

## Ultralow-power accelerometer with AI & anti-aliasing



LGA-12L  
2.0 x 2.0 x 0.74 (max) mm

### Product status link

[LIS2DUX12](#)

### Product summary

Order code	LIS2DUX12TR
Temperature range [°C]	-40 to +85
Package	LGA-12L
Packing	Tape and reel

### Product resources

[TN0018](#) (design and soldering)

### Product label



## Features

- Supply voltage range from 1.62 V to 3.6 V
  - Independent IO supply (1.62 V to 3.6 V) for I<sup>2</sup>C and SPI interfaces
  - Independent IO supply (extended range: 1.08 V to 3.6 V) for MIPI I3C<sup>®</sup> interface
- Four operating power modes
- Ultralow power consumption
  - High-performance mode with anti-aliasing filter: 10.8 μA
  - Low-power mode with anti-aliasing filter: 6.2 μA
  - Ultralow-power mode: 2.7 μA
  - Power-down: 0.01 μA
- Low noise down to 220 μg/√Hz
- ±2g/±4g/±8g/±16g programmable full-scale
- ODR from 1.6 Hz to 800 Hz
- Embedded machine learning core
- Programmable finite state machine
- Adaptive self-configuration (ASC) based on the sensor processing output (FSM / MLC)
- Embedded temperature sensor
- Embedded FIFO: up to 512 samples of accelerometer and temperature data in high resolution or up to 768 samples of acceleration data at low resolution
- High-speed I<sup>2</sup>C/SPI/MIPI I3C<sup>®</sup> digital output interface
- Embedded digital functions (free-fall, wake-up, single/double/triple-tap recognition, activity/inactivity, 6D/4D orientation)
- Advanced pedometer, step detector and step counter
- Significant motion detection, tilt detection
- Self-test
- Small package: 2.0 x 2.0 x 0.74 (max) mm LGA 12-lead
- 10000 g high shock survivability
- [ECOPACK](#) and RoHS compliant

## Applications

- [Wearable devices](#) (wristband and smart watches)
- [Game controllers](#)
- Hearing aids and portable healthcare devices
- True wireless stereo
- Wireless sensor nodes
- Motion-activated user interfaces (screen rotation, tap, double tap)
- [Asset trackers](#)

## Description

The LIS2DUX12 is a smart, digital, 3-axis linear accelerometer whose MEMS and ASIC have been expressly designed to combine the lowest current consumption possible with features such as always-on anti-aliasing filtering, a finite state machine (FSM) and machine learning core (MLC) with adaptive self-configuration (ASC).

The FSM and MLC with ASC deliver outstanding always-on, edge processing capabilities to the LIS2DUX12. The LIS2DUX12 MIPI I3C<sup>®</sup> slave interface and embedded 128-level FIFO buffer complete a set of features that make this accelerometer a reference in terms of system integration from a standpoint of the bill of materials, processing, or power consumption.

The LIS2DUX12 has user-selectable full scales of  $\pm 2g/\pm 4g/\pm 8g/\pm 16g$  and is capable of measuring accelerations with output data rates from 1.6 Hz to 800 Hz.

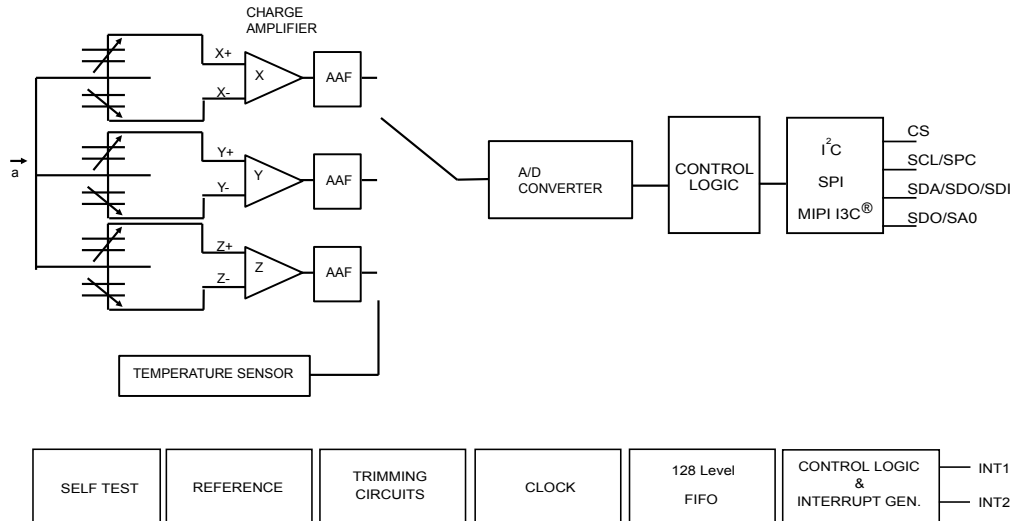
The LIS2DUX12 has a dedicated internal engine to process motion and acceleration detection including free-fall, wake-up, single/double/triple-tap recognition, activity/inactivity, and 6D/4D orientation.

The LIS2DUX12 is available in a small thin plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

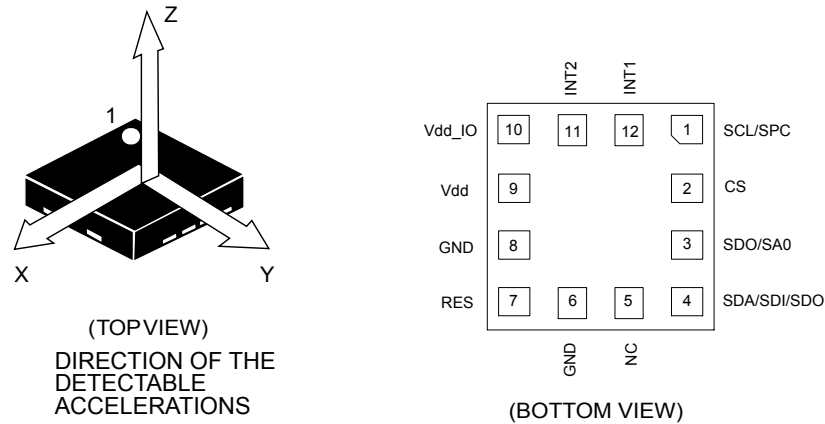
# 1 Block diagram and pin description

## 1.1 Block diagram

Figure 1. Block diagram



## 1.2 Pin description

**Figure 2. Pin connections**

**Table 1. Pin description**

Pin#	Name	Function
1	SCL SPC	I <sup>2</sup> C/MIPI I3C <sup>®</sup> serial clock (SCL) SPI serial port clock (SPC)
2 <sup>(1)</sup>	CS	SPI/I <sup>2</sup> C/MIPI I3C <sup>®</sup> mode selection (1: SPI idle mode / I <sup>2</sup> C/MIPI I3C <sup>®</sup> enabled; 0: SPI enabled / I <sup>2</sup> C/MIPI I3C <sup>®</sup> disabled)
3 <sup>(2)</sup>	SDO SA0	SPI serial data output (SDO) I <sup>2</sup> C less significant bit of the device address (SA0)
4 <sup>(2)</sup>	SDA SDI SDO	I <sup>2</sup> C/MIPI I3C <sup>®</sup> serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)
5	NC	Internally not connected. Can be tied to Vdd, Vdd_IO, or GND.
6	GND	0 V supply
7	RES	Connect to GND if not used as interrupt pin 1 <sup>(3)</sup>
8	GND	0 V supply
9	Vdd	Power supply
10	Vdd_IO	Power supply for I/O pins
11 <sup>(4)</sup>	INT2	Interrupt pin 2. Clock input when selected in one-shot mode
12 <sup>(4)</sup>	INT1	Interrupt pin 1

1. The CS pin is internally pulled up by default. The pull-up of the CS pin can be disconnected by setting the bit CS\_PU\_DIS of register PIN\_CTRL (0Ch) to 1.
2. The internal pull-up of the SDO/SA0 and SDA/SDI/SDO pins is disconnected by default. The pull-up of the SDO/SA0 pin can be enabled by setting bit SDO\_PU\_EN of register PIN\_CTRL (0Ch) to 1. The pull-up of the SDA/SDI/SDO pin can be enabled by setting bit SDA\_PU\_EN of register PIN\_CTRL (0Ch) to 1.
3. When the INT1\_ON\_RES bit of register CTRL1 (10h) is set to 1, the interrupt signals configured on the INT1 pin are routed to the RES pin.
4. The INT1 and INT2 pins are internally pulled down by default. The internal pull-down of the INT1 pin can be disconnected by setting the PD\_DIS\_INT1 bit in PIN\_CTRL (0Ch) to 1. The internal pull-down of the INT2 pin can be disconnected by setting the PD\_DIS\_INT2 bit in PIN\_CTRL (0Ch) to 1.

## 2 Mechanical and electrical specifications

### 2.1 Mechanical characteristics

@ V<sub>dd</sub> = 1.8 V, T = 25 °C unless otherwise noted.

The product is factory calibrated at 1.8 V. The operational power supply range is from 1.62 V to 3.6 V.

**Table 2. Mechanical characteristics**

Symbol	Parameter	Test conditions	Min.	Typ. <sup>(1)</sup>	Max.	Unit
FS	Measurement range			±2		g
				±4		
				±8		
				±16		
So	Sensitivity <sup>(2)</sup>	@ FS ±2 g		0.061		mg/digit
		@ FS ±4 g		0.122		
		@ FS ±8 g		0.244		
		@ FS ±16 g		0.488		
An	Noise density - high-performance mode	@ FS ±8 g ODR = 800 Hz, BW = ODR/2		220		μg/√Hz
TyOff	Zero-g level offset accuracy <sup>(3)</sup>			±30		mg
TCO	Zero-g offset change vs. temperature			±1		mg/°C
TCS	Sensitivity change vs. temperature			±0.035		%/°C
ST	Self-test positive difference	X-axis	50	-	700	mg
		Y-axis	50	-	700	
		Z-axis	200	-	1200	

1. Typical specifications are not guaranteed.

2. 16-bit format

3. Values after factory calibration test and trimming

## 2.2 Electrical characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted.

The product is factory calibrated at 1.8 V. The operational power supply range is from 1.62 V to 3.6 V.

**Table 3. Electrical characteristics**

Symbol	Parameter	Test conditions	Min.	Typ. <sup>(1)</sup>	Max.	Unit
Vdd	Supply voltage		1.62	1.8	3.6	V
Vdd_IO	I/O pins supply voltage <sup>(2)</sup>	I <sup>2</sup> C and SPI interfaces	1.62		3.6	V
		MIPI I3C <sup>®</sup> interface	1.08		3.6	
IddHP	Current consumption in high-performance mode	FS = ±8 g ODR = all ODRs BW = ODR/2 with anti-aliasing filter Temperature sensor off		10.8		μA
IddLP	Current consumption in low-power mode	FS = ±8 g ODR = 50 Hz, BW = ODR/2 with anti-aliasing filter Temperature sensor off		6.2		μA
IddULP	Current consumption in ultralow-power mode	FS = ±8 g ODR = 1.6 Hz, BW = ODR/2 Temperature sensor off		2.7		μA
IddPD	Current consumption in deep power-down			10		nA
V <sub>IH</sub>	Digital high-level input voltage		0.7*Vdd_IO			V
V <sub>IL</sub>	Digital low-level input voltage				0.3*Vdd_IO	V
V <sub>OH</sub>	Digital high-level output voltage	I <sub>OH</sub> = 4 mA <sup>(3)</sup>	Vdd_IO - 0.2 V			
V <sub>OL</sub>	Digital low-level output voltage	I <sub>OL</sub> = 4 mA <sup>(3)</sup>			0.2 V	

1. Typical specifications are not guaranteed.
2. It is possible to remove Vdd, maintaining Vdd\_IO without blocking the communication busses. In this condition the measurement chain is powered off.
3. 4 mA is the maximum driving capability, that is, the maximum DC current that can be sourced/sunk by the digital pin in order to guarantee the correct digital output voltage levels V<sub>OH</sub> and V<sub>OL</sub>.

## 2.3 Temperature sensor characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted.

**Table 4. Temperature sensor characteristics**

Symbol	Parameter	Min.	Typ. <sup>(1)</sup>	Max.	Unit
Top	Operating temperature range	-40		+85	°C
Toff	Temperature offset <sup>(2)</sup>	-15		+15	°C
TSDr	Temperature sensor output change vs. temperature		0.045 <sup>(3)</sup>		°C/LSB
TODR	Temperature refresh rate		ODR		Hz

1. Typical specifications are not guaranteed.
2. The output of the temperature sensor is 0 LSB (typ.) at 25 °C.
3. 12-bit resolution.

## 2.4 Communication interface characteristics

### 2.4.1 SPI - serial peripheral interface

Subject to general operating conditions for V<sub>DD</sub> and Top.

