.html#step_detector.

Step Detector

If FEATURES_IN.step_counter.settings_1.en_detector is set, an interrupt is triggered for every step detected. So, every time a new step is detected, it asserts the corresponding interrupt output INT_STATUS_0.step_counter_out. In this case, the step detector feature is optimized on low latency, so when a step is detected, it is immediately reported. Due to this functionality, there are situations when sum of the detected steps is different from the step counting value.

Step Counter

The step counter accumulates the steps detected by the step detector interrupt, and makes available the 32-bit current step counter value in the following four registers, each holding 8-bit: STEP_COUNTER_0, STEP_COUNTER_1, STEP_COUNTER_2 and corresponding, STEP_COUNTER_3. By enabling the FEATURES_IN.step_counter.settings_1.reset_counter flag, the accumulated step number value is reset. Afterwards, the value of this flag is automatically reset and counting is restarted.

The step counter watermark option can be useful if host needs to receive an interrupt every time a certain number of steps were counter, in other words, the step counter is selected. If FEATURES_IN.step_counter.settings_26.watermark_level is set to 10 (holding an implicit factor of 20x), every 200 steps are counted an interrupt will be raised on INT_STATUS_0.step_counter_out. As the steps are buffered internally, the output may be triggered between 200-210 steps. The exact number of steps recorded is available in the registers STEP_COUNTER_0, STEP_COUNTER_1, STEP_COUNTER_2 and STEP_COUNTER_3. When the watermark level was reached, the corresponding interrupt bit is asserted.

The configuration parameters for step counter are stored in the registers FEATURE_IN.step_counter.settings_1.param_1 to FEATURE_IN.step_counter.settings_25.param_25.

Customized step counter sensitivity configuration

The step counter and detector sensitivity can be modified manually by setting the step counter parameters in the register map with the support of the corresponding field application engineer.

Configuration settings

- FEATURES_IN.step_counter.settings_26.watermark_level – watermark level; the step counter will trigger output every time this number of steps are counted. Holds implicitly a 20x factor, so the range is 0 to 20460, with resolution of 20 steps. If 0, the Step counter watermark is disabled. Also if step detector is enabled, the watermark interrupt is disabled (as being mutually exclusive).
- FEATURES_IN.step_counter.settings_26.reset_counter – flag to reset the counted steps. This is only interpreted if the step counter is enabled.
- FEAT_EN_2.sc_en – enables step counter
- FEAT_EN_2.sd_en – enables step detector
- FEAT_EN_2.act_en – enables activity detection

- FEATUREs_IN.step_counter.settings_1.param_1 to FEATUREs_IN.step_counter.settings_1.param_25 - step counter configuration parameters. Those parameters will be initialized for hearables configuration by host.

Walking activity recognition

This feature can detect the actual walking activity status of a user. It can distinguish between walking, running and still. The change of the status can be read in INT_STATUS_0.activity_type_out, which will be set everytime the activity status changes; the status itself can be read in FEAT_OUT.activity_type_out. The walking activity recognition can be enabled by FEAT_EN_2.act_en.

Configuration settings:
FEAT_EN_2.act_en – enables walking activity recognition.

2.4. **Auto low power**

Auto low power feature is used for the advanced power saving operation of the sensor. The power modes of the sensor are switched automatically on the no-motion and any-motion conditions. The auto low power feature is enabled by setting bit FEAT_EN_2.alp_en to 0b1. Set FEAT_EN_2.alp_en to 0b0, disables auto low power feature, where power consumption of the sensor is not automatically controlled.
In case auto low power feature is enabled, the sensor operates in two power modes:

- auto sleep mode (power consumption of the sensor typ. <10uA)
- auto wake mode (power consumption of the sensor typ. <60uA, depends on the enabled features)

Auto sleep mode

Auto sleep mode is lowest current consumption power mode at which the acceleration measurement and feature processing is active. In auto sleep mode only any-motion and no-motion features can be processed. The any-motion and no-motion features must be enabled in the FEAT_EN_1 register.
In auto low power mode the acceleration measurement data rate can be configured by setting FEATURES_IN.auto_low_power.settings.lp_odr. The data rates in auto low power can be selected from 1.5625Hz to 12.5Hz. The any-motion condition is used to put the sensor auto sleep mode into auto wake mode.

Auto wake mode

In auto wake mode all enabled features are processed (e.g. any-motion, no-motion and tap detection) and sensor is operated in the low power mode according to settings in ACC_CONF. The features must be enabled in FEAT_EN_1 and FEAT_EN_2 registers.

FEATURES_IN.auto_low_power.settings.pwr_mgt can be used for auto-configuration of the sensor settings required for feature processing ACC_CONF. If FEATURES_IN.auto_low_power.settings.pwr_mgt is set to 0b0, ACC_CONF is not automatically optimized based on feature set, host need to configure the sensor properly. If FEATURES_IN.auto_low_power.settings.pwr_mgt is set to 0b1, ACC_CONF is automatically optimized based on the enabled feature set. In automated mode (pwr_mgt = 1) following data rates are used:

- 50Hz data rate is used for processing of any-motion, no-motion detection features
- 200Hz data rate is used if tap detection feature is active

Mode transition happens from auto wake mode to auto sleep mode, either when no-motion is detected (and / or) any motion is not detected for specific duration.
If FEATURES_IN.auto_low_power.settings.no_motion bit is set to 0b1, no motion is used as a condition to enter to auto sleep mode.
If FEATURES_IN.auto_low_power.settings.time_out is set to 0b1, any motion should not be detected for specific duration as mentioned in FEATURES_IN.auto_low_power.settings.time_out_duration is used as a condition to enter to auto sleep mode.

Configuration settings

- FEAT_EN_2.alp_en – enables the feature.
- FEATURES_IN.auto_low_power.settings.no_motion – enter auto sleep mode, when no-motion interrupt condition is detected.
- FEATURES_IN.auto_low_power.settings.time_out – enter to auto sleep, when any motion is not detected for time_out_dur period.
- FEATURES_IN.auto_low_power.settings.time_out_dur – duration to enter to auto sleep, when any motion event is not detected.
- FEATURES_IN.auto_low_power.settings.lp_odr – data rate configuration for auto sleep mode.
- FEATURES_IN.auto_low_power.settings.pwr_mgt – power management.

Notes:

- host shall not change the ACC_CONF when FEAT_EN_2.alp_en is set to 0b1.
- In case of no-Motion being set as condition for auto wake to auto sleep (FEATURES_IN.auto_low_power.settings.no_motion), the no-motion feature must be enabled in FEAT_EN_1 register. Failure to enable the no-motion feature will lead to no transition from auto wake to auto sleep mode

2.5. **Multi-tap detection**

Tap gestures are generally used for user interaction with the device. Especially, in the small form factor devices without display or not directly observable by user such as hearables, tap detection can be used natural way to control the device. In addition, integrated tap detection feature allows to save significantly power consumption of the system / device by using low power integrated tap sensing feature.

The multi-tap detection feature supports detection of the single tap, double tap and triple tap gesture event. The timings diagram of the acceleration signals and according tap detection parameters are shown in the figure below.