**Table 5. SPI slave timing values**

Symbol	Parameter	Value <sup>(1)</sup>			Unit	
		Min	Typ	Max		
$f_c(\text{SPC})$	SPI clock frequency			10	MHz	
$t_c(\text{SPC})$	SPI clock period			100	ns	
$t_{\text{high}}(\text{SPC})$	SPI clock high	45				
$t_{\text{low}}(\text{SPC})$	SPI clock low	45				
$t_{\text{su}}(\text{CS})$	CS setup time (mode 3)	5				
	CS setup time (mode 0)	20				
$t_{\text{h}}(\text{CS})$	CS hold time (mode 3)	20				
	CS hold time (mode 0)	20				
$t_{\text{su}}(\text{SI})$	SDI input setup time	5				
$t_{\text{h}}(\text{SI})$	SDI input hold time	15				
$t_{\text{v}}(\text{SO})$	SDO valid output time		15	25		
$t_{\text{dis}}(\text{SO})$	SDO output disable time			50		
$C_{\text{load}}$	Bus capacitance			100		pF

1. Values are evaluated at 10 MHz clock frequency for SPI with both 4 and 3 wires, based on characterization results, not tested in production

**Figure 3. SPI slave timing in mode 0**

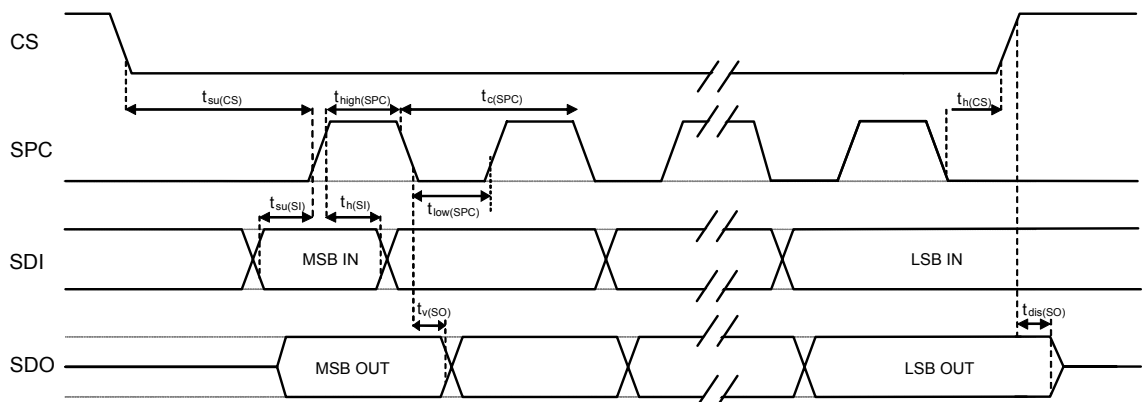
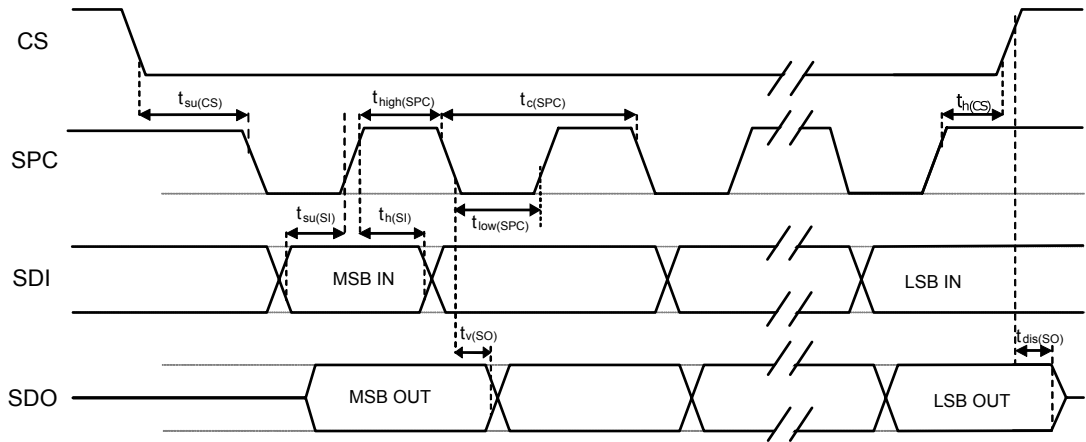


Figure 4. SPI slave timing in mode 3



Note: Measurement points are done at  $0.3 \cdot V_{dd\_IO}$  and  $0.7 \cdot V_{dd\_IO}$  for both input and output ports.

**2.4.2 I<sup>2</sup>C - inter-IC control interface**

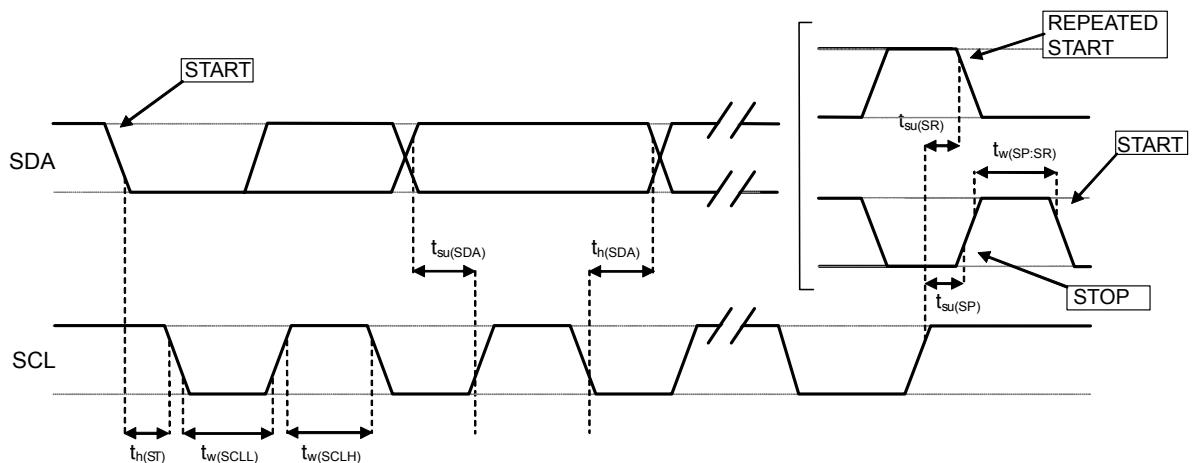
 Subject to general operating conditions for V<sub>dd</sub> and Top.

**Table 6. I<sup>2</sup>C slave timing values**

Symbol	Parameter	I <sup>2</sup> C fast mode <sup>(1)(2)</sup>		I <sup>2</sup> C fast mode plus <sup>(1)(2)</sup>		Unit
		Min	Max	Min	Max	
f <sub>(SCL)</sub>	SCL clock frequency	0	400	0	1000	kHz
t <sub>w(SCLL)</sub>	SCL clock low time	1.3		0.5		μs
t <sub>w(SCLH)</sub>	SCL clock high time	0.6		0.26		
t <sub>su(SDA)</sub>	SDA setup time	100		50		ns
t <sub>h(SDA)</sub>	SDA data hold time	0	0.9	0		μs
t <sub>h(ST)</sub>	START/REPEATED START condition hold time	0.6		0.26		
t <sub>su(SR)</sub>	REPEATED START condition setup time	0.6		0.26		
t <sub>su(SP)</sub>	STOP condition setup time	0.6		0.26		
t <sub>w(SP:SR)</sub>	Bus free time between STOP and START condition	1.3		0.5		
	Data valid time		0.9		0.45	
	Data valid acknowledge time		0.9		0.45	
C <sub>B</sub>	Capacitive load for each bus line		400		550	

 1. Data based on standard I<sup>2</sup>C protocol requirement, not tested in production.

 2. Data for I<sup>2</sup>C fast mode and I<sup>2</sup>C fast mode plus have been validated by characterization, not tested in production.

**Figure 5. I<sup>2</sup>C slave timing diagram**

 Note: Measurement points are done at 0.3·V<sub>dd\_IO</sub> and 0.7·V<sub>dd\_IO</sub> for both ports.

## 2.5 Absolute maximum ratings

Stresses above those listed as “absolute maximum ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device under these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

**Table 7. Absolute maximum ratings**

Symbol	Ratings	Maximum value	Unit
V <sub>dd</sub>	Supply voltage	-0.3 to 4.3	V
V <sub>dd_IO</sub>	I/O pins supply voltage	-0.3 to 4.3	V
V <sub>in</sub>	Input voltage on any control pin (CS, SCL/SPC, SDA/SDI/SDO, SDO/SA0)	-0.3 to V <sub>dd_IO</sub> +0.3	V
A <sub>POW</sub>	Acceleration (any axis, powered, V <sub>dd</sub> = 1.8 V)	3000 g for 0.5 ms	g
		10000 g for 0.2 ms	g
A <sub>UNP</sub>	Acceleration (any axis, unpowered)	3000 g for 0.5 ms	g
		10000 g for 0.2 ms	g
T <sub>OP</sub>	Operating temperature range	-40 to +85	°C
T <sub>STG</sub>	Storage temperature range	-40 to +125	°C
ESD	Electrostatic discharge protection	2 (HBM)	kV

*Note:* Supply voltage on any pin should never exceed 4.3 V.



This device is sensitive to mechanical shock, improper handling can cause permanent damage to the part.



This device is sensitive to electrostatic discharge (ESD), improper handling can cause permanent damage to the part.

## 3 Terminology and functionality

### 3.1 Terminology

#### 3.1.1 Sensitivity

Sensitivity describes the gain of the sensor and can be determined by applying 1 g acceleration to it. As the sensor can measure DC accelerations this can be done easily by pointing the axis of interest towards the center of the Earth, noting the output value, rotating the sensor by 180 degrees (pointing to the sky) and noting the output value again. By doing so,  $\pm 1$  g acceleration is applied to the sensor. Subtracting the larger output value from the smaller one, and dividing the result by 2, leads to the actual sensitivity of the sensor. This value changes very little over temperature and time. The sensitivity tolerance describes the range of sensitivities of a large population of sensors.

#### 3.1.2 Zero-g level offset

Zero-g level offset describes the deviation of an actual output signal from the ideal output signal if no acceleration is present. A sensor in a steady state on a horizontal surface measures 0 g on the X-axis and 0 g on the Y-axis whereas the Z-axis measures 1 g. The output is ideally in the middle of the dynamic range of the sensor (content of OUT registers 00h, data expressed as two's complement number). A deviation from ideal value in this case is called zero-g level offset. Offset is to some extent a result of stress to the MEMS sensor and therefore the offset can slightly change after mounting the sensor onto a printed circuit board or exposing it to extensive mechanical stress. Offset changes little over temperature, see "Zero-g level offset change vs. temperature".

### 3.2 Functionality

#### 3.2.1 Operating modes

The LIS2DUX12 has 4 operating modes: high-performance, low-power, ultralow-power, and one-shot mode. In low-power mode, an aggressive anti-aliasing filter is active, but the overall current consumption remains extraordinarily low (refer to [Table 3](#)).

#### 3.2.2 One-shot modes

The device features two one-shot modes: one-shot triggered by the INT2 pin, and one-shot triggered by the I<sup>2</sup>C/SPI/I<sup>3</sup>C digital interface.

#### 3.2.3 Self-test

Self-test mode allows checking the sensor functionality without moving it, applying an actuation force to the sensor and simulating a definite input acceleration.

### 3.2.4 Activity/inactivity, Android stationary/motion detection functions

The activity/inactivity function recognizes the device's sleep state and allows reducing system power consumption.

When the activity/inactivity function is activated by setting the SLEEP\_ON bit in [WAKE\\_UP\\_THS \(1Ch\)](#), the device automatically goes to the inactivity output data rate selected by the INACT\_ODR[1:0] bits in register [CTRL4 \(13h\)](#).

With this feature the system may be efficiently switched from low-power mode to full performance depending on user-selectable positioning and acceleration events, thus ensuring power saving and flexibility.

The Android stationary/motion detection function only recognizes the device's sleep state.

When the Android stationary/motion detection function is activated by setting to a stationary condition the INACT\_ODR[1:0] bits in register [CTRL4 \(13h\)](#), the device detects acceleration below a fixed threshold but does not change the ODR after sleep state detection.

The activity/inactivity recognition and Android stationary/motion detection functions are activated by writing the desired threshold in the [WAKE\\_UP\\_THS \(1Ch\)](#) register. The high-pass filter is automatically enabled.

If the device is in sleep (inactivity/stationary) mode, when at least one of the axes exceeds the threshold in [WAKE\\_UP\\_THS \(1Ch\)](#), the device goes into a sleep-to-wake state (as wake-up).

For the activity/inactivity function, the device, in a wake-up state, returns to the ODR before sleep state detection.

Activity/inactivity, Android stationary/motion detection threshold and duration can be configured in the following control registers:

[WAKE\\_UP\\_THS \(1Ch\)](#)

[WAKE\\_UP\\_DUR \(1Dh\)](#)

### 3.2.5 Interrupt event recognition

The device may be configured to generate interrupt signals coming from an independent inertial wake-up/free-fall event or from the position of the device itself. Thresholds and timing of this interrupt generator are programmable by the end user in runtime.