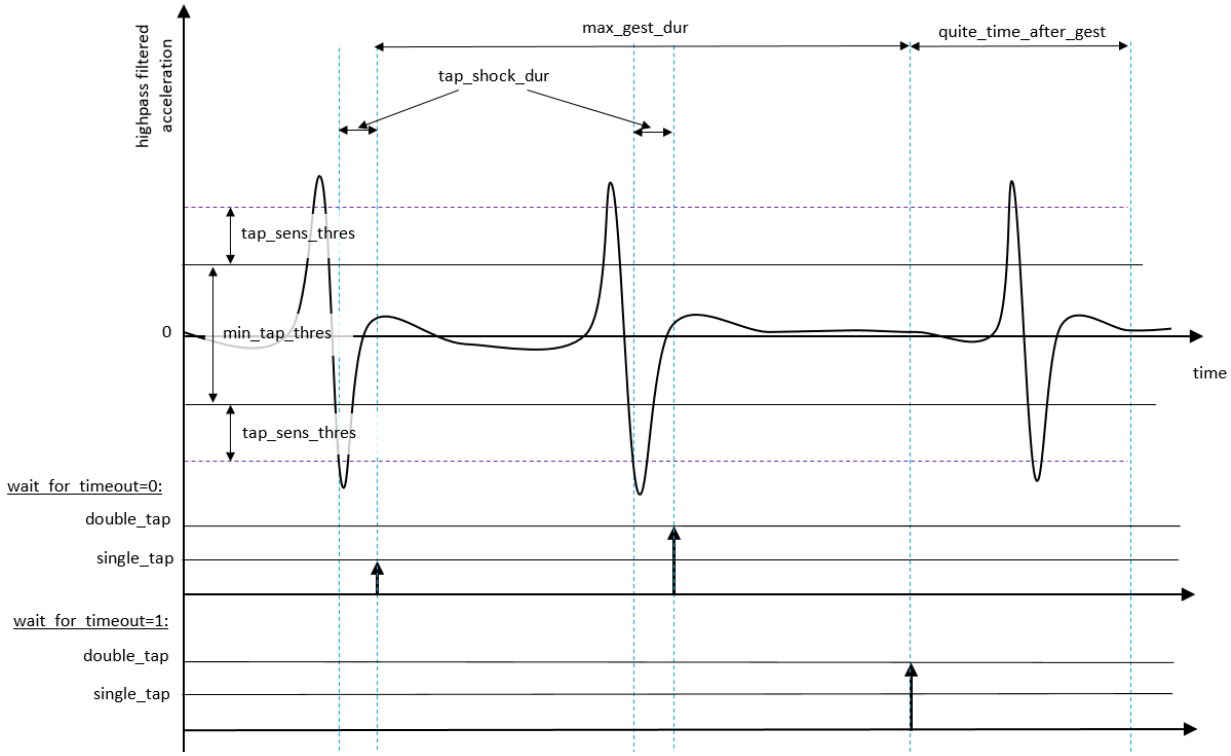

Figure 2: Timing diagram of the multi-tap detection feature (as an example of double tap)

The multi-tap detection feature supports only detection of taps along one of the sensing axis of the accelerometer. The axis of tap-detection can be selected using the FEATURES_IN.tap_detector.settings_10.axis_sel configuration parameter. In case the device coordinate system and the sensor coordinate system are different, the required axis remapping needs to be configured (see chapter axis-remapping).

The tap detection feature evaluates continuously the acceleration signals, especially the timings of the tap events. After the first-tap has been detected, the next tap should be performed within the configurable time duration set by FEATURES_IN.tap_detector.settings_3.max_gest_dur. Once the tap interrupt is triggered, the corresponding status bits FEAT_OUT.s_tap, FEAT_OUT.d_tap and FEAT_OUT.t_tap shall be read from register.

Configuration settings

- FEAT_EN_2.s_tap_en – Enable the detection of single-tap gesture
- FEAT_EN_2.d_tap_en – Enable the detection of double-tap gesture
- FEAT_EN_2.t_tap_en – Enable the detection of triple-tap gesture
- FEATURES_IN.tap_detector.settings_2.tap_sens_thres - scaling factor of additional threshold increment for detection of positive and negative peak of a tap. Default value = 9, Recommended

range = 0 to 15. Resolution of each LSB of scaling factor in terms of filtered acceleration signal magnitude is 78.125 mg.

- FEATURES_IN.tap_detector.settings_3.max_gest_dur - maximum duration after the first tap within which the second and/or third tap have to be performed for being detected as double-tap or triple-tap. Default value = 130 (650 ms), Resolution = 5 ms, Recommended range = 250 to 1000 ms.
- FEATURES_IN.tap_detector.settings_5.tap_shock_dur - settling time of high frequency acceleration signal components after tap. Default value = 6 (30 ms), Resolution = 5 ms, Recommended range = 20 to 100 ms.
- FEATURES_IN.tap_detector.settings_7.quite_time_after_gest - minimum quite time between the two gesture detection. Default value = 80 (400 ms), Resolution = 5 ms, Recommended range = 250 to 500 ms.
- FEATURES_IN.tap_detector.settings_8.wait_for_timeout - wait for the duration set by FEATURES_IN.tap_detector.settings_3.max_gest_dur after the first tap and report the tap-gesture based on number of taps detected. Default value = 0 (disabled). Allowed values = 0 / 1 (disabled / enabled).
- FEATURES_IN.tap_detector.settings_2.tap_sens_thres.
- FEATURES_IN.tap_detector.settings_10.axis_sel - selection of axis from 3D-acceleration signal vector for tap detection. Default value = 2 (z-axis). Other supported values 0 (x-axis) and 1 (y-axis). Any other selection leads to usage of default value.

Known limitations:

- Single tap can be sensitive to touch, pick-up and knock gestures due to similarity of the acceleration signals.

3. Register Description

3.1. General Remarks

All registers with the exception of FEATURES_IN can be read and written in all power configurations. In order to read or write to/from FEATURES_IN registers, the power saving mode need to be disabled (PWR_CONF.adv_power_save set to 0b0).

3.2. Register Map

read/write	read only	write only	reserved

Corresponding to BMA456H_hearable.tbin version 1.8, register map version 1.7

Register Address	Register Name	Default Value	7	6	5	4	3	2	1	0
0x7E	CMD	0x00	cmd							
0x7D	PWR_CTRL	0x00	reserved					acc_en	reserved	aux_en
0x7C	PWR_CONF	0x03	reserved						fifo_self_wakeup	adv_power_save
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	any_motion_out	reserved	activity_type_out	step_counter_out	tap_out
0x56	INT1_MAP	0x00	error_int_out	reserved	no_motion_out	any_motion_out	reserved	activity_type_out	step_counter_out	tap_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						
...	-	-	reserved						
0x2B	-	-	reserved						
0x2A	INTERNAL_STATUS	0x00	odr_high_error	odr_50Hz_error	axes_remap_error	alp_state	message		
0x29	FEAT_EN_2	0x00	avg2_en	t_tap_en	d_tap_en	s_tap_en	alp_en	act_en	sc_en	sd_en
0x28	FEAT_EN_1	0x00	reserved		any_z_en	any_y_en	any_x_en	nomo_z_en	nomo_y_en	nomo_x_en
0x27	FEAT_OUT	0x03	reserved			t_tap	d_tap	s_tap	activity_type_out	
0x26	FIFO_DATA	0x00	fifo_data							
0x25	FIFO_LENGTH_1	0x00	reserved	fifo_byte_counter_13_8						
0x24	FIFO_LENGTH_0	0x00	fifo_byte_counter_7_0							
0x23	-	-	reserved							
0x22	TEMPERATURE	0x00	temperature							
0x21	STEP_COUNTER_3	0x00	step_counter_out_3							
0x20	STEP_COUNTER_2	0x00	step_counter_out_2							
0x1F	STEP_COUNTER_1	0x00	step_counter_out_1							
0x1E	STEP_COUNTER_0	0x00	step_counter_out_0							
0x1D	INT_STATUS_1	0x00	acc_drdy_int	reserved	aux_drdy_int	reserved			fwm_int	ffull_int
0x1C	INT_STATUS_0	0x00	error_int_out	reserved	no_motion_out	any_motion_out	reserved	activity_type_out	step_counter_out	tap_out

0x1B	EVENT	0x01	reserved						por_detected
0x1A	SENSORTIME_2	0x00	sensor_time_23_16						
0x19	SENSORTIME_1	0x00	sensor_time_15_8						
0x18	SENSORTIME_0	0x00	sensor_time_7_0						
0x17	DATA_13	0x00	acc_z_15_8						
0x16	DATA_12	0x00	acc_z_7_0						
0x15	DATA_11	0x00	acc_y_15_8						
0x14	DATA_10	0x00	acc_y_7_0						
0x13	DATA_9	0x00	acc_x_15_8						
0x12	DATA_8	0x00	acc_x_7_0						
0x11	DATA_7	0x00	aux_r_15_8						
0x10	DATA_6	0x00	aux_r_7_0						
0x0F	DATA_5	0x00	aux_z_15_8						
0x0E	DATA_4	0x00	aux_z_7_0						
0x0D	DATA_3	0x00	aux_y_15_8						
0x0C	DATA_2	0x00	aux_y_7_0						
0x0B	DATA_1	0x00	aux_x_15_8						
0x0A	DATA_0	0x00	aux_x_7_0						
0x09	-	-	reserved						
...	-	-	reserved						
0x04	-	-	reserved						
0x03	STATUS	0x10	drdy_acc	reserved	drdy_aux	cmd_rdy	reserved	aux_man_op	reserved
0x02	ERR_REG	0x00	aux_err	fifo_err	reserved	error_code			cmd_err	fatal_err
0x01	-	-	reserved						
0x00	CHIP_ID	0x16	chip_id						

FEATURES_IN

Register Address	**Register Name**	**Default Value**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0x5E: 0x5D	general_settings.axes_re	0x00	reserved							map_z_axis_sign

	mapping[1]							
0x5E:0x5C	general_settings.axes_remapping[0]	0x88	map_z_axis	map_y_axis_sign	map_y_axis	map_x_axis_sign	map_x_axis	
0x5E:0x5B	general_settings.config_id[1]	0x00	identification					
0x5E:0x5A	general_settings.config_id[0]	0x00	identification					
0x5E:0x59	auto_low_power.settings[1]	0x41	pwr_mgt	lp_odr	time_out_dur			
0x5E:0x58	auto_low_power.settings[0]	0x91	time_out_dur				time_out	no_motion
0x5E:0x57	software_lock.software_lock_out[1]	0x00	reserved					
0x5E:0x56	software_lock.software_lock_out[0]	0x00	reserved					
0x5E:0x55	software_lock.software_lock_in[1]	0x00	reserved					
0x5E:0x54	software_lock.software_lock_in[0]	0x00	reserved					
0x5E:0x53	multi-tap.TAP_12[1]	0x00	reserved					
0x5E:0x52	multi-tap.TAP_12[0]	0x00	reserved					
0x5E:0x51	multi-tap.TAP_11[1]	0x00	reserved					

0x5E: 0x50	multi-tap.TAP_11[0]	0x03	reserved	
0x5E: 0x4F	multi-tap.TAP_10[1]	0x00	reserved	
0x5E: 0x4E	multi-tap.TAP_10[0]	0x02	reserved	axis_sel
0x5E: 0x4D	multi-tap.TAP_9[1]	0x04	reserved	
0x5E: 0x4C	multi-tap.TAP_9[0]	0x4C	reserved	
0x5E: 0x4B	multi-tap.TAP_8[1]	0x00	wait_for_timeout	
0x5E: 0x4A	multi-tap.TAP_8[0]	0x00	wait_for_timeout	
0x5E: 0x49	multi-tap.TAP_7[1]	0x00	quite_time_after_gest	
0x5E: 0x48	multi-tap.TAP_7[0]	0x50	quite_time_after_gest	
0x5E: 0x47	multi-tap.TAP_6[1]	0x00	reserved	
0x5E: 0x46	multi-tap.TAP_6[0]	0x08	reserved	
0x5E: 0x45	multi-tap.TAP_5[1]	0x00	tap_shock_dur	
0x5E: 0x44	multi-tap.TAP_5[0]	0x06	tap_shock_dur	
0x5E: 0x43	multi-tap.TAP_4[1]	0x00	reserved	
0x5E: 0x42	multi-tap.TAP_4[0]	0x06	reserved	
0x5E: 0x41	multi-tap.TAP_3[1]	0x00	max_gest_dur	

0x5E: 0x40	multi-tap.TAP_3[0]	0x82	max_gest_dur		
0x5E: 0x3F	multi-tap.TAP_2[1]	0x00	tap_sens_thres		
0x5E: 0x3E	multi-tap.TAP_2[0]	0x09	tap_sens_thres		
0x5E: 0x3D	multi-tap.TAP_1[1]	0x00	reserved		
0x5E: 0x3C	multi-tap.TAP_1[0]	0x06	reserved		
0x5E: 0x3B	step_counter.settings_26[1]	0x00	reserved	reset_counter	watermark_level
0x5E: 0x3A	step_counter.settings_26[0]	0x00	watermark_level		
0x5E: 0x39	step_counter.settings_25[1]	0x00	param_25		
0x5E: 0x38	step_counter.settings_25[0]	0x08	param_25		
0x5E: 0x37	step_counter.settings_24[1]	0x00	param_24		
0x5E: 0x36	step_counter.settings_24[0]	0x01	param_24		
0x5E: 0x35	step_counter.settings_23[1]	0x00	param_23		
0x5E: 0x34	step_counter.settings_23[0]	0x03	param_23		
0x5E: 0x33	step_counter.set	0x00	param_22		

	tings_22 [1]		
0x5E: 0x32	step_counter.settings_22 [0]	0x01	param_22
0x5E: 0x31	step_counter.settings_21 [1]	0x01	param_21
0x5E: 0x30	step_counter.settings_21 [0]	0x00	param_21
0x5E: 0x2F	step_counter.settings_20 [1]	0x0F	param_20
0x5E: 0x2E	step_counter.settings_20 [0]	0x3C	param_20
0x5E: 0x2D	step_counter.settings_19 [1]	0x00	param_19
0x5E: 0x2C	step_counter.settings_19 [0]	0x03	param_19
0x5E: 0x2B	step_counter.settings_18 [1]	0x00	param_18
0x5E: 0x2A	step_counter.settings_18 [0]	0x00	param_18
0x5E: 0x29	step_counter.settings_17 [1]	0x00	param_17
0x5E: 0x28	step_counter.settings_17 [0]	0xA0	param_17
0x5E: 0x27	step_counter.settings_16 [1]	0x00	param_16

0x5E: 0x26	step_counter.settings_16[0]	0x4A	param_16
0x5E: 0x25	step_counter.settings_15[1]	0x00	param_15
0x5E: 0x24	step_counter.settings_15[0]	0x0C	param_15
0x5E: 0x23	step_counter.settings_14[1]	0x00	param_14
0x5E: 0x22	step_counter.settings_14[0]	0x0D	param_14
0x5E: 0x21	step_counter.settings_13[1]	0x00	param_13
0x5E: 0x20	step_counter.settings_13[0]	0x01	param_13
0x5E: 0x1F	step_counter.settings_12[1]	0x41	param_12
0x5E: 0x1E	step_counter.settings_12[0]	0xEF	param_12
0x5E: 0x1D	step_counter.settings_11[1]	0xE8	param_11
0x5E: 0x1C	step_counter.settings_11[0]	0x96	param_11
0x5E: 0x1B	step_counter.settings_10[1]	0x05	param_10
0x5E: 0x1A	step_counter.set	0x5F	param_10

	tings_10[0]		
0x5E:0x19	step_counter.settings_9[1]	0x0A	param_9
0x5E:0x18	step_counter.settings_9[0]	0xBE	param_9
0x5E:0x17	step_counter.settings_8[1]	0x05	param_8
0x5E:0x16	step_counter.settings_8[0]	0x5F	param_8
0x5E:0x15	step_counter.settings_7[1]	0x73	param_7
0x5E:0x14	step_counter.settings_7[0]	0x33	param_7
0x5E:0x13	step_counter.settings_6[1]	0x79	param_6
0x5E:0x12	step_counter.settings_6[0]	0x9A	param_6
0x5E:0x11	step_counter.settings_5[1]	0x00	param_5
0x5E:0x10	step_counter.settings_5[0]	0x07	param_5
0x5E:0x0F	step_counter.settings_4[1]	0x6C	param_4
0x5E:0x0E	step_counter.settings_4[0]	0xCD	param_4

0x5E: 0x0D	step_counter.settings_3[1]	0x00	param_3			
0x5E: 0x0C	step_counter.settings_3[0]	0x85	param_3			
0x5E: 0x0B	step_counter.settings_2[1]	0x78	param_2			
0x5E: 0x0A	step_counter.settings_2[0]	0xF6	param_2			
0x5E: 0x09	step_counter.settings_1[1]	0x01	param_1			
0x5E: 0x08	step_counter.settings_1[0]	0x33	param_1			
0x5E: 0x07	no_motion.NOMO_2[1]	0x00	reserved	duration		
0x5E: 0x06	no_motion.NOMO_2[0]	0x64	duration			
0x5E: 0x05	no_motion.NOMO_1[1]	0x00	reserved	int_bhvr	threshold	
0x5E: 0x04	no_motion.NOMO_1[0]	0xCC	threshold			
0x5E: 0x03	any_motion.ANYMO_2[1]	0x00	reserved	duration		
0x5E: 0x02	any_motion.ANYMO_2[0]	0x05	duration			
0x5E: 0x01	any_motion.ANYMO_1[1]	0x00	reserved	slope	int_bhvr	threshold
0x5E: 0x00	any_motion.ANYMO_1[0]	0xCC	threshold			

1.1.1 Register (0x00) CHIP_ID

DESCRIPTION: Chip identification code
RESET: 0x16
DEFINITION (Go to register map):

Name	**Register (0x00) CHIP_ID**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	1
Content	chip_id			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	1	1	0
Content	chip_id			

chip_id: Chip identification code for BMA456.