Automatic programmable sleep-to-wake-up and return-to-sleep functions are also available for enhanced power saving.

The device interrupts signal can behave as:

- Free-fall: 3-axis underthreshold recognition;
- Wake-up: axis recognition;
- Wake-to-sleep: change of state recognition active-sleep (also known as activity-inactivity);
- 6D and 4D orientation detection: change of position recognition;
- Tap-tap: single, double, triple axis and sign recognition.

All these functions are parallel but during sleep it is not possible to recognize a tap-tap event. All these signals can be driven to the two interrupt pins (INT1 and INT2) through registers [MD1\\_CFG \(1Fh\)](#) and [MD2\\_CFG \(20h\)](#).

All these functions are enabled by setting the INTERRUPTS\_ENABLE bit in register [INTERRUPT\\_CFG \(17h\)](#) to 1.

It is possible to configure the duration of the interrupt using the LIR bit in [INTERRUPT\\_CFG \(17h\)](#) as shown in the following table.

**Table 8. Configuration of duration of interrupt**

LIR	Interrupt type
0	Level mode
1	Latched mode

- Interrupt level mode: the interrupt signal goes high when an interrupt event occurs and is reset when the acceleration data fall below the threshold.
- Interrupt latched mode: the interrupt signal on the INT1/INT2 pins is the OR of the interrupt flags enabled through the [MD1\\_CFG \(1Fh\)](#) and [MD2\\_CFG \(20h\)](#) registers. Each interrupt flag goes to 1 when an interrupt event occurs and is reset when the dedicated source register is read. The interrupt generator block is inhibited 1 ODR after the reset event. It is possible to reset all the interrupt flags simultaneously by reading the [ALL\\_INT\\_SRC \(24h\)](#) register.

### 3.3 Sensing element

A proprietary process is used to create a surface micromachined accelerometer. The technology allows processing suspended silicon structures which are attached to the substrate in a few points called anchors and are free to move in the direction of the sensed acceleration. In order to be compatible with the traditional packaging techniques, a cap is placed on top of the sensing element to avoid blocking the moving parts during the molding phase of the plastic encapsulation. When an acceleration is applied to the sensor the proof mass displaces from its nominal position, causing an imbalance in the capacitive half-bridge. This imbalance is measured using charge integration in response to a voltage pulse applied to the capacitor.

At steady-state the nominal value of the capacitors are a few pF and when an acceleration is applied, the maximum variation of the capacitive load is in the fF range.

### 3.4 IC interface

The complete measurement chain is composed of a low-noise capacitive amplifier which converts the capacitive unbalancing of the MEMS sensor into an analog voltage using an analog-to-digital converter.

The acceleration data may be accessed through an I<sup>2</sup>C/SPI/MIPI I3C<sup>®</sup> interface thus making the device particularly suitable for direct interfacing with a microcontroller.

The LIS2DUX12 features a data-ready signal which indicates when a new set of measured acceleration data is available, thus simplifying data synchronization in the digital system that uses the device.

### 3.5 Factory calibration

The IC interface is factory-calibrated for sensitivity ( $S_0$ ) and zero- $g$  level offset.

The trim values are stored inside the device in nonvolatile memory. Any time the device is turned on, the trimming parameters are downloaded into the registers to be used during active operation. This allows using the device without further calibration. If an accidental write occurs in the registers where the trimming parameters are stored, the BOOT bit in CTRL4 (13h) can help to retrieve the correct trimming parameters from nonvolatile memory without the need to switch on/off the device. This bit is automatically reset at the end of the download operation. Setting this bit has no impact on the control registers.

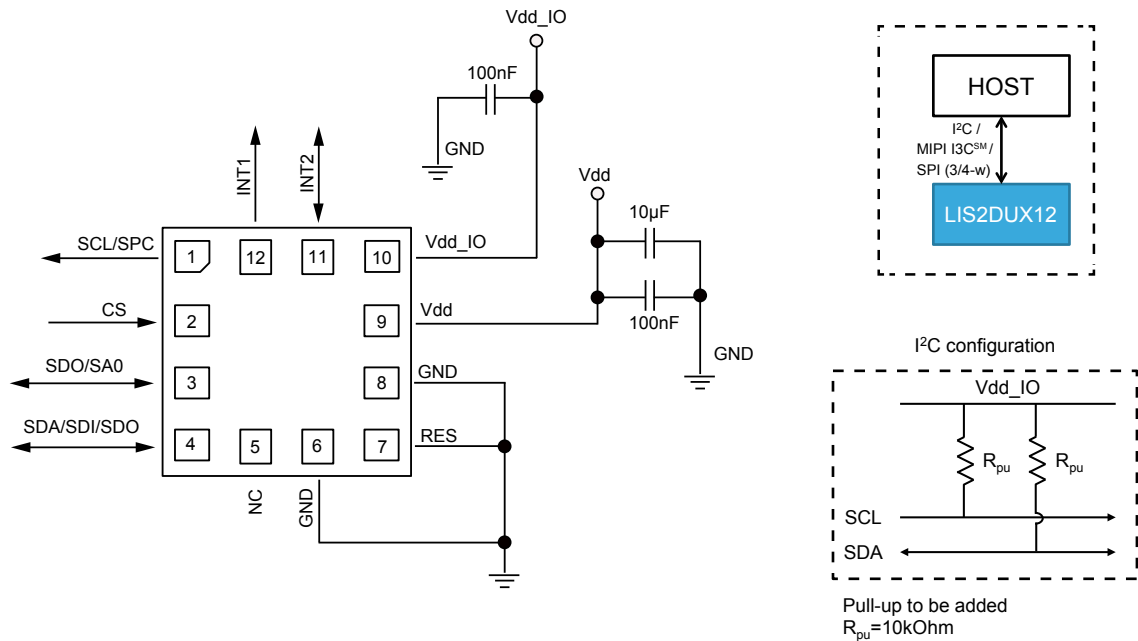
### 3.6 Temperature sensor

The temperature is available in OUT\_T\_L (2Eh), OUT\_T\_H (2Fh) stored as two's complement data, left-justified in 12-bit mode.

Refer to [Table 4. Temperature sensor characteristics](#) for the conversion factor.

## 4 Application hints

Figure 6. LIS2DUX12 electrical connections (top view)



The device core is supplied through the Vdd line while the I/O pins are supplied through the Vdd\_IO line. Power supply decoupling capacitors (100 nF ceramic, 10 µF aluminum) should be placed as near as possible to pin 9 of the device (common design practice).

All the voltage and ground supplies must be present at the same time to have proper behavior of the IC (refer to Figure 6). It is possible to remove Vdd while maintaining Vdd\_IO without blocking the communication bus, in this condition the measurement chain is powered off.

The functionality of the device and the measured acceleration data are selectable and accessible through the I<sup>2</sup>C/MIPI I3C<sup>®</sup> or SPI interfaces. When using the I<sup>2</sup>C, CS must be tied high (that is, connected to Vdd\_IO).

The functions, the threshold and the timing of the two interrupt pins (INT1 and INT2) can be completely programmed by the user through the I<sup>2</sup>C/MIPI I3C<sup>®</sup>/SPI interface.

**Table 9. Internal pin status**

Pin #	Name	Function	Pin status
1	SCL SPC	I <sup>2</sup> C/MIPI I3C <sup>®</sup> serial clock (SCL) SPI serial port clock (SPC)	Default: input without pull-up
2	CS	SPI/I <sup>2</sup> C/MIPI I3C <sup>®</sup> mode selection 1: SPI idle mode / I <sup>2</sup> C/MIPI I3C <sup>®</sup> enabled 0: SPI enabled / I <sup>2</sup> C/MIPI I3C <sup>®</sup> disabled	Default: input with internal pull-up
3	SDO SA0	Serial data output (SDO) I <sup>2</sup> C less significant bit of the device address (SA0)	Default: input without internal pull-up
4	SDA SDI SDO	I <sup>2</sup> C/MIPI I3C <sup>®</sup> serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)	Default: (SDA) input without internal pull-up
5	NC	Internally not connected. Can be tied to Vdd, Vdd_IO, or GND.	
6	GND	0 V supply	
7	RES	Connect to GND if not used as interrupt pin 1 <sup>(1)</sup>	
8	GND	0 V supply	
9	Vdd	Power supply	
10	Vdd_IO	Power supply for I/O pins	
11	INT2	Interrupt pin 2. Clock input when selected in one-shot mode.	Default: input with internal pull-down <sup>(2)(3)</sup>
12	INT1	Interrupt pin 1	Default: input with internal pull-down <sup>(4)(5)</sup>

1. When the `INT1_ON_RES` bit of register `CTRL1` (10h) is set to 1, the interrupt signals configured on the `INT1` pin are routed to the `RES` pin.
2. The internal pull-down can be disconnected by setting the `PD_DIS_INT2` bit of register `PIN_CTRL` (0Ch) to 1. When this is done, the `INT2` pin needs to be externally biased.
3. The `INT2` pin is configured as "push-pull output forced to GND" (and the internal pull-down disabled) as soon as it is configured with the interrupt configuration bits in the `CTRL3` (12h), `MD2_CFG` (20h), `EMB_FUNC_INT2` (0Eh), `FSM_INT2` (0Fh), and `MLC_INT2` (11h) registers.
4. The internal pull-down can be disconnected by setting the `PD_DIS_INT1` bit of register `PIN_CTRL` (0Ch) to 1. When this is done, the `INT1` pin needs to be externally biased.
5. The `INT1` pin is configured as "push-pull output forced to GND" (and the internal pull-down disabled) as soon as it is configured with the interrupt configuration bits in the `CTRL2` (11h), `MD1_CFG` (1Fh), `EMB_FUNC_INT1` (0Ah), `FSM_INT1` (0Bh), and `MLC_INT1` (0Dh) registers.

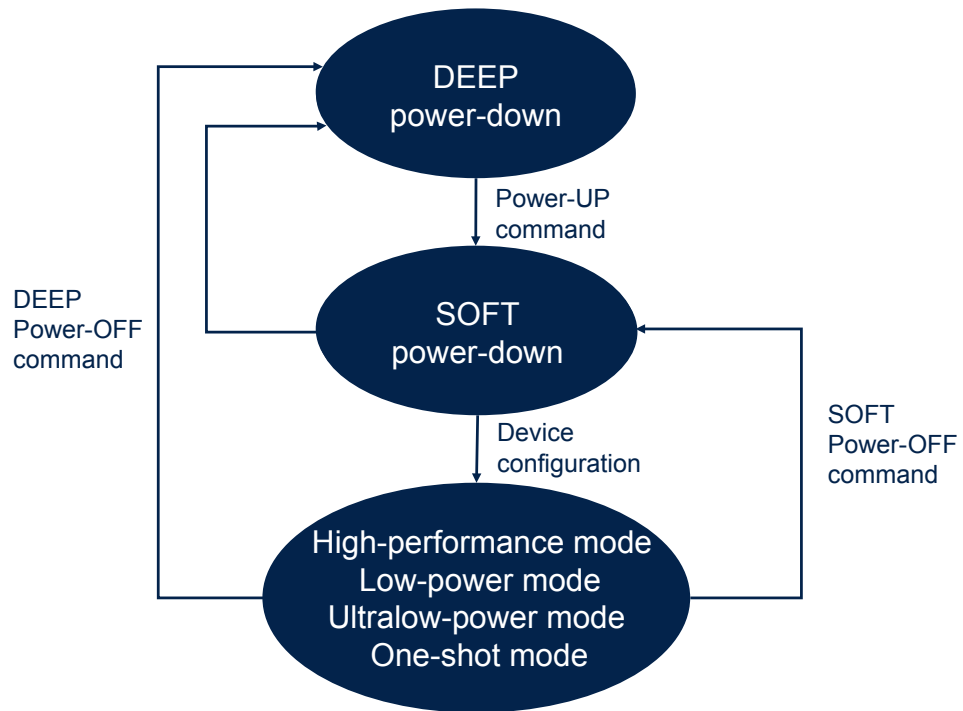
### 4.1 Power-up sequence

When Vdd and Vdd\_IO are set, the device enters a deep power-down state: this is an ultralow current condition in which the device is powered but with a very aggressive trade-off in current consumption.

In order to wake up the device, the first step is to perform a power-up command bringing the device into a soft power-down state: the device is now ready to be configured and generate data.

The LIS2DUX12 offers 4 different operating modes able to generate accelerometer and temperature data: high-performance mode, low-power mode, ultralow-power mode, and one-shot mode.

Figure 7. Power-up sequence



#### 4.1.1 Power-up command

The power-up command allows the LIS2DUX12 to transition from deep power-down to soft power-down. It differs if either the I<sup>2</sup>C/I<sup>3</sup>C interface or the SPI interface is used. See [Section 6](#) for more details on the digital interfaces.

##### 4.1.1.1 I<sup>2</sup>C/I<sup>3</sup>C interfaces

If the I<sup>2</sup>C or I<sup>3</sup>C interfaces are used, the following sequence should be provided to the device:

- ST/SR+ STATIC ADDRESS+R/W (both R and W sequences are supported)

The device generates a NACK and starts power-up. The operation takes 25 ms (maximum) and once completed LIS2DUX12 is in the SOFT\_PD state. It is possible to verify the correct transition in the soft power-down state providing again the power-up command (ST/SR+ STATIC ADDRESS+R/W) and checking the ACK generation from the device.

To guarantee the current execution of the power-up command, the I<sup>2</sup>C/I<sup>3</sup>C master should operate at open-drain speed using I<sup>2</sup>C fast mode plus reference timing.

In the LIS2DUX12 if the bus is at 1.2 V and the device is in deep power-down, the master should use I<sup>2</sup>C fast mode timing instead of I<sup>2</sup>C fast mode plus to perform the power-up command. Once the device is awake, the soft power-down rules apply in the same way as the other voltages.

If the I<sup>3</sup>C interface is used, a dynamic address should be assigned before starting device configuration. Once the DAA procedure is performed, the dynamic address is stored inside the device and it is maintained if the device returns to the deep power-down state. In this event, no other DAA procedures are needed and the power-up commands can be executed directly using the dynamic address.

##### 4.1.1.2 SPI interface

If the SPI interface is used, the LIS2DUX12 can move from deep power-down to soft power-down by writing the bit SOFT\_PD of IF\_WAKE\_UP (3Eh) to 1. The device starts the power-up and this operation takes 25 ms (maximum). In order to verify that device has correctly completed the transition to soft power-down, the who\_am\_I value (expected to be equal to 47h) can be checked by reading register WHO\_AM\_I (0Fh).

*Note:* When the power-up command is performed using the SPI interface, the I<sup>2</sup>C and the I<sup>3</sup>C interfaces are automatically disabled as soon as the device exits deep power-down condition. They are automatically re-enabled after a deep power-off command is executed.

#### 4.1.2 Soft power-off command

When the LIS2DUX12 is configured in one of the four operating modes, it is possible to switch to the soft power-down condition, writing the ODR[3:0] bits in register CTRL5 (14h) to 0000.

#### 4.1.3 Deep power-off command

When device is in soft power-down or it is configured in one of the four operating modes, it is possible to switch to the deep power-down condition, writing the bit DEEP\_PD in register SLEEP (3Dh) to 1. When a transition to deep power-down occurs, all the registers are reset to their default value and a new power-up command and device configuration need to be done.

## 5 Digital main blocks and embedded low-power features

The LIS2DUX12 has been designed to be fully compliant with Android, featuring the following on-chip functions:

- FIFO data buffering
  - 100% efficiency with flexible configurations and partitioning
  - Possibility to store timestamp
- Event-detection interrupts (fully configurable)
  - Free-fall
  - Wake-up
  - 6D/4D orientation
  - Single/double/triple-tap detection
  - Activity/inactivity recognition
  - Stationary/motion detection
- Specific IP blocks (called "embedded functions") with negligible power consumption and high-performance
  - Pedometer functions: step detector and step counters
  - Tilt
  - Significant motion detection
  - Finite state machine (FSM)
  - Machine learning core (MLC) with exportable features and filters for AI applications

### 5.1 FIFO

The LIS2DUX12 embeds 128 slots of 7 bytes each (1 byte TAG + 6 bytes DATA). This allows consistent power saving for the system, since the host processor does not need to continuously poll data from the sensor, but it can wake up only when needed and burst the significant data out from the FIFO.

FIFO is designed in order to allow the batching of different kinds of sensors. It is possible to store in FIFO the data of the accelerometer and temperature physical sensors along with the data of virtual sensors like the step counter, the MLC features / filters / results and FSM results.

The reconstruction of a FIFO stream is a simple task thanks to the FIFO\_DATA\_OUT\_TAG byte that allows recognizing the meaning of a word in FIFO.

The applications have maximum flexibility in choosing the rate of batching for physical sensors with FIFO dedicated configurations.

FIFO allows correctly reconstructing the timestamp information for each sensor stored in FIFO. Also, if a change in the ODR or BDR (batch data rate) configuration is performed, the application can correctly reconstruct the timestamp and know exactly when the change was applied in a FIFO stream without disabling FIFO batching. FIFO stores information of the new configuration and timestamp in which the change was applied in the device.

In order to maximize the amount of data collected in FIFO, it is possible to double the slots of FIFO data (from 128 to 256) by writing the FIFO\_DEPTH bit to 1 in FIFO\_CTRL (15h) with 2x depth mode. When this mode is enabled, the most significant 8 bits for each acceleration data are stored in FIFO. Each FIFO data word contains data of two consecutive ODRs, the actual and the previous one.

In high-resolution batch mode, accelerometer and temperature data are stored in FIFO in 12-bit format at the ODR rate.

In 2x depth batch mode, each FIFO word contains two accelerometer data in 8-bit format at the ODR/2 rate.

It is possible to avoid storing the temperature data in FIFO by setting the XL\_ONLY\_FIFO bit in FIFO\_WTM (16h) register to 1. In this case, the accelerometer data are stored in FIFO in 16-bit format at the ODR rate.

The FIFO buffer can work according to six different modes:

- Bypass mode
- FIFO mode
- Continuous mode
- Continuous-to-FIFO mode
- Bypass-to-continuous
- Bypass-to-FIFO

Each mode is selected by the FIFO\_MODE[2:0] bits in the FIFO\_CTRL (15h) register. A programmable FIFO watermark is selected in the FIFO\_WTM (16h) register.

FIFO status is available in the FIFO\_STATUS1 (26h) and FIFO\_STATUS2 (27h) registers and can be used to generate dedicated interrupts on the INT1 and INT2 pins using the CTRL2 (11h) and CTRL3 (12h) registers.

The FIFO\_WTM\_IA bit in the FIFO\_STATUS1 (26h) register goes to 1 when the number of unread samples is greater than or equal to FTH[6:0] in FIFO\_WTM (16h). If FTH[6:0] is equal to 0, the FIFO\_WTM\_IA bit in FIFO\_STATUS1 (26h) goes to 0.

The FIFO\_OVR\_IA bit in FIFO\_STATUS1 (26h) is equal to 1 if a FIFO sample is overwritten.

FSS[7:0] in FIFO\_STATUS2 (27h) contains stored data levels of unread samples.

When FSS[7:0] is equal to 00000000, FIFO is empty. When FSS[7:0] is equal to 10000000, FIFO is full and the unread samples are 128.

### 5.1.1 Bypass mode

In bypass mode FIFO\_CTRL (15h) (FIFO\_MODE[2:0] = 000), the FIFO is not operational, no data is collected in FIFO memory, and it remains empty with only the actual sample available in the output registers.

Bypass mode is also used to reset the FIFO when in FIFO mode.

### 5.1.2 FIFO mode

In FIFO mode FIFO\_CTRL (15h) (FIFO\_MODE[2:0] = 001) data from the output channels are stored in the FIFO memory until it is full. When 128 unread samples are stored in memory, data collecting is stopped.

To reset FIFO content, bypass mode should be selected by writing FIFO\_CTRL (15h) (FIFO\_MODE[2:0]) to 000. After this reset command, it is possible to restart FIFO mode, writing FIFO\_CTRL (15h) (FIFO\_MODE[2:0]) to 001.

### 5.1.3 Continuous mode

Continuous mode FIFO\_CTRL (15h) (FIFO\_MODE[2:0] = 110) provides a continuous FIFO update: when 128 unread samples are stored in memory, as new data arrives, the oldest data is discarded and overwritten by the newer.

A FIFO threshold flag FIFO\_WTM\_IA bit in FIFO\_STATUS1 (26h) is asserted when the number of unread samples in FIFO is greater than or equal to FTH[6:0] in FIFO\_WTM (16h).

It is possible to route the FIFO\_WTM\_IA bit to the INT1 pin by writing the INT1\_FIFO\_TH bit to 1 in register CTRL2 (11h) or to the INT2 pin by writing the INT2\_FIFO\_TH bit to 1 in register CTRL3 (12h).

If an overrun occurs, the oldest sample in FIFO is overwritten and the FIFO\_OVR\_IA flag in FIFO\_STATUS1 (26h) is asserted.

### 5.1.4 Continuous-to-FIFO mode

In continuous-to-FIFO mode FIFO\_MODE[2:0] = 011 in the FIFO\_CTRL (15h) register, FIFO operates in continuous mode and FIFO mode starts upon an edge trigger event. When the FIFO is full, data collecting is stopped. The trigger event could be single/double/triple-tap, wake-up, free-fall, 6D interrupt or any combination of these events, but every interrupt has to be routed to the corresponding pin to be used as a trigger.

### 5.1.5 Bypass-to-continuous mode

In bypass-to-continuous mode [FIFO\\_CTRL \(15h\)](#) ([FIFO\\_MODE\[2:0\]](#) = 100), data measurement storage inside FIFO starts in continuous mode upon an edge trigger event.

The trigger event could be single/double/triple-tap, wake-up, free-fall, 6D interrupt or any combination of these events, but every interrupt has to be routed to the corresponding pin to be used as a trigger. The sample that generated the trigger is available in FIFO.

### 5.1.6 Bypass-to-FIFO

In bypass-to-FIFO mode [FIFO\\_CTRL \(15h\)](#)([FIFO\\_MODE\\_\[2:0\]](#) = 111), data measurement storage inside FIFO operates in FIFO mode when selected triggers are equal to 1, otherwise FIFO content is reset (bypass mode).

The trigger event could be single/double/triple-tap, wake-up, free-fall, 6D interrupt or any combination of these events, but every interrupt has to be routed to the corresponding pin to be used as a trigger.

The sample that generated the trigger is available in FIFO.

### 5.1.7 FIFO reading procedure

When FIFO is enabled and the mode is different from bypass, reading the FIFO output registers return the oldest FIFO sample set. Whenever these registers are read, their content is moved to the SPI/I<sup>2</sup>C/MIPI I3C<sup>®</sup> output buffer.

The data stored in FIFO are accessible from dedicated registers and each FIFO word is composed of 7 bytes: one tag byte ([FIFO\\_DATA\\_OUT\\_TAG \(40h\)](#)), in order to identify the sensor, and 6 bytes of fixed data ([FIFO\\_DATA\\_OUT](#) registers from (41h) to (46h)).

The [FSS\[7:0\]](#) field in the [FIFO\\_STATUS2 \(27h\)](#) registers contains the number of words (1 byte TAG + 6 bytes DATA) collected in FIFO.

Meta information about accelerometer configuration changes can be managed by enabling the [CFG\\_CHG\\_EN](#) bit in [FIFO\\_CTRL \(15h\)](#).

The entire FIFO content is retrieved by performing a certain number of read operations from the FIFO output registers until the buffer becomes empty ([FSS\[7:0\]](#) bits of the [FIFO\\_STATUS2 \(27h\)](#) register are equal to 0).

FIFO output data must be read with multiples of 7-byte reads starting from the [FIFO\\_DATA\\_OUT\\_TAG \(40h\)](#) register.

The rounding function (automatic wraparound) from address [FIFO\\_DATA\\_OUT\\_Z\\_L \(45h\)](#) and [FIFO\\_DATA\\_OUT\\_Z\\_H \(46h\)](#) to [FIFO\\_DATA\\_OUT\\_TAG \(40h\)](#) is done automatically in the device, in order to allow reading many words with a unique multiple read operation.

The recommended way to retrieve data from the FIFO is the following:

1. Read the [FIFO\\_STATUS2 \(27h\)](#) register to check how many words are stored in the FIFO. This information is contained in the [FSS\[7:0\]](#) bits.
2. For each word in FIFO, read the FIFO word (tag and output data) and interpret it on the basis of the FIFO tag.
3. Go to step 1.

### 5.1.8 FIFO empty condition

When FIFO is emptied, a dedicated FIFO tag value (equal to 00000) is used in order to recognize an empty condition and no duplicated samples are read.

## 5.2 Pedometer functions: step detector and step counters

The LIS2DUX12 embeds an advanced pedometer with an algorithm running in an ultralow-power domain in order to ensure extensive battery life in battery-constrained applications.

Leveraging on enhanced configurability, the advanced embedded pedometer is suitable for a large range of applications from mobile to wearable devices.

The algorithm processes and analyzes the accelerometer waveform in order to count the user's steps during walking and running activities.

The pedometer works at 25 Hz and it is not affected by the selected device power mode (ultralow-power, low-power, high-performance), thus guaranteeing an ultralow-power experience and extreme flexibility in conjunction with other device functionalities.

The accelerometer operating mode can be changed at runtime and is based on user requirements without impacting the performance of the pedometer.

The pedometer output can be batched in the device's FIFO buffer, in order to decrease overall system current consumption.