1.1.2 Register (0x02) ERR_REG

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

Name	**Register (0x02) ERR_REG**			
Bit	7	6	5	4
Read/Write	R	R	n/a	R
Reset Value	0	0	0	0
Content	aux_err	fifo_err	reserved	error_code
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	error_code		cmd_err	fatal_err

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.
cmd_err: Command execution failed.
error_code: Error codes for persistent errors

error_code		
0x00	no_error	no error is reported
0x01	acc_err	error in Register ACC_CONF

fifo_err: Error in FIFO detected: Input data was discarded in stream mode. This flag will be reset when read.
aux_err: Error in I2C-Master detected. This flag will be reset when read.

1.1.3 Register (0x03) STATUS

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

Name	**Register (0x03) STATUS**			
Bit	7	6	5	4
Read/Write	R	n/a	R	R
Reset Value	0	0	0	1
Content	drdy_acc	reserved	drdy_aux	cmd_rdy
Bit	3	2	1	0
Read/Write	n/a	R	n/a	n/a
Reset Value	0	0	0	0
Content	reserved	aux_man_op	reserved	

aux_man_op: ‘1’(‘0’) indicate a (no) manual auxiliary interface operation is ongoing.
cmd_rdy: CMD decoder status. `0´ -> Command in progress `1´ -> Command decoder is ready to accept a new command
drdy_aux: Data ready for auxiliary sensor. It gets reset when one auxiliary DATA register is read out
drdy_acc: Data ready for accelerometer. It gets reset when one accelerometer DATA register is read out

1.1.4 Register (0x0A) DATA_0

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

Name	**Register (0x0A) DATA_0**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_x_7_0			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_x_7_0			

1.1.5 Register (0x0B) DATA_1

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

Name	**Register (0x0B) DATA_1**			
Bit	7	6	5	4

Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_x_15_8			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_x_15_8			

1.1.6 Register (0x0C) DATA_2

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

Name	**Register (0x0C) DATA_2**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_y_7_0			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_y_7_0			

1.1.7 Register (0x0D) DATA_3

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

Name	**Register (0x0D) DATA_3**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_y_15_8			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_y_15_8			

1.1.8 Register (0x0E) DATA_4

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

Name	**Register (0x0E) DATA_4**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_z_7_0			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_z_7_0			

1.1.9 Register (0x0F) DATA_5

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

Name	**Register (0x0F) DATA_5**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_z_15_8			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_z_15_8			

1.1.10 Register (0x10) DATA_6

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

Name	**Register (0x10) DATA_6**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_r_7_0			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_r_7_0			

1.1.11 Register (0x11) DATA_7

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

Name	**Register (0x11) DATA_7**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_r_15_8			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	aux_r_15_8			

1.1.12 Register (0x12) DATA_8

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

Name	**Register (0x12) DATA_8**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_x_7_0			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_x_7_0			

1.1.13 Register (0x13) DATA_9

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

Name	**Register (0x13) DATA_9**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_x_15_8			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_x_15_8			

1.1.14 Register (0x14) DATA_10

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

Name	**Register (0x14) DATA_10**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_y_7_0			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_y_7_0			

1.1.15 Register (0x15) DATA_11

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

Name	**Register (0x15) DATA_11**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_y_15_8			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_y_15_8			

1.1.16 Register (0x16) DATA_12

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

Name	**Register (0x16) DATA_12**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_z_7_0			
Bit	3	2	1	0

Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_z_7_0			

1.1.17 Register (0x17) DATA_13

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

Name	**Register (0x17) DATA_13**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_z_15_8			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	acc_z_15_8			

1.1.18 Register (0x18) SENSORTIME_0

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

Name	**Register (0x18) SENSORTIME_0**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	sensor_time_7_0			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	sensor_time_7_0			

sensor_time_7_0: Sensor time <7:0> in units of 39.0625 us.

1.1.19 Register (0x19) SENSORTIME_1

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

Name	**Register (0x19) SENSORTIME_1**			
Bit	7	6	5	4

Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	sensor_time_15_8			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	sensor_time_15_8			

sensor_time_15_8: Sensor time <15:8> in units of 10 ms.

1.1.20 Register (0x1A) SENSORTIME_2

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

Name	**Register (0x1A) SENSORTIME_2**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	sensor_time_23_16			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	sensor_time_23_16			

sensor_time_23_16: Sensor time <23:16> in units of 2.56 s.

1.1.21 Register (0x1B) EVENT

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

Name	**Register (0x1B) EVENT**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			
Bit	3	2	1	0
Read/Write	n/a	n/a	n/a	R
Reset Value	0	0	0	1
Content	reserved			por_detected

por_detected: '1' after device power up or softreset. Clear-on-read

1.1.22 Register (0x1C) INT_STATUS_0

DESCRIPTION: Interrupt (or) feature status. Will be cleared on read
RESET: 0x00
DEFINITION (Go to register map):

Name	**Register (0x1C) INT_STATUS_0**			
Bit	7	6	5	4
Read/Write	R	n/a	R	R
Reset Value	0	0	0	0
Content	error_int_out	reserved	no_motion_out	any_motion_out
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	reserved	activity_type_out	step_counter_out	tap_out

tap_out: Tap detector output
step_counter_out: Step counter watermark or step detector output
activity_type_out: Activity output (running, walking, stationary)
reserved: reserved
any_motion_out: Any-motion detection output
no_motion_out: No-motion detection output
error_int_out: Error interrupt output

1.1.23 Register (0x1D) INT_STATUS_1

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

Name	**Register (0x1D) INT_STATUS_1**			
Bit	7	6	5	4
Read/Write	R	n/a	R	n/a
Reset Value	0	0	0	0
Content	acc_drdy_int	reserved	aux_drdy_int	reserved
Bit	3	2	1	0
Read/Write	n/a	n/a	R	R
Reset Value	0	0	0	0
Content	reserved		fwm_int	ffull_int

ffull_int: FIFO Full Interrupt
fwm_int: FIFO Watermark Interrupt
aux_drdy_int: Auxiliary sensor data ready interrupt
acc_drdy_int: Accelerometer data ready interrupt

1.1.24 Register (0x1E) STEP_COUNTER_0

DESCRIPTION: Step counting value byte-0
RESET: 0x00
DEFINITION (Go to register map):

Name	**Register (0x1E) STEP_COUNTER_0**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	step_counter_out_0			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	step_counter_out_0			

step_counter_out_0: Step counting value byte-0 (least significant byte)

1.1.25 Register (0x1F) STEP_COUNTER_1

DESCRIPTION: Step counting value byte-1
RESET: 0x00
DEFINITION (Go to register map):

Name	**Register (0x1F) STEP_COUNTER_1**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	step_counter_out_1			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	step_counter_out_1			

step_counter_out_1: Step counting value byte-1

1.1.26 Register (0x20) STEP_COUNTER_2

DESCRIPTION: Step counting value byte-2
RESET: 0x00
DEFINITION (Go to register map):

Name	**Register (0x20) STEP_COUNTER_2**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	step_counter_out_2			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	step_counter_out_2			

step_counter_out_2: Step counting value byte-2

1.1.27 Register (0x21) STEP_COUNTER_3

DESCRIPTION: Step counting value byte-3
RESET: 0x00
DEFINITION (Go to register map):

Name	**Register (0x21) STEP_COUNTER_3**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	step_counter_out_3			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	step_counter_out_3			

step_counter_out_3: Step counting value byte-3 (most significant byte)

1.1.28 Register (0x22) TEMPERATURE

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

Name	**Register (0x22) TEMPERATURE**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	temperature			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	temperature			

temperature: Temperature value in two's complement representation in units of 1 Kelvin: 0x00 corresponds to 23 degree Celsius.