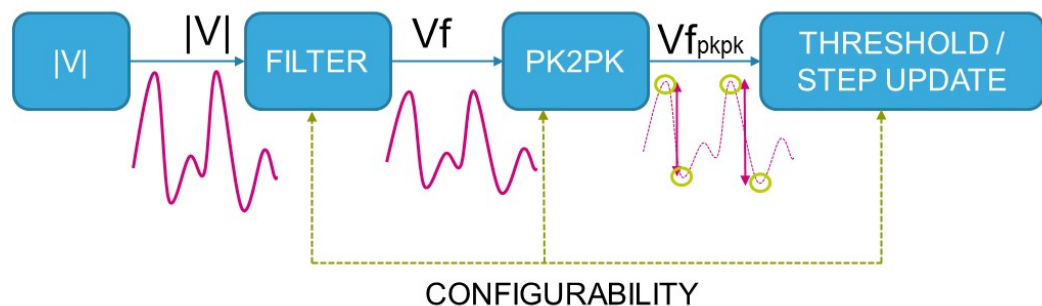
ST freely provides the support and the tools for easily configuring the device and tuning the algorithm configuration for a best-in-class user experience.

## 5.3 Pedometer algorithm

The pedometer algorithm is composed of a cascade of four stages:

1. Computation of the acceleration magnitude signal in order to detect the signal independently from device orientation;
2. FIR filter to extract relevant frequency components and to smooth the signal by cutting off high frequencies;
3. Peak detector to find the maximum and minimum of the waveform and compute the peak-to-peak value;
4. Step count: if the peak-to-peak value is greater than the settled threshold, a step is counted.

**Figure 8. Four-stage pedometer algorithm**



The LIS2DUX12 embeds a dynamic internal threshold for step detection that is updated after each peak-to-peak evaluation: the internal threshold is increased with a configurable speed if a step is detected or decreased with a configurable speed if a step is not detected.

This approach ensures high accuracy when the user starts to walk and a false peak rejection when the user is walking or running.

An internal configurable debounce algorithm can be also set to filter false walks: indeed, an accelerometer pattern is recognized as a walk or run only if a minimum number of steps are counted.

The LIS2DUX12 has been designed to reject a false-positive signal inside the algorithm core.

On top of the mechanisms detailed above, the LIS2DUX12 allows enabling and configuring a dedicated false-positive rejection block to further boost pedometer accuracy.

## 5.4 Tilt detection

The tilt function helps to detect activity change and has been implemented in hardware using only the accelerometer to achieve targets of both ultralow power consumption and robustness during the short duration of dynamic accelerations.

The tilt function is based on a trigger of an event each time the device's tilt changes and can be used with different scenarios, for example:

- Triggers when the phone is in a front pants pocket and the user goes from sitting to standing or standing to sitting;
- Does not trigger when the phone is in a front pants pocket and the user is walking, running, or going upstairs.

## 5.5 Significant motion detection

The significant motion detection (SMD) function generates an interrupt when a 'significant motion', that could be due to a change in user location, is detected. In the LIS2DUX12 device this function has been implemented in hardware using only the accelerometer.

SMD functionality can be used in location-based applications in order to receive a notification indicating when the user is changing location.

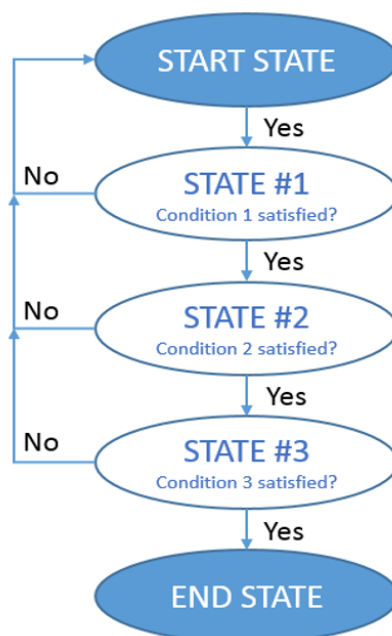
## 5.6 Finite state machine

The LIS2DUX12 can be configured to generate interrupt signals activated by user-defined motion patterns. To do this, up to 8 embedded finite state machines can be programmed independently for motion detection such as glance gestures, absolute wrist tilt, shake and double-shake detection.

### Definition of finite state machine

A state machine is a mathematical abstraction used to design logic connections. It is a behavioral model composed of a finite number of states and transitions between states, similar to a flow chart in which one can inspect the way logic runs when certain conditions are met. The state machine begins with a start state, goes to different states through transitions dependent on the inputs, and can finally end in a specific state (called stop state). The current state is determined by the past states of the system. The following figure shows a generic state machine.

Figure 9. Generic state machine



### Finite state machine in the LIS2DUX12

LIS2DUX12 accelerometer data can be used as input of up to 8 programs in the embedded finite state machine (FSM). The embedded temperature sensor data can also be processed by FSM logic (Figure 10. State machine in the LIS2DUX12).

All 8 finite state machines are independent: each one has its dedicated memory area and it is independently executed. An interrupt is generated when the end state is reached or when some specific command is performed.

Figure 10. State machine in the LIS2DUX12



## 5.7 Machine learning core

The LIS2DUX12 embeds a dedicated core for machine learning processing that provides system flexibility, allowing some algorithms run in the application processor to be moved to the MEMS sensor with the advantage of consistent reduction in power consumption.

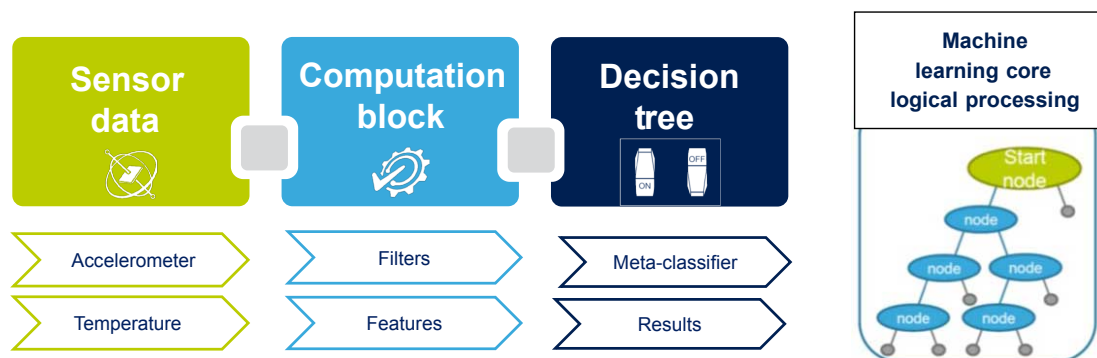
Machine learning core logic allows identifying if a data pattern matches a user-defined set of classes. Typical examples of applications could be activity detection like running, walking, driving, and so on.

The LIS2DUX12 machine learning core works on data patterns coming from the accelerometer sensor, but it is also possible to process the embedded temperature sensor data.

The input data can be filtered using a dedicated configurable computation block containing filters and features computed in a fixed time window defined by the user. Computed feature values and filtered data values can also be read through the FIFO buffer.

Machine learning processing is based on logical processing composed of a series of configurable nodes characterized by "if-then-else" conditions where the "feature" values are evaluated against defined thresholds.

Figure 11. Machine learning core in the LIS2DUX12



The LIS2DUX12 can be configured to run up to 4 decision trees simultaneously and independently and every decision tree can generate up to 16 results. The total number of nodes can be up to 128.

The results of the machine learning processing are available in dedicated output registers readable from the application processor at any time.

The LIS2DUX12 machine learning core can be configured to generate an interrupt when a change in the result occurs.

## 5.8 Adaptive self-configuration (ASC)

The LIS2DUX12 supports the adaptive self-configuration (ASC) feature, which allows the FSM to automatically reconfigure the device in real time based on the detection of a specific motion pattern or based on the output of a specific decision tree configured in the MLC, without any intervention from the host processor. The FSM can write a subset of the device registers using the SETR command, which allows indicating the register address and the new value to be written in such a register. The access to these device registers is mutually exclusive with respect to the host.

## 6 Digital interfaces

The registers embedded inside the LIS2DUX12 may be accessed through both the I<sup>2</sup>C, MIPI I3C<sup>®</sup> and SPI serial interfaces. The latter may be software configured to operate either in 3-wire or 4-wire interface mode.

The serial interfaces are mapped to the same pins. To select/exploit the I<sup>2</sup>C/MIPI I3C<sup>®</sup> interface, the CS line must be tied high (that is, connected to Vdd\_IO).

**Table 10. Serial interface pin description**

Pin name	Pin description
CS	SPI/I <sup>2</sup> C/MIPI I3C <sup>®</sup> mode selection 1: SPI idle mode / I <sup>2</sup> C/MIPI I3C <sup>®</sup> enabled 0: SPI enabled / I <sup>2</sup> C/MIPI I3C <sup>®</sup> disabled
SCL	I <sup>2</sup> C/MIPI I3C <sup>®</sup> serial clock (SCL)
SPC	SPI serial port clock (SPC)
SDA	I <sup>2</sup> C/MIPI I3C <sup>®</sup> serial data (SDA)
SDI	SPI serial data input (SDI)
SDO	3-wire interface serial data output (SDO)
SA0	I <sup>2</sup> C address selection (SA0)
SDO	SPI serial data output (SDO)

### 6.1 I<sup>2</sup>C serial interface

The LIS2DUX12 I<sup>2</sup>C is a bus slave. The I<sup>2</sup>C is employed to write data into registers whose content can also be read back.

The relevant I<sup>2</sup>C terminology is given in the table below.

**Table 11. I<sup>2</sup>C terminology**

Term	Description
Transmitter	The device that sends data to the bus
Receiver	The device that receives data from the bus
Master	The device that initiates a transfer, generates clock signals, and terminates a transfer
Slave	The device addressed by the master

There are two signals associated with the I<sup>2</sup>C bus: the serial clock line (SCL) and the serial data line (SDA). The latter is a bidirectional line used for sending and receiving the data to/from the interface. Both lines must be connected to Vdd\_IO through an external pull-up resistor. When the bus is free, both the lines are high. The I<sup>2</sup>C interface is compliant with fast mode (400 kHz) and fast mode + (1000 kHz) I<sup>2</sup>C standards as well as with normal mode.

### 6.1.1 I<sup>2</sup>C operation

The transaction on the bus is started through a start (ST) signal. A start condition is defined as a high to low transition on the data line while the SCL line is held high. After this has been transmitted by the master, the bus is considered busy. The next byte of data transmitted after the start condition contains the address of the slave in the first 7 bits and the eighth bit tells whether the master is receiving data from the slave or transmitting data to the slave. When an address is sent, each device in the system compares the first seven bits after a start condition with its address. If they match, the device considers itself addressed by the master.

The slave address (SAD) associated to the LIS2DUX12 is 001100xb where the x bit is modified by the SA0/SDO pin in order to modify the device address. If the SA0/SDO pin is connected to the supply voltage, the address is 0011001b, otherwise if the SA0/SDO pin is connected to ground, the address is 0011000b. This solution permits to connect and address two different accelerometers to the same I<sup>2</sup>C lines.

Data transfer with acknowledge is mandatory. The transmitter must release the SDA line during the acknowledge pulse. The receiver must then pull the data line low so that it remains stable low during the high period of the acknowledge clock pulse. A receiver which has been addressed is obliged to generate an acknowledge after each byte of data received.

The I<sup>2</sup>C embedded inside the LIS2DUX12 behaves like a slave device and the following protocol must be adhered to. After the start condition (ST) a slave address is sent. Once a slave acknowledge (SAK) has been returned, an 8-bit subaddress (SUB) is transmitted: the 7 LSb represents the actual register address while the CTRL1 (10h) (IF\_ADD\_INC) bit defines the address increment.

The slave address is completed with a read/write bit. If the bit is 1 (read), a repeated start (SR) condition must be issued after the two subaddress bytes. If the bit is 0 (write) the master transmits to the slave with direction unchanged. Table 12 explains how the SAD+read/write bit pattern is composed, listing all the possible configurations.

**Table 12. SAD+read/write patterns**

Command	SAD[6:1]	SAD[0] = SA0	R/W	SAD+R/W
Read	001100	0	1	00110001 (31h)
Write	001100	0	0	00110000 (30h)
Read	001100	1	1	00110011 (33h)
Write	001100	1	0	00110010 (32h)

**Table 13. Transfer when master is writing one byte to slave**

Master	ST	SAD + W		SUB		DATA		SP
Slave			SAK		SAK		SAK	

**Table 14. Transfer when master is writing multiple bytes to slave**

Master	ST	SAD + W		SUB		DATA		DATA		SP
Slave			SAK		SAK		SAK		SAK	

**Table 15. Transfer when master is receiving (reading) one byte of data from slave**

Master	ST	SAD + W		SUB		SR	SAD + R			NMAK	SP
Slave			SAK		SAK			SAK	DATA		

**Table 16. Transfer when master is receiving (reading) multiple bytes of data from slave**

Master	ST	SAD+W		SUB		SR	SAD+R			MAK		MAK		NMAK	SP
Slave			SAK		SAK			SAK	DATA		DATA		DATA		

Data are transmitted in byte format (DATA). Each data transfer contains 8 bits. The number of bytes transferred per transfer is unlimited. Data is transferred with the most significant bit (MSb) first. If a slave receiver doesn't acknowledge the slave address (that is, it is not able to receive because it is performing some real-time function) the data line must be left high by the slave. The master can then abort the transfer. A low to high transition on the SDA line while the SCL line is high is defined as a stop condition. Each data transfer must be terminated by the generation of a stop (SP) condition.

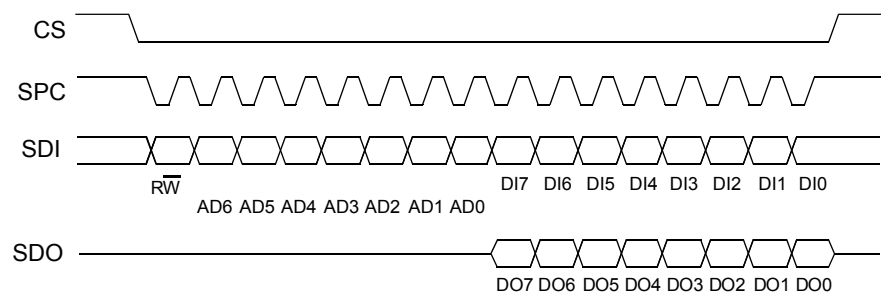
In the presented communication format MAK is master acknowledge and NMAK is no master acknowledge.

## 6.2 SPI bus interface

The LIS2DUX12 SPI is a bus slave. The SPI allows writing to and reading from the registers of the device.

The serial interface interacts with the application using 4 wires: **CS**, **SPC**, **SDI** and **SDO**.

Figure 12. Read and write protocol



**CS** enables the serial port and it is controlled by the SPI master. It goes low at the start of the transmission and goes back high at the end. **SPC** is the serial port clock and it is controlled by the SPI master. It is stopped high when **CS** is high (no transmission). **SDI** and **SDO** are respectively the serial port data input and output. Those lines are driven at the falling edge of **SPC** and should be captured at the rising edge of **SPC**.

Both the read register and write register commands are completed in 16 clock pulses or in multiples of 8 in case of multiple read/write bytes. Bit duration is the time between two falling edges of **SPC**. The first bit (bit 0) starts at the first falling edge of **SPC** after the falling edge of **CS** while the last bit (bit 15, bit 23, ...) starts at the last falling edge of **SPC** just before the rising edge of **CS**.

**bit 0**:  $\overline{RW}$  bit. When 0, the data  $DI(7:0)$  is written into the device. When 1, the data  $DO(7:0)$  from the device is read. In latter case, the chip drives **SDO** at the start of bit 8.

**bit 1-7**: address  $AD(6:0)$ . This is the address field of the indexed register.

**bit 8-15**: data  $DI(7:0)$  (write mode). This is the data that is written into the device (MSb first).

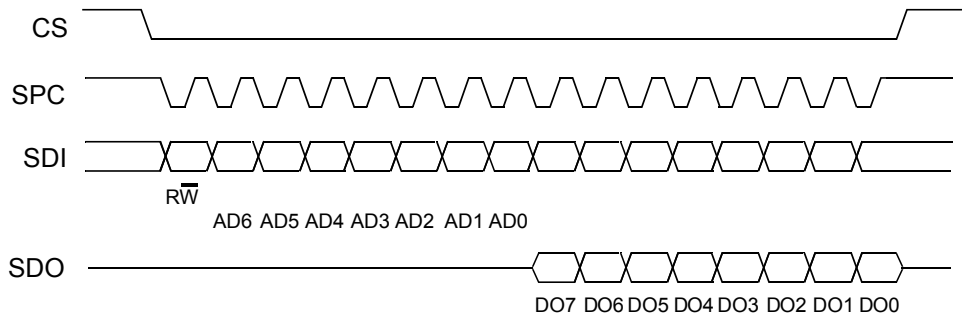
**bit 8-15**: data  $DO(7:0)$  (read mode). This is the data that is read from the device (MSb first).

In multiple read/write commands additional blocks of 8 clock periods are added. When the **CTRL1 (10h)** (**IF\_ADD\_INC**) bit is 0, the address used to read/write data remains the same for every block. When the **CTRL1 (10h)** (**IF\_ADD\_INC**) bit is 1, the address used to read/write data is increased at every block.

The function and the behavior of **SDI** and **SDO** remain unchanged.

### 6.2.1 SPI read

Figure 13. SPI read protocol



The SPI read command is performed with 16 clock pulses. A multiple byte read command is performed by adding blocks of 8 clock pulses to the previous one.

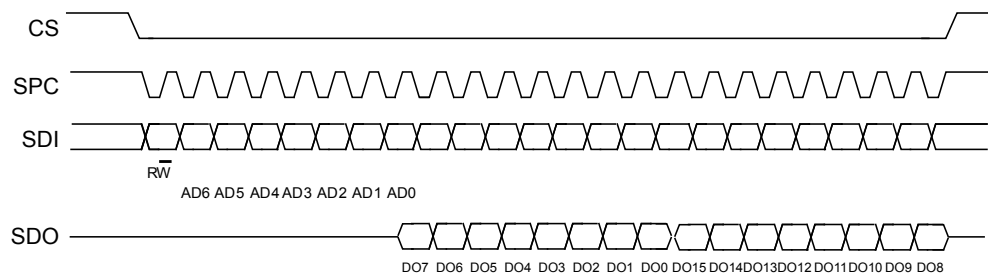
**bit 0:** READ bit. The value is 1.

**bit 1-7:** address AD(6:0). This is the address field of the indexed register.

**bit 8-15:** data DO(7:0) (read mode). This is the data that is read from the device (MSb first).

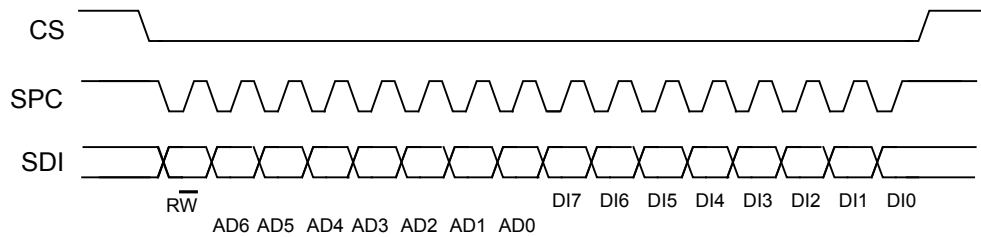
**bit 16-...** : data DO(...-8). Additional data in multiple byte reads.

Figure 14. Multiple byte SPI read protocol (2-byte example)



### 6.2.2 SPI write

Figure 15. SPI write protocol



The SPI write command is performed with 16 clock pulses. A multiple byte write command is performed by adding blocks of 8 clock pulses to the previous one.

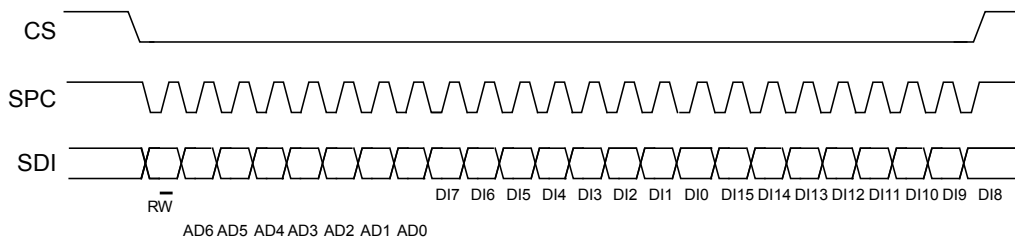
**bit 0:** WRITE bit. The value is 0.

**bit 1-7:** address AD(6:0). This is the address field of the indexed register.

**bit 8-15:** data DI(7:0) (write mode). This is the data that is written inside the device (MSb first).

**bit 16-...** : data DI(...-8). Additional data in multiple byte writes.

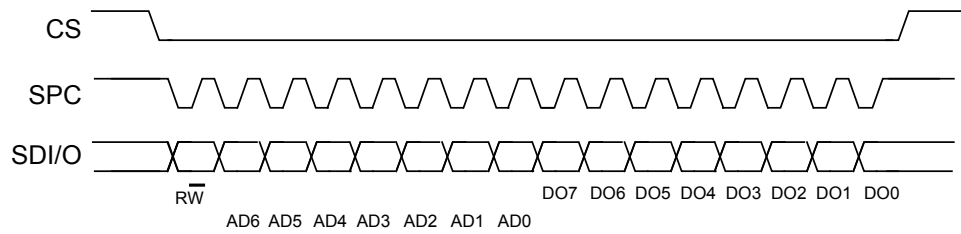
Figure 16. Multiple byte SPI write protocol (2-byte example)



### 6.2.3 SPI read in 3-wire mode

3-wire mode is entered by setting the PIN\_CTRL (0Ch) (SIM) bit equal to 1 (SPI serial interface mode selection).

Figure 17. SPI read protocol in 3-wire mode



The SPI read command is performed with 16 clock pulses:

**bit 0:** READ bit. The value is 1.

**bit 1-7:** address AD(6:0). This is the address field of the indexed register.

**bit 8-15:** data DO(7:0) (read mode). This is the data that is read from the device (MSb first).

A multiple read command is also available in 3-wire mode.

## 6.3 MIPI I3C® interface

### 6.3.1 MIPI I3C® slave interface

The LIS2DUX12 interface includes a MIPI I3C® SDR-only slave interface able to work up to 12.5 MHz of the SCL frequency (compliant with release v1.1 of the specification) with MIPI I3C® SDR embedded features:

- CCC command
- Direct CCC communication (SET and GET)
- Broadcast CCC communication
- Private communications
- Private read and write for single byte
- Multiple read and write
- In-band interrupt request
- Slave reset pattern for reset
- Error detection and recovery (S0 - S6)
- Group address

### 6.3.2 MIPI I3C® CCC supported commands

The list of MIPI I3C® CCC commands supported by the device is detailed in the following table.

**Table 17. MIPI I3C® CCC commands**

Command	Command code	Default	Description
ENTDAA	0x07		DAA procedure
SETDASA	0x87		Assign dynamic address using static address. Static address values are 0x18 / 0x19 depending on SDO pin.
ENEC	0x80 / 0x00		Slave activity control (direct and broadcast)
DISEC	0x81 / 0x01		Slave activity control (direct and broadcast)
ENTAS0	0x82 / 0x02		Enter activity state (direct and broadcast)
RSTDAA	0x86 <sup>(1)</sup> / 0x06		Reset the assigned dynamic address (direct <sup>(1)</sup> and broadcast)
SETMWL	0x89 / 0x08		Define maximum write length during private write (direct and broadcast)
SETMRL	0x8A / 0x09		Define maximum read length during private read (direct and broadcast)
SETNEWDA	0x88		Change dynamic address
GETMWL	0x8B	0x00 0x08 (2 byte)	Get maximum write length during private write
GETMRL	0x8C	0x00 0x10 0x08 (3 byte)	Get maximum read length during private read
GETPID	0x8D	0x02 0x08 0x00 0x47 0x92 0x0B	SDO = 1
		0x02 0x08 0x00 0x47 0x12 0x0B	SDO = 0
GETBCR	0x8E	0x0F (1 byte)	Bus characteristics register
GETDCR	0x8F	0x41 default	MIPI I3C® device characteristics register
GETSTATUS	0x90	0x00 0x00 (2 byte)	Status register
GETMXDS	0x94	0x08 0x60 (2 byte)	Return max data speed
SETGRPA	0x9B		Group address assignment

Command	Command code	Default	Description
RSTGRPA	0x2C / 0x9C		Reset the group address
RSTACT	0x9A / 0x2A		Configure slave reset action
GETCAPS	0x95	0x00 0x11 0x18 0x00	Provide information about device capabilities and supported extended features

1. Direct RSTDAAs can be disabled by writing bit *DIS\_DRSTDAAs* in *I3C\_IF\_CTRL (33h)* to 1.

### 6.3.3 Anti-spike filter management on mixed I<sup>2</sup>C/MIPI I3C® bus

In the LIS2DUX12, the SDA and SCL lines are common to both I<sup>2</sup>C and I3C. The I<sup>2</sup>C bus requires anti-spike filters on the SDA and SCL pins that are not compatible with I3C timing.

The device acts as a standard I<sup>2</sup>C target as long as it is in deep power-down or in soft power-down with an I<sup>2</sup>C static address.

When in deep power-down, the master must emit START, STATIC ADDRESS R/W (or dynamic address if previously assigned) at open-drain speed using I<sup>2</sup>C fast mode plus reference timing to perform a power-up command.

When the device is in soft power-down for the first time after a transition from the deep power-down state, the device is capable of detecting and disabling the I<sup>2</sup>C anti-spike filter after detecting the broadcast address (7'h7E/W). In order to guarantee proper behavior of the device, the I3C master must emit the first START, 7'h7E/W at open-drain speed using I<sup>2</sup>C fast mode plus reference timing.

After detecting the broadcast address, the device can receive the I3C dynamic address following the I3C push-pull timing. If the device is not assigned a dynamic address, then it continues to operate as an I<sup>2</sup>C device with no anti-spike filter. For the case in which the host decides to keep the device as I<sup>2</sup>C with an anti-spike filter, there is a configuration required to keep the anti-spike filter active. This configuration is done by writing the *ASF\_ON* bit to 1 in the *I3C\_IF\_CTRL (33h)* register. This configuration forces the anti-spike filter to always be turned on instead of being managed by the communication on the bus.