1.1.29 Register (0x24) FIFO_LENGTH_0

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

Name	**Register (0x24) FIFO_LENGTH_0**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0

Content	fifo_byte_counter_7_0			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	fifo_byte_counter_7_0			

fifo_byte_counter_7_0: Current fill level of FIFO buffer.

1.1.30 Register (0x25) FIFO_LENGTH_1

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

Name	**Register (0x25) FIFO_LENGTH_1**			
Bit	7	6	5	4
Read/Write	n/a	n/a	R	R
Reset Value	0	0	0	0
Content	reserved		fifo_byte_counter_13_8	
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	fifo_byte_counter_13_8			

fifo_byte_counter_13_8: FIFO byte counter bits 13..8

1.1.31 Register (0x26) FIFO_DATA

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

Name	**Register (0x26) FIFO_DATA**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	fifo_data			
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	fifo_data			

fifo_data: FIFO read data.

1.1.32 Register (0x27) FEAT_OUT

DESCRIPTION: Feature output
RESET: 0x03

DEFINITION (Go to register map):

Name	**Register (0x27) FEAT_OUT**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	reserved			t_tap
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	1	1
Content	d_tap	s_tap	activity_type_out	

activity_type_out: Output value of the activity detection feature. Value after device initialization is 0b11 i.e. unknown state.

activity_type_out		
0x00	still	user stationary
0x01	walking	user walking
0x02	running	user running
0x03	unknown	unknown state

s_tap: Single tap detected
d_tap: Double tap detected
t_tap: Triple tap detected
reserved: reserved

1.1.33 Register (0x28) FEAT_EN_1

DESCRIPTION: Enable bits of feature engines
RESET: 0x00
DEFINITION (Go to register map):

Name	**Register (0x28) FEAT_EN_1**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	reserved		any_z_en	any_y_en
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	any_x_en	nomo_z_en	nomo_y_en	nomo_x_en

nomo_x_en: Enables no motion feature for x-axis
nomo_y_en: Enables no motion feature for y-axis
nomo_z_en: Enables no motion feature for z-axis
any_x_en: Enables any motion feature for x-axis
any_y_en: Enables any motion feature for y-axis
any_z_en: Enables any motion feature for z-axis
reserved: Reserved

reserved: Triggers software lock calculation, and this bit will be cleared after sensor key is generated. User needs to wait for this bit to be cleared back to 0 before setting or clearing other bits.

1.1.34 Register (0x29) FEAT_EN_2

DESCRIPTION: Enable bits of feature engines
RESET: 0x00
DEFINITION (Go to register map):

Name	**Register (0x29) FEAT_EN_2**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	avg2_en	t_tap_en	d_tap_en	s_tap_en
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	alp_en	act_en	sc_en	sd_en

sd_en: Enables step detector feature
sc_en: Enables step counter feature
act_en: Enables activity detection feature
alp_en: Enables auto low power feature
s_tap_en: Enables single tap feature
d_tap_en: Enables double tap feature
t_tap_en: Enables triple tap feature
avg2_en: Enables averaging2 for tap feature

1.1.35 Register (0x2A) INTERNAL_STATUS

DESCRIPTION: Error bits and message indicating internal status
RESET: 0x00
DEFINITION (Go to register map):

Name	**Register (0x2A) INTERNAL_STATUS**			
Bit	7	6	5	4
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	odr_high_error	odr_50Hz_error	axes_remap_error	alp_state
Bit	3	2	1	0
Read/Write	R	R	R	R
Reset Value	0	0	0	0
Content	message			

message: Internal Status Message

message		
0x00	not_init	ASIC is not initialized
0x01	init_ok	ASIC initialized

0x02	init_err	Initialization error
0x03	drv_err	Invalid driver
0x04	sns_stop	Sensor stopped

alp_state: Indicates the current state of auto low power mode

alp_state		
0x00	auto_wake	Wake state, where all enabled features shall be processed
0x01	auto_sleep	Sleep state, where any motion and no motion shall be processed

axes_remap_error: Incorrect axes remapping. X, Y and Z axes must be mapped to exclusively separate axes i.e. they cannot be mapped to same axes.
odr_50Hz_error: The minimum bandwidth conditions are not respected for the features which require 50Hz data.
odr_high_error: The minimum bandwidth conditions are not respected for the features which require 200Hz data.

1.1.36 Register (0x40) ACC_CONF

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

Name	**Register (0x40) ACC_CONF**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	1	0	1	0
Content	acc_perf_mode	acc_bwp		
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	1	0	0	0
Content	acc_odr			

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.

acc_odr		
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

acc_bwp: Bandwidth parameter, determines filter configuration (acc_perf_mode=1) and averaging for undersampling mode (acc_perf_mode=0)

acc_bwp		
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

acc_perf_mode: Select accelerometer filter performance mode:

acc_perf_mode		
0x00	cic_avg	averaging mode.
0x01	cont	continuous filter function.

1.1.37 Register (0x41) ACC_RANGE

DESCRIPTION: Selection of the Accelerometer g-range
RESET: 0x01
DEFINITION (Go to register map):

Name	**Register (0x41) ACC_RANGE**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			
Bit	3	2	1	0
Read/Write	n/a	n/a	RW	RW
Reset Value	0	0	0	1
Content	reserved		acc_range	

acc_range: Accelerometer g-range

acc_range		

0x00	range_2g	+/-2g
0x01	range_4g	+/-4g
0x02	range_8g	+/-8g
0x03	range_16g	+/-16g

1.1.38 Register (0x44) AUX_CONF

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

Name	**Register (0x44) AUX_CONF**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	1	0	0
Content	aux_offset			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	1	1	0
Content	aux_odr			

aux_odr: Select the poll rate for the sensor attached to the Auxiliary interface.

aux_odr		
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

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.

1.1.39 Register (0x45) FIFO_DOWNS

DESCRIPTION: Configure Accelerometer downsampling rates for FIFO
RESET: 0x80

DEFINITION (Go to register map):

Name	**Register (0x45) FIFO_DOWNS**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	1	0	0	0
Content	acc_fifo_filt_data	acc_fifo_downs		
Bit	3	2	1	0
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			

acc_fifo_downs: Downsampling for accelerometer data (2**acc_fifo_downs)
acc_fifo_filt_data: selects filtered or unfiltered Accelerometer data for fifo

acc_fifo_filt_data		
0x00	unfiltered	Unfiltered data
0x01	filtered	Filtered data

1.1.40 Register (0x46) FIFO_WTM_0

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

Name	**Register (0x46) FIFO_WTM_0**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	fifo_water_mark_7_0			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	fifo_water_mark_7_0			

1.1.41 Register (0x47) FIFO_WTM_1

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

Name	**Register (0x47) FIFO_WTM_1**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	RW
Reset Value	0	0	0	0
Content	reserved			fifo_water_mark_12_8

Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	1	0
Content	fifo_water_mark_12_8			

1.1.42 Register (0x48) FIFO_CONFIG_0

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

Name	**Register (0x48) FIFO_CONFIG_0**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			
Bit	3	2	1	0
Read/Write	n/a	n/a	RW	RW
Reset Value	0	0	1	0
Content	reserved		fifo_time_en	fifo_stop_on_full

fifo_stop_on_full: Stop writing samples into FIFO when FIFO is full.

fifo_stop_on_full		
0x00	disable	do not stop writing to FIFO when full
0x01	enable	Stop writing into FIFO when full.

fifo_time_en: Return sensortime frame after the last valid data frame.

fifo_time_en		
0x00	disable	do not return sensortime frame
0x01	enable	return sensortime frame