## 7 Register mapping

The table given below provides a list of the 8-bit registers embedded in the device and the corresponding addresses.

**Table 18. Register map**

Name	Type <sup>(1)</sup>	Register address		Default	Comment
		Hex	Binary		
PIN_CTRL	R/W	0C	00001100	00000000	
WAKE_UP_DUR_EXT	R/W	0E	00001110	00000000	
WHO_AM_I	R	0F	00001111	01000111	
CTRL1	R/W	10	00010000	00010000	
CTRL2	R/W	11	00010001	00000000	
CTRL3	R/W	12	00010010	00000000	
CTRL4	R/W	13	00010011	00000000	
CTRL5	R/W	14	00010100	00000000	
FIFO_CTRL	R/W	15	00010101	00000000	
FIFO_WTM	R/W	16	00010110	00000000	
INTERRUPT_CFG	R/W	17	00010111	00000000	
SIXD	R/W	18	00011000	00000000	
WAKE_UP_THS	R/W	1C	00011100	00000000	
WAKE_UP_DUR	R/W	1D	00011101	00000000	
FREE_FALL	R/W	1E	00011110	00000000	
MD1_CFG	R/W	1F	00011111	00000000	
MD2_CFG	R/W	20	00100000	00000000	
WAKE_UP_SRC	R	21	00100001	00000000	
TAP_SRC	R	22	00100010	00000000	
SIXD_SRC	R	23	00100011	00000000	
ALL_INT_SRC	R	24	00100100	00000000	
STATUS	R	25	00100101	00000000	
FIFO_STATUS1	R	26	00100110	00000000	
FIFO_STATUS2	R	27	00100111	00000000	
OUT_X_L	R	28	00101000	00000000	
OUT_X_H	R	29	00101001	00000000	
OUT_Y_L	R	2A	00101010	00000000	
OUT_Y_H	R	2B	00101011	00000000	
OUT_Z_L	R	2C	00101100	00000000	
OUT_Z_H	R	2D	00101101	00000000	
OUT_T_L	R	2E	00101110	00000000	
OUT_T_H	R	2F	00101111	00000000	
SELF_TEST	R/W	32	00110010	00000000	
I3C_IF_CTRL	R/W	33	00110011	00000000	
EMB_FUNC_STATUS_MAINPAGE	R	34	00110100	00000000	

Name	Type <sup>(1)</sup>	Register address		Default	Comment
		Hex	Binary		
FSM_STATUS_MAINPAGE	R	35	00110101	00000000	
MLC_STATUS_MAINPAGE	R	36	00110110	00000000	
SLEEP	R/W	3D	00111101	00000000	
IF_WAKE_UP	W	3E	00111110	00000000	
FUNC_CFG_ACCESS	R/W	3F	00111111	00000000	
FIFO_DATA_OUT_TAG	R	40	01000000	00000000	
FIFO_DATA_OUT_X_L	R	41	01000001	00000000	
FIFO_DATA_OUT_X_H	R	42	01000010	00000000	
FIFO_DATA_OUT_Y_L	R	43	01000011	00000000	
FIFO_DATA_OUT_Y_H	R	44	01000100	00000000	
FIFO_DATA_OUT_Z_L	R	45	01000101	00000000	
FIFO_DATA_OUT_Z_H	R	46	01000110	00000000	
FIFO_BATCH_DEC	R/W	47	01000111	00000000	
TAP_CFG0	R/W	6F	01101111	00000000	
TAP_CFG1	R/W	70	01110000	00000000	
TAP_CFG2	R/W	71	01110001	00000000	
TAP_CFG3	R/W	72	01110010	00000000	
TAP_CFG4	R/W	73	01110011	00000000	
TAP_CFG5	R/W	74	01110100	00000000	
TAP_CFG6	R/W	75	01110101	00000000	
TIMESTAMP3	R	7A	01111010	00000000	
TIMESTAMP2	R	7B	01111011	00000000	
TIMESTAMP1	R	7C	01111100	00000000	
TIMESTAMP0	R	7D	01111101	00000000	

1. R = read-only register, R/W = readable/writable register

Reserved registers must not be changed. Writing to those registers may cause permanent damage to the device. The content of the registers that are loaded at boot should not be changed. They contain the factory calibration values. Their content is automatically restored when the device is powered up.

## 8 Register description

### 8.1 PIN\_CTRL (0Ch)

R/W

Table 19. Table 20. PIN\_CTRL register

SDO_PU_EN	SDA_PU_EN	PD_DIS_INT2	PD_DIS_INT1	H_LACTIVE	CS_PU_DIS	PP_OD	SIM
-----------	-----------	-------------	-------------	-----------	-----------	-------	-----

Table 20. PIN\_CTRL register description

SDO_PU_EN	If 1, enables the internal pull-up of the SDO/SA0 pin.
SDA_PU_EN	If 1, enables the internal pull-up of the SDA/SDI/SDO pin.
PD_DIS_INT2	If 1, disables the internal pull-down of the INT2 pin.
PD_DIS_INT1	If 1, disables the internal pull-down of the INT1 pin.
H_LACTIVE	Interrupt active level (0: interrupts active-high (default); 1: Interrupts active-low)
CS_PU_DIS	If 1, disables the internal pull-up of the CS pin.
PP_OD	Push-pull/open-drain mode for INT pins (0: INT pins in push-pull mode (default); 1: INT pins in open-drain mode)
SIM	SPI 3 or 4-wire mode (0: 4-wire SPI (default); 1: 3-wire SPI)

### 8.2 WAKE\_UP\_DUR\_EXT (0Eh)

R/W

Table 21. WAKE\_UP\_DUR\_EXT register

0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	WU_DUR_EXTENDED	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>
------------------	------------------	------------------	-----------------	------------------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

Table 22. WAKE\_UP\_DUR\_EXT register description

WU_DUR_EXTENDED	This bit is used to select the resolution of WAKE_UP_DUR[1:0] bits in register WAKE_UP_DUR (1Dh). Default value: 0
-----------------	---

### 8.3 WHO\_AM\_I (0Fh)

This register is a read-only register. Its value is fixed at 47h.

**Table 23. WHO\_AM\_I register default values**

0	1	0	0	0	1	1	1
---	---	---	---	---	---	---	---

### 8.4 CTRL1 (10h)

R/W

**Table 24. CTRL1 register**

0 <sup>(1)</sup>	INT1_ON_RES	SW_RESET	IF_ADD_INC	DRDY_PULSED	WU_X_EN	WU_Y_EN	WU_Z_EN
------------------	-------------	----------	------------	-------------	---------	---------	---------

1. This bit must be set to 0 for the correct operation of the device.

**Table 25. CTRL1 register description**

INT1_ON_RES	Enables routing the interrupt signals configured on the INT1 pin to the RES pin. Default value: 0 (0: disabled; 1: enabled)
SW_RESET	Software reset, resets all CTRL registers to their default values. Default value: 0 (0: disabled; 1: enabled) This bit is automatically reset to 0 at the end of the procedure.
IF_ADD_INC	Register address is automatically incremented during a multiple-byte access with a serial interface. (0: disabled; 1: enabled (default))
DRDY_PULSED	Enables pulsed data-ready mode (0: data-ready latched mode (returns to 0 only after reading over an interface) (default); 1: data-ready pulsed mode (the data-ready pulses are typ. 90 µs long))
WU_X_EN	Enables wake-up event detection status on X-axis. Default value: 0 (0: disabled; 1: enabled)
WU_Y_EN	Enables wake-up event detection status on Y-axis. Default value: 0 (0: disabled; 1: enabled)
WU_Z_EN	Enables wake-up event detection status on Z-axis. Default value: 0 (0: disabled; 1: enabled)

## 8.5 CTRL2 (11h)

R/W

**Table 26. CTRL2 register**

INT1_BOOT	INT1_FIFO_FULL	INT1_FIFO_TH	INT1_FIFO_OVR	INT1_DRDY	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>
-----------	----------------	--------------	---------------	-----------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 27. CTRL2 register description**

INT1_BOOT	Enables boot status on INT1 pin. Default value: 0 (0: disabled; 1: enabled)
INT1_FIFO_FULL	Enables FIFO full on INT1 pin. Default value: 0 (0: disabled; 1: enabled)
INT1_FIFO_TH	Enables FIFO threshold interrupt on INT1 pin. Default value: 0 (0: disabled; 1: enabled)
INT1_FIFO_OVR	Enables overrun interrupt on INT1 pin. Default value: 0 (0: disabled; 1: enabled)
INT1_DRDY	Data-ready interrupt on INT1 pin. Default value: 0 (0: disabled; 1: enabled)

## 8.6 CTRL3 (12h)

R/W

**Table 28. CTRL3 register**

INT2_BOOT	INT2_FIFO_FULL	INT2_FIFO_TH	INT2_FIFO_OVR	INT2_DRDY	HP_EN	ST_SIGN_Y	ST_SIGN_X
-----------	----------------	--------------	---------------	-----------	-------	-----------	-----------

**Table 29. CTRL3 register description**

INT2_BOOT	Enables boot status on INT2 pin. Default value: 0 (0: disabled; 1: enabled)
INT2_FIFO_FULL	Enables FIFO full on INT2 pin. Default value: 0 (0: disabled; 1: enabled)
INT2_FIFO_TH	Enables FIFO threshold interrupt on INT2 pin. Default value: 0 (0: disabled; 1: enabled)
INT2_FIFO_OVR	Enables overrun interrupt on INT2 pin. Default value: 0 (0: disabled; 1: enabled)
INT2_DRDY	Data-ready interrupt on INT2 pin. Default value: 0 (0: disabled; 1: enabled)
HP_EN	Enables high-performance mode. Default value: 0 (0: low-power mode; 1: high-performance mode)
ST_SIGN_Y	Configures the sign of the self-test for the Y-axis. Default value: 0
ST_SIGN_X	Configures the sign of the self-test for the X-axis. Default value: 0

## 8.7 CTRL4 (13h)

R/W

**Table 30. CTRL4 register**

INACT_ODR1	INACT_ODR0	BDU	EMB_FUNC_EN	FIFO_EN	0 <sup>(1)</sup>	SOC	BOOT
------------	------------	-----	-------------	---------	------------------	-----	------

1. This bit must be set to 0 for the correct operation of the device.

**Table 31. CTRL4 register description**

INACT_ODR[1:0]	If the activity/inactivity function is enabled, then these bits select the accelerometer ODR during inactivity status, see <a href="#">Table 32</a> .
BDU	Sensing chain block data update (0: output registers MSByte and LSByte independent continuous update (default); 1: output registers are not updated until MSByte and LSByte have both been read)
EMB_FUNC_EN	Enables embedded functions. To be set to 1 before configuring the embedded functions. Default value: 0 (0: disabled; 1: enabled)
FIFO_EN	Enables batching in FIFO. To be set to 1 before configuring the FIFO buffer. Default value: 0 (0: disabled; 1: enabled)
SOC	Start of conversion bit. When one-shot mode using the interface (ODR[3:0] = 1111 in the <a href="#">CTRL5 (14h)</a> register) is enabled, this bit provides the start for the measurement. This bit is automatically cleared.
BOOT	Reboots memory content. Default value: 0 (0: normal operating mode; 1: reboot memory content)  This bit is automatically cleared. For proper execution of the boot procedure, set the device in high-performance mode.

**Table 32. ODR frequency in inactivity state**

INACT_ODR1	INACT_ODR0	Frequency [Hz]
0	0	Stationary/motion detection: when selected, no ODR change is done if inactivity condition is detected (default)
0	1	1.6
1	0	3
1	1	25

## 8.8 CTRL5 (14h)

R/W

**Table 33. CTRL5 register**

ODR3	ODR2	ODR1	ODR0	BW1	BW0	FS1	FS0
------	------	------	------	-----	-----	-----	-----

**Table 34. CTRL5 register description**

ODR[3:0]	ODR selection, see <a href="#">Table 35</a> .
BW[1:0]	<p>Selects the device bandwidth, which is dependent on the ODR selected. In high-performance mode (all ODR values) and in low-power mode for ODR ≥ 50 Hz, the available bandwidths are:</p> <p>ODR/2 (BW[1:0] = 00);</p> <p>ODR/4 (BW[1:0] = 01);</p> <p>ODR/8 (BW[1:0] = 10);</p> <p>ODR/16 (BW[1:0] = 11).</p> <p>In low-power mode for ODR &lt; 50 Hz, refer to <a href="#">Table 36</a>.</p>
FS[1:0]	Sets the full scale, see <a href="#">Table 37</a> .