1.1.43 Register (0x49) FIFO_CONFIG_1

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

Name	**Register (0x49) FIFO_CONFIG_1**			
Bit	7	6	5	4
Read/Write	n/a	RW	RW	RW
Reset Value	0	0	0	1
Content	reserved	fifo_acc_en	fifo_aux_en	fifo_header_en
Bit	3	2	1	0
Read/Write	RW	RW	n/a	n/a
Reset Value	0	0	0	0
Content	fifo_tag_int1_en	fifo_tag_int2_en	reserved	

fifo_tag_int2_en: FIFO interrupt 2 tag enable

fifo_tag_int2_en		
0x00	disable	disable tag
0x01	enable	enable tag

fifo_tag_int1_en: FIFO interrupt 1 tag enable

fifo_tag_int1_en		
0x00	disable	disable tag
0x01	enable	enable tag

fifo_header_en: FIFO frame header enable

fifo_header_en		
0x00	disable	no header is stored (output data rate of all enabled sensors need to be identical)
0x01	enable	header is stored

fifo_aux_en: Store Auxiliary data in FIFO (all 3 axes)

fifo_aux_en		
0x00	disable	no Auxiliary data is stored
0x01	enable	Auxiliary data is stored

fifo_acc_en: Store Accelerometer data in FIFO (all 3 axes)

fifo_acc_en		
0x00	disable	no Accelerometer data is stored
0x01	enable	Accelerometer data is stored

1.1.44 Register (0x4B) AUX_DEV_ID

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

Name	**Register (0x4B) AUX_DEV_ID**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	1	0
Content	i2c_device_addr			
Bit	3	2	1	0
Read/Write	RW	RW	RW	n/a
Reset Value	0	0	0	0
Content	i2c_device_addr			reserved

i2c_device_addr: I2C device address of Auxiliary slave

1.1.45 Register (0x4C) AUX_IF_CONF

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

Name	**Register (0x4C) AUX_IF_CONF**			
Bit	7	6	5	4
Read/Write	RW	n/a	n/a	n/a
Reset Value	1	0	0	0
Content	aux_manual_en	reserved		
Bit	3	2	1	0
Read/Write	n/a	n/a	RW	RW
Reset Value	0	0	1	1
Content	reserved		aux_rd_burst	

aux_rd_burst: Burst data length (1,2,6,8 byte)

aux_rd_burst		
0x00	BL1	Burst length 1
0x01	BL2	Burst length 2
0x02	BL6	Burst length 6
0x03	BL8	Burst length 8

aux_manual_en: Enable auxiliary interface manual mode.

aux_manual_en		
0x00	disable	Data mode
0x01	enable	Setup mode

1.1.46 Register (0x4D) AUX_RD_ADDR

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

Name	**Register (0x4D) AUX_RD_ADDR**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	1	0	0
Content	read_addr			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	1	0
Content	read_addr			

read_addr: Address to read

1.1.47 Register (0x4E) AUX_WR_ADDR

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

Name	**Register (0x4E) AUX_WR_ADDR**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	1	0	0
Content	write_addr			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	1	1	0	0
Content	write_addr			

write_addr: Address to write

1.1.48 Register (0x4F) AUX_WR_DATA

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

Name	**Register (0x4F) AUX_WR_DATA**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	write_data			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	1	0
Content	write_data			

write_data: Data to write

1.1.49 Register (0x53) INT1_IO_CTRL

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

Name	**Register (0x53) INT1_IO_CTRL**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	RW
Reset Value	0	0	0	0
Content	reserved			input_en
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW

Reset Value	0	0	0	0
Content	output_en	od	lvl	edge_ctrl

edge_ctrl: Configure trigger condition of INT1 pin (input)

edge_ctrl		
0x00	level_tr	Level
0x01	edge_tr	Edge

lvl: Configure level of INT1 pin

lvl		
0x00	active_low	active low
0x01	active_high	active high

od: Configure behaviour of INT1 pin to open drain.

od		
0x00	push_pull	push-pull
0x01	open_drain	open drain

output_en: Output enable for INT1 pin

output_en		
0x00	off	Output disabled
0x01	on	Output enabled

input_en: Input enable for INT1 pin

input_en		
0x00	off	Input disabled
0x01	on	Input enabled

1.1.50 Register (0x54) INT2_IO_CTRL

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

Name	**Register (0x54) INT2_IO_CTRL**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	RW
Reset Value	0	0	0	0
Content	reserved			input_en
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	output_en	od	lvl	edge_ctrl

edge_ctrl: Configure trigger condition of INT2 pin (input)

edge_ctrl		

0x00	level_tr	Level
0x01	edge_tr	Edge

lvl: Configure level of INT2 pin

lvl		
0x00	active_low	active low
0x01	active_high	active high

od: Configure behaviour of INT2 pin to open drain.

od		
0x00	push_pull	push-pull
0x01	open_drain	open drain

output_en: Output enable for INT2 pin

output_en		
0x00	off	Output disabled
0x01	on	Output enabled

input_en: Input enable for INT2 pin

input_en		
0x00	off	Input disabled
0x01	on	Input enabled

1.1.51 Register (0x55) INT_LATCH

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

Name	**Register (0x55) INT_LATCH**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			
Bit	3	2	1	0
Read/Write	n/a	n/a	n/a	RW
Reset Value	0	0	0	0
Content	reserved			int_latch

int_latch: Latched/non-latched/temporary interrupt modes

int_latch		
0x00	none	non latched
0x01	permanent	latched

1.1.52 Register (0x56) INT1_MAP

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

Name	**Register (0x56) INT1_MAP**			
Bit	7	6	5	4
Read/Write	RW	n/a	RW	RW
Reset Value	0	0	0	0
Content	error_int_out	reserved	no_motion_out	any_motion_out
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	reserved	activity_type_out	step_counter_out	tap_out

tap_out: Tap detector output
step_counter_out: Step counter watermark or step detector output
activity_type_out: Activity output (running, walking, stationary)
reserved: reserved
any_motion_out: Any-motion detection output
no_motion_out: No-motion detection output
error_int_out: Error interrupt output

1.1.53 Register (0x57) INT2_MAP

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

Name	**Register (0x57) INT2_MAP**			
Bit	7	6	5	4
Read/Write	RW	n/a	RW	RW
Reset Value	0	0	0	0
Content	error_int_out	reserved	no_motion_out	any_motion_out
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	reserved	activity_type_out	step_counter_out	tap_out

tap_out: Tap detector output
step_counter_out: Step counter watermark or step detector output
activity_type_out: Activity output (running, walking, stationary)
reserved: reserved
any_motion_out: Any-motion detection output
no_motion_out: No-motion detection output
error_int_out: Error interrupt output

1.1.54 Register (0x58) INT_MAP_DATA

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

Name	**Register (0x58) INT_MAP_DATA**			
Bit	7	6	5	4
Read/Write	n/a	RW	RW	RW
Reset Value	0	0	0	0
Content	reserved	int2_drdy	int2_fwm	int2_ffull
Bit	3	2	1	0
Read/Write	n/a	RW	RW	RW
Reset Value	0	0	0	0
Content	reserved	int1_drdy	int1_fwm	int1_ffull

int1_ffull: FIFO Full interrupt mapped to INT1
int1_fwm: FIFO Watermark interrupt mapped to INT1
int1_drdy: Data Ready interrupt mapped to INT1
int2_ffull: FIFO Full interrupt mapped to INT2
int2_fwm: FIFO Watermark interrupt mapped to INT2
int2_drdy: Data Ready interrupt mapped to INT2

1.1.55 Register (0x59) INIT_CTRL

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

Name	**Register (0x59) INIT_CTRL**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	1	0	0	1
Content	init_ctrl			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	init_ctrl			

init_ctrl: Commands to start initialization

init_ctrl		
0x00	Load configuration file	Enable the mode for accept configuration file
0x01	Start initialization	Enable sensor features after loading configuration file

Note: The command must not be used more than once after POR or softreset. The process to start initialization described in chapter 4.3 must strictly be followed.

1.1.56 Register (0x5E) FEATURES_IN

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

Name	**Register (0x5E) FEATURES_IN**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	features_in			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	features_in			

features_in: Feature configuration read/write data

Address	**Bit**	**Name**	**Description**	**Reset**	**Access**
any_motion					
0x5E: 0x00		ANYMO_1	Configurations for any-motion detection - Part 1	0x00CC	
	10...0	threshold	Threshold for acceleration signal slope to detect any-motion event. Range is 0 to 1g. Resolution is 0.4883mg. Default value is 100mg.	0xCC	RW
	11	int_bhvr	Defines any motion interrupt behaviour **Value** / **Name** / **Description** 0x00 / multi_int / Generates interrupt as long as condition is valid 0x01 / single_shot / Generate one interrupt for every valid condition	0x0	RW
	12	slope	Configuration for acceleration slope computation **Value** / **Name** / **Description** 0x00 / non-consecutive / Computes the slope between acceleration vector at	0x0	RW

			0x01 consecutive: last event detection to current. Computes the slope between consecutive acceleration vector samples		
0x5E: 0x02		ANYMO_2	Configurations for any-motion detection - Part 2	0x0005	
	12...0	duration	Threshold for duration to detect any-motion event. Range 0 to 163 seconds. Resolution is 20 ms. Default value is 100 ms.	0x5	RW
no_motion					
0x5E: 0x04		NOMO_1	Configurations for no-motion detection - Part 1	0x00CC	
	10...0	threshold	Threshold for acceleration signal slope to detect no-motion event. Range is 0 to 1g. Resolution is 0.4883mg. Default value is 100mg.	0xCC	RW
	11	int_bhvr	Defines no motion interrupt behaviour **Value / Name / Description** 0x00 multi_int: Generates interrupt as long as condition is valid 0x01 single_shot: Generate one interrupt for every valid condition	0x0	RW
0x5E: 0x06		NOMO_2	Configurations for no-motion detection - Part 2	0x0064	
	12...0	duration	Threshold for duration to detect no-motion event. Range 0 to 163 seconds. Resolution is 20 ms. Default value is 2000 ms.	0x64	RW
step_counter					
		settings_1	Step counter setting	0x0133	

0x5E: 0x08	15...0	param_1	Step counter param 1	0x133	RW
0x5E: 0x0A		settings_2	Step counter setting	0x78F6	
	15...0	param_2	Step counter param 2	0x78F6	RW
0x5E: 0x0C		settings_3	Step counter setting	0x0085	
	15...0	param_3	Step counter param 3	0x85	RW
0x5E: 0x0E		settings_4	Step counter setting	0x6CCD	
	15...0	param_4	Step counter param 4	0x6CCD	RW
0x5E: 0x10		settings_5	Step counter setting	0x0007	
	15...0	param_5	Step counter param 5	0x7	RW
0x5E: 0x12		settings_6	Step counter setting	0x799A	
	15...0	param_6	Step counter param 6	0x799A	RW
0x5E: 0x14		settings_7	Step counter setting	0x7333	
	15...0	param_7	Step counter param 7	0x7333	RW
0x5E: 0x16		settings_8	Step counter setting	0x055F	
	15...0	param_8	Step counter param 8	0x55F	RW
0x5E: 0x18		settings_9	Step counter setting	0x0ABE	
	15...0	param_9	Step counter param 9	0xABE	RW
0x5E: 0x1A		settings_10	Step counter setting	0x055F	
	15...0	param_10	Step counter param 10	0x55F	RW
0x5E: 0x1C		settings_11	Step counter setting	0xE896	
	15...0	param_11	Step counter param 11	0xE896	RW
0x5E: 0x1E		settings_12	Step counter setting	0x41EF	
	15...0	param_12	Step counter param 12	0x41EF	RW
0x5E: 0x20		settings_13	Step counter setting	0x0001	
	15...0	param_13	Step counter param 13	0x1	RW
0x5E: 0x22		settings_14	Step counter setting	0x000D	
	15...0	param_14	Step counter param 14	0xD	RW
0x5E: 0x24		settings_15	Step counter setting	0x000C	
	15...0	param_15	Step counter param 15	0xC	RW
0x5E: 0x26		settings_16	Step counter setting	0x004A	
	15...0	param_16	Step counter param 16	0x4A	RW
0x5E: 0x28		settings_17	Step counter setting	0x00A0	
	15...0	param_17	Step counter param 17	0xA0	RW
0x5E: 0x2A		settings_18	Step counter setting	0x0000	
	15...0	param_18	Step counter param 18	0x0	RW
0x5E: 0x2C		settings_19	Step counter setting	0x0003	
	15...0	param_19	Step counter param 19	0x3	RW
0x5E: 0x2E		settings_20	Step counter setting	0x0F3C	
	15...0	param_20	Step counter param 20	0xF3C	RW
0x5E: 0x30		settings_21	Step counter setting	0x0100	
	15...0	param_21	Step counter param 21	0x100	RW
0x5E: 0x32		settings_22	Step counter setting	0x0001	
	15...0	param_22	Step counter param 22	0x1	RW

0x5E: 0x34		settings_23	Step counter setting	0x0003	
	15...0	param_23	Step counter param 23	0x3	RW
0x5E: 0x36		settings_24	Step counter setting	0x0001	
	15...0	param_24	Step counter param 24	0x1	RW
0x5E: 0x38		settings_25	Step counter setting	0x0008	
	15...0	param_25	Step counter param 25	0x8	RW
0x5E: 0x3A		settings_26	Step counter and step detector settings	0x0000	
	9...0	watermark_level	Watermark level; the step counter will trigger output every time this number of steps are counted. Holds implicitly a 20x factor, so the range is 0 to 20460, with resolution of 20 steps. If 0, the output is disabled.	0x0	RW
	10	reset_counter	Step count value can be reset only when step counter or step detector or activity is enabled	0x0	RW
multi-tap					
0x5E: 0x3C		TAP_1	Configurations for tap detector - Part 1	0x0006	
	15...0	reserved	Reserved	0x6	RW
0x5E: 0x3E		TAP_2	Configurations for tap detector - Part 2	0x0009	
	15...0	tap_sens_thres	Scaling factor of additional threshold increment for detection of positive and negative peak of a tap. Default value = 9, Recommended range = 0 to 15. Resolution of each LSB of scaling factor in terms of filtered acceleration signal magnitude is 78.125 mg.	0x9	RW
0x5E: 0x40		TAP_3	Configurations for tap detector - Part 3	0x0082	
	15...0	max_gest_dur	Maximum duration after the first tap within which the second and/or third tap have to be performed for being detected as double-tap or triple-tap. Default value = 130 (650 ms), Resolution = 5 ms, Recommended range = 250 to 1000 ms.	0x82	RW
0x5E: 0x42		TAP_4	Configurations for tap detector - Part 4	0x0006	
	15...0	reserved	Reserved	0x6	RW
0x5E: 0x44		TAP_5	Configurations for tap detector - Part 5	0x0006	
	15...0	tap_shock_dur	Settling time of high frequency acceleration signal components after tap. Default value = 6 (30 ms),	0x6	RW

			Resolution = 5 ms, Recommended range = 20 to 100 ms.		
0x5E: 0x46		TAP_6	Configurations for tap detector - Part 6	0x0008	
	15...0	reserved	Reserved	0x8	RW
0x5E: 0x48		TAP_7	Configurations for tap detector - Part 7	0x0050	
	15...0	quite_time_after_gest	Minimum quite time between the two gesture detection. Default value = 80 (400 ms), Resolution = 5 ms, Recommended range = 250 to 500 ms.	0x50	RW
0x5E: 0x4A		TAP_8	Configurations for tap detector - Part 8	0x0000	
	15...0	wait_for_timeout	Wait for the duration set by max_gest_dur after the first tap and report the tap-gesture based on number of taps detected. Default value = 0 (disabled). Allowed values = 0 / 1 (disabled / enabled).	0x0	RW
0x5E: 0x4C		TAP_9	Configurations for tap detector - Part 9	0x044C	
	15...0	reserved	Reserved	0x44C	RW
0x5E: 0x4E		TAP_10	Configurations for tap detector - Part 10	0x0002	
	1...0	axis_sel	Selection of axis from 3D-acceleration signal vector for tap detection. Default value = 2 (z-axis). Other supported values 0 (x-axis) and 1 (y-axis). Any other selection leads to usage of default value **Value** **Name** **Description** 0x00 x-axis Use x-axis for tap detection 0x01 y-axis Use y-axis for tap detection 0x02 z-axis Use z-axis for tap detection 0x03 reserved Reserved	0x2	RW
0x5E: 0x50		TAP_11	Configurations for tap detector - Part 11	0x0003	
	15...0	reserved	Reserved	0x3	RW
0x5E: 0x52		TAP_12	Configurations for tap detector - Part 12	0x0000	
	15...0	reserved	Reserved	0x0	RW
software_lock					
0x5E: 0x54		software_lock_in	Reserved	0x0000	
	15...0	reserved	Reserved	0x0	RW

0x5E: 0x56		software_lock_out	Reserved	0x0000	
	15...0	reserved	Reserved	0x0	R
auto_low_power					
0x5E: 0x58		settings	Auto low power feature settings	0x4191	
	0	no_motion	Enter to auto sleep, when no motion is detected	0x1	RW
	1	time_out	Enter to auto sleep, when any motion is not detected for time_out_dur period	0x0	RW
	12...2	time_out_dur	Duration to enter to auto sleep, when any motion event is not detected. Range 0 to 40960ms. Resolution is 20 ms. Default value is 2000 ms.	0x64	RW
	14...13	lp_odr	ODR for low power mode **Value Name Description** 0x00 odr_1p5 25/16 Hz 0x01 odr_3p1 25/8 Hz 0x02 odr_6p25 25/4 Hz 0x03 odr_12p5 25/2 Hz	0x2	RW
	15	pwr_mgt	Power management **Value Name Description** 0x00 disable Disable feature optimized acc_conf. Uses host desired configuration. 0x01 enable Enable feature optimized acc_conf	0x0	RW
general_settings					
0x5E: 0x5A		config_id	Describes configuration identification code	0x0000	
	15...0	identification	Describes configuration identification code	0x0	R
0x5E: 0x5C		axes_remapping	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 reserved	0x0	RW
	2	map_x_axis_sign	Map the x axis sign to the desired one **Value Name Description**	0x0	RW

			0x00 not_invert Clear this bit to not invert the x axis 0x01 inverted Set this bit to invert the x axis		
	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 reserved	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 reserved	0x2	RW
	8	map_z_axis_sign	Map the z axis sign to the desired one **Value Name Description** 0x00 not_invert Clear this bit to not invert the z axis 0x01 inverted Set this bit to invert the z axis	0x0	RW

1.1.57 Register (0x5F) INTERNAL_ERROR

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

Name	**Register (0x5F) INTERNAL_ERROR**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			

Bit	3	2	1	0
Read/Write	n/a	R	R	n/a
Reset Value	0	0	0	0
Content	reserved	int_err_2	int_err_1	reserved

int_err_1: Internal error flag - long processing time, processing halted
int_err_2: Internal error flag - fatal error, processing halted

1.1.58 Register (0x6A) NVM_CONF

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

Name	**Register (0x6A) NVM_CONF**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			
Bit	3	2	1	0
Read/Write	n/a	n/a	RW	n/a
Reset Value	0	0	0	0
Content	reserved		nvm_prog_en	reserved

nvm_prog_en: Enable NVM programming

nvm_prog_en		
0x00	disable	disable
0x01	enable	enable

1.1.59 Register (0x6B) IF_CONF

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

Name	**Register (0x6B) IF_CONF**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	RW
Reset Value	0	0	0	0
Content	reserved			if_mode
Bit	3	2	1	0
Read/Write	n/a	n/a	n/a	RW
Reset Value	0	0	0	0
Content	reserved			spi3

spi3: Configure SPI Interface Mode for primary interface

spi3		

0x00	spi4	SPI 4-wire mode
0x01	spi3	SPI 3-wire mode

if_mode: Auxiliary interface configuration

if_mode		
0x00	p_auto_s_off	Auxiliary interface:off
0x01	p_auto_s_mag	Auxilary interface:Magnetometer

1.1.60 Register (0x6D) ACC_SELF_TEST

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

Name	**Register (0x6D) ACC_SELF_TEST**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			
Bit	3	2	1	0
Read/Write	RW	RW	n/a	RW
Reset Value	0	0	0	0
Content	acc_self_test_amp	acc_self_test_sign	reserved	acc_self_test_en

acc_self_test_en: Enable accelerometer self-test

acc_self_test_en		
0x00	disabled	disabled
0x01	enabled	enabled

acc_self_test_sign: select sign of self-test excitation as

acc_self_test_sign		
0x00	negative	negative
0x01	positive	positive

acc_self_test_amp: select amplitude of the selftest deflection:

acc_self_test_amp		
0x00	low	low
0x01	high	high

1.1.61 Register (0x70) NV_CONF

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

Name	**Register (0x70) NV_CONF**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	acc_off_en	i2c_wdt_en	i2c_wdt_sel	spi_en

spi_en: disable the I2C and enable SPI for the primary interface, when it is in autoconfig mode

spi_en		
0x00	disabled	I2C enabled
0x01	enabled	I2C disabled

i2c_wdt_sel: Select timer period for I2C Watchdog

i2c_wdt_sel		
0x00	wdt_short	I2C watchdog timeout after 1.25 ms
0x01	wdt_long	I2C watchdog timeout after 40 ms

i2c_wdt_en: I2C Watchdog at the SDA pin in I2C interface mode

i2c_wdt_en		
0x00	Disable	Disable I2C watchdog
0x01	Enable	Enable I2C watchdog

acc_off_en: Add the offset defined in the off_acc_[xyz] OFFSET register to filtered and unfiltered Accelerometer data

acc_off_en		
0x00	disabled	Disabled
0x01	enabled	Enabled

1.1.62 Register (0x71) OFFSET_0

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

Name	**Register (0x71) OFFSET_0**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	off_acc_x			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	off_acc_x			

off_acc_x: Accelerometer offset compensation (X-axis).

1.1.63 Register (0x72) OFFSET_1

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

Name	**Register (0x72) OFFSET_1**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	off_acc_y			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	off_acc_y			

off_acc_y: Accelerometer offset compensation (Y-axis).

1.1.64 Register (0x73) OFFSET_2

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

Name	**Register (0x73) OFFSET_2**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	off_acc_z			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	off_acc_z			

off_acc_z: Accelerometer offset compensation (Z-axis).

1.1.65 Register (0x7C) PWR_CONF

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

Name	**Register (0x7C) PWR_CONF**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a

Reset Value	0	0	0	0
Content	reserved			
Bit	3	2	1	0
Read/Write	n/a	n/a	RW	RW
Reset Value	0	0	1	1
Content	reserved		fifo_self_wakeup	adv_power_save

adv_power_save		
0x00	aps_off	advanced power save disabled (fast clk always enabled).
0x01	aps_on	advanced power mode enabled (slow clk is active when no measurement is ongoing.)

fifo_self_wakeup		
0x00	fsw_off	FIFO read disabled in advanced power saving mode.
0x01	fsw_on	FIFO read enabled after interrupt in advanced power saving mode.

1.1.66 Register (0x7D) PWR_CTRL

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

Name	**Register (0x7D) PWR_CTRL**			
Bit	7	6	5	4
Read/Write	n/a	n/a	n/a	n/a
Reset Value	0	0	0	0
Content	reserved			
Bit	3	2	1	0
Read/Write	n/a	RW	n/a	RW
Reset Value	0	0	0	0
Content	reserved	acc_en	reserved	aux_en

aux_en		
0x00	mag_off	Disables the auxiliary sensor.
0x01	mag_on	Enables the auxiliary sensor.

acc_en		
0x00	acc_off	Disables the Accelerometer.
0x01	acc_on	Enables the Accelerometer.

1.1.67 Register (0x7E) CMD

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

Name	**Register (0x7E) CMD**			
Bit	7	6	5	4
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	cmd			
Bit	3	2	1	0
Read/Write	RW	RW	RW	RW
Reset Value	0	0	0	0
Content	cmd			

cmd: Available commands (Note: Register will always read as 0x00):

cmd		
0xa0	nvm_prog	Writes the NVM backed registers into NVM
0xb0	fifo_flush	Clears all data in the FIFO, does not change FIFO_CONFIG and FIFO_DOWNS registers
0xb6	softreset	Triggers a reset, all user configuration settings are overwritten with their default state

4. Document history and modification

Rev. No	Chapter	Description of modification/changes	Date
1.0		Document creation	August 2019
1.1	2.5	Update of timing diagram for tap detector in Figure 3	January 2020
1.2		In-ear and Out-ear feature set removed Disclaimer removed and a reference added to the note in the first page. Product page link included.	February 2021
1.3	2.1	Figure 1 updated	November 2021

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