**Table 35. Operating modes**

ODR[3:0]	Operating mode
0000	Power-down
0001	1.6 Hz in ultralow-power
0010	3 Hz in ultralow-power
0011	25 Hz in ultralow-power
0100	6 Hz
0101	12.5 Hz
0110	25 Hz
0111	50 Hz
1000	100 Hz
1001	200 Hz
1010	400 Hz
1011	800 Hz
1110	One-shot using the INT2 pin
1111	One-shot using the interface

**Table 36. Bandwidth selection (low-power mode with ODR < 50 Hz)**

ODR [Hz]	BW[1:0]	BW [Hz]
6	00	-
	01	-
	10	-
	11	3
12.5	00	-
	01	-
	10	6
	11	3
25	00	-
	01	12.5
	10	6
	11	3

**Table 37. Full-scale selection**

FS1	FS0	Full scale
0	0	$\pm 2 g$
0	1	$\pm 4 g$
1	0	$\pm 8 g$
1	1	$\pm 16 g$

## 8.9 FIFO\_CTRL (15h)

R/W

CFG_CHG_EN	FIFO_DEPTH	0 <sup>(1)</sup>	0 <sup>(1)</sup>	STOP_ON_FTH	FIFO_MODE2	FIFO_MODE1	FIFO_MODE0
------------	------------	------------------	------------------	-------------	------------	------------	------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 38. FIFO\_CTRL register description**

CFG_CHG_EN	Enables batching in FIFO of the device configuration and timestamp value when the ODR (output data rate) or the BDR (batch data rate) changes. Default value: 0 (0: disabled; 1: enabled)
FIFO_DEPTH	If 1, enables 2x depth mode for FIFO buffer.
STOP_ON_FTH	Sensing chain FIFO stop values memorization at threshold level. (0: FIFO depth is not limited (default); 1: FIFO depth is limited to threshold level)
FIFO_MODE[2:0] <sup>(1)</sup>	Different FIFO modes are enabled as shown in Table 39.

1. User must set the FIFO\_EN bit to 1 in the CTRL4 (13h) register before setting the FIFO\_MODE[2:0] bits.

**Table 39. Selection of FIFO mode**

FIFO_MODE2	FIFO_MODE1	FIFO_MODE0	Mode
0	0	0	Bypass mode
0	0	1	FIFO mode: stops collecting data when FIFO is full
0	1	0	Reserved
0	1	1	Continuous-to-FIFO: stream mode until trigger is deasserted, then FIFO mode
1	0	0	Bypass-to-continuous: bypass mode until trigger is deasserted, then continuous mode
1	0	1	Reserved
1	1	0	Continuous mode: if the FIFO is full, the new sample overwrites the older sample.
1	1	1	Bypass-to-FIFO: bypass mode until trigger is deasserted, then FIFO mode

## 8.10 FIFO\_WTM (16h)

R/W

**Table 40. FIFO\_WTM register**

XL_ONLY_FIFO	FTH6	FTH5	FTH4	FTH3	FTH2	FTH1	FTH0
--------------	------	------	------	------	------	------	------

**Table 41. FIFO\_WTM register description**

XL_ONLY_FIFO	FIFO data configuration. If this bit is set to 0 (default), both the accelerometer data and the temperature data are stored in FIFO. If this bit is set to 1, only accelerometer data are stored in FIFO.
FTH[6:0]	FIFO watermark threshold, maximum value is 127.

## 8.11 INTERRUPT\_CFG (17h)

R/W

**Table 42. INTERRUPT\_CFG register**

TIMESTAMP_EN	0 <sup>(1)</sup>	WAKE_THS_W	0 <sup>(1)</sup>	SLEEP_STAT_US_ON_INT	DIS_RST_LIR_ALL_INT	LIR	INTERRUPTS_ENABLE
--------------	------------------	------------	------------------	----------------------	---------------------	-----	-------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 43. INTERRUPT\_CFG register description**

TIMESTAMP_EN	Enables timestamp counter. The counter is readable in <a href="#">TIMESTAMP3 (7Ah)</a> , <a href="#">TIMESTAMP2 (7Bh)</a> , <a href="#">TIMESTAMP1 (7Ch)</a> , and <a href="#">TIMESTAMP0 (7Dh)</a> . Default value: 0 (0: disabled; 1: enabled)
WAKE_THS_W	Weight of 1 LSB of wake-up threshold. Default value: 0 (0: 1 LSB = $FS_{XL} / (2^6)$ ; 1: 1 LSB = $FS_{XL} / (2^8)$ )
SLEEP_STATUS_ON_INT	Sends the sleep status instead of sleep change to INT pins (only if <a href="#">INT1_SLEEP_CHANGE</a> or <a href="#">INT2_SLEEP_CHANGE</a> bits are enabled, respectively in registers <a href="#">MD1_CFG (1Fh)</a> and <a href="#">MD2_CFG (20h)</a> ). Default value: 0 (0: sleep change on INT pins; 1: sleep status on INT pins)
DIS_RST_LIR_ALL_INT	If 1, disables the reset of the interrupt flags when <a href="#">ALL_INT_SRC (24h)</a> is read.
LIR	Interrupt mode configuration (see <a href="#">Table 8</a> ). Default value: 0 (0: interrupt level mode; 1: interrupt latched mode)
INTERRUPTS_ENABLE	Enables basic interrupts (6D/4D, free-fall, wake-up, single/double/triple-tap, activity/inactivity). Default value: 0 (0: interrupt disabled; 1: interrupt enabled)

## 8.12 SIXD (18h)

R/W

**Table 44. SIXD register**

D4D_EN	D6D_THS1	D6D_THS0	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>
--------	----------	----------	------------------	------------------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 45. SIXD register description**

D4D_EN	Enables 4D orientation detection. Z-axis position detection is disabled. Default value: 0 (0: disabled; 1: enabled)
D6D_THS[1:0]	Thresholds for 4D/6D function (00: 80 degrees (default); 01: 70 degrees; 10: 60 degrees; 11: 50 degrees)

## 8.13 WAKE\_UP\_THS (1Ch)

R/W

**Table 46. WAKE\_UP\_THS register**

0 <sup>(1)</sup>	SLEEP_ON	WK_THS5	WK_THS4	WK_THS3	WK_THS2	WK_THS1	WK_THS0
------------------	----------	---------	---------	---------	---------	---------	---------

1. This bit must be set to 0 for the correct operation of the device.

**Table 47. WAKE\_UP\_THS register description**

SLEEP_ON	If 1, activity/inactivity function is enabled.
WK_THS[5:0]	Threshold for wake-up: 1 LSB weight depends on WAKE_THS_W in INTERRUPT_CFG (17h). Default value: 000000

## 8.14 WAKE\_UP\_DUR (1Dh)

R/W

**Table 48. WAKE\_UP\_DUR register**

FF_DUR5	WAKE_DUR1	WAKE_DUR0	ST_SIGN_Z	SLEEP_DUR3	SLEEP_DUR2	SLEEP_DUR1	SLEEP_DUR0
---------	-----------	-----------	-----------	------------	------------	------------	------------

**Table 49. WAKE\_UP\_DUR register description**

FF_DUR5	Free-fall duration. Default value: 0 In conjunction with FF_DUR[4:0] in <a href="#">FREE_FALL (1Eh)</a> . 1 LSB: 1 ODR_time
WAKE_DUR[1:0]	Wake-up duration. Default value: 00 When the WU_DUR_EXTENDED bit in register <a href="#">WAKE_UP_DUR_EXT (0Eh)</a> is set to 0, 1LSB of WAKE_DUR = 1 ODR_time, otherwise the following durations are selectable: (00: 3 ODR_time; 01: 7 ODR_time; 10: 11 ODR_time; 11: 15 ODR_time)
ST_SIGN_Z	Configures the sign of the self-test for the Z-axis. Default value: 0
SLEEP_DUR[3:0]	Duration to go in sleep mode. Default value: 0000 which corresponds to 16 ODR_time 1 LSB: 512 ODR_time

## 8.15 FREE\_FALL (1Eh)

R/W

**Table 50. FREE\_FALL register**

FF_DUR4	FF_DUR3	FF_DUR2	FF_DUR1	FF_DUR0	FF_THS2	FF_THS1	FF_THS0
---------	---------	---------	---------	---------	---------	---------	---------

**Table 51. FREE\_FALL register description**

FF_DUR[4:0]	Free-fall duration. Default value: 0 In conjunction with FF_DUR5 in <a href="#">WAKE_UP_DUR (1Dh)</a> . 1 LSB: 1 ODR_time
FF_THS[2:0]	Free-fall threshold (000: 156 mg; 001: 219 mg; 010: 250 mg; 011: 312 mg; 100: 344 mg; 101: 406 mg; 110: 469 mg; 111: 500 mg)

## 8.16 MD1\_CFG (1Fh)

R/W

Each bit in this register enables a signal to be carried over INT1; the pin's output is the OR combination of the signals selected here and in register CTRL2 (11h).

**Table 52. MD1\_CFG register**

INT1_SLEEP_CHANGE	0 <sup>(1)</sup>	INT1_WU	INT1_FF	INT1_TAP	INT1_6D	INT1_TIMESTAMP	INT1_EMB_FUNC
-------------------	------------------	---------	---------	----------	---------	----------------	---------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 53. MD1\_CFG register description**

INT1_SLEEP_CHANGE	Enables sleep change (or sleep status, depending on SLEEP_STATUS_ON_INT bit) on INT1 pin.
INT1_WU	Enables routing wake-up event to the INT1 pin.
INT1_FF	Enables routing free-fall event to the INT1 pin.
INT1_TAP	Enables routing tap event to the INT1 pin.
INT1_6D	Enables routing 6D recognition event to the INT1 pin.
INT1_TIMESTAMP	Enables routing the alert of timestamp overflow within 2.5 ms to the INT1 pin.
INT1_EMB_FUNC	Enables routing embedded functions event to the INT1 pin.

## 8.17 MD2\_CFG (20h)

R/W

Each bit in this register enables a signal to be carried over INT2; the pin's output is the OR combination of the signals selected here and in register CTRL3 (12h).

**Table 54. MD2\_CFG register**

INT2_SLEEP_CHANGE	0 <sup>(1)</sup>	INT2_WU	INT2_FF	INT2_TAP	INT2_6D	INT2_TIMESTAMP	INT2_EMB_FUNC
-------------------	------------------	---------	---------	----------	---------	----------------	---------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 55. MD2\_CFG register description**

INT2_SLEEP_CHANGE	Enables sleep change (or sleep status, depending on SLEEP_STATUS_ON_INT bit) on INT2 pin.
INT2_WU	Enables routing wake-up event to the INT2 pin.
INT2_FF	Enables routing free-fall event to the INT2 pin.
INT2_TAP	Enables routing tap event to the INT2 pin.
INT2_6D	Enables routing 6D recognition event to the INT2 pin.
INT2_TIMESTAMP	Enables routing the alert of timestamp overflow within 2.5 ms to the INT2 pin.
INT2_EMB_FUNC	Enables routing embedded functions event to INT2.

## 8.18 WAKE\_UP\_SRC (21h)

R

**Table 56. WAKE\_UP\_SRC register**

-	SLEEP_CHANGE_IA	FF_IA	SLEEP_STATE	WU_IA	X_WU	Y_WU	Z_WU
---	-----------------	-------	-------------	-------	------	------	------

**Table 57. WAKE\_UP\_SRC register description**

SLEEP_CHANGE_IA	Detection of change in activity/inactivity status. Default value: 0 (0: change status not detected; 1: change status detected)
FF_IA	Free-fall event detection status. Default value: 0 (0: free-fall event not detected; 1: free-fall event detected)
SLEEP_STATE	Sleep status bit. Default value: 0 (0: activity status; 1: inactivity status)
WU_IA	Wake-up event detection status. Default value: 0 (0: wake-up event not detected; 1: wake-up event detected)
X_WU	Wake-up event detection status on X-axis. Default value: 0 (0: wake-up event on X-axis not detected; 1: wake-up event on X-axis detected)
Y_WU	Wake-up event detection status on Y-axis. Default value: 0 (0: wake-up event on Y-axis not detected; 1: wake-up event on Y-axis detected)
Z_WU	Wake-up event detection status on Z-axis. Default value: 0 (0: wake-up event on Z-axis not detected; 1: wake-up event on Z-axis detected)

## 8.19 TAP\_SRC (22h)

R

**Table 58. TAP\_SRC register**

TAP_IA	SINGLE_TAP_IA	DOUBLE_TAP_IA	TRIPLE_TAP_IA	-	-	-	-
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**Table 59. TAP\_SRC register description**

TAP_IA	Tap event detection status. Default: 0 (0: tap event not detected; 1: tap event detected)
SINGLE_TAP_IA	Single-tap event status. Default value: 0 (0: single-tap event not detected; 1: single-tap event detected)
DOUBLE_TAP_IA	Double-tap event detection status. Default value: 0 (0: double-tap event not detected; 1: double-tap event detected)
TRIPLE_TAP_IA	Triple-tap event detection status. Default value: 0 (0: triple-tap event not detected; 1: triple-tap event detected)

## 8.20 SIXD\_SRC (23h)

R

**Table 60. SIXD\_SRC register**

-	D6D_IA	ZH	ZL	YH	YL	XH	XL
---	--------	----	----	----	----	----	----

**Table 61. SIXD\_SRC register description**

D6D_IA	Source of change in 6D/4D orientation. Default value: 0 (0: change orientation not detected; 1: change orientation detected)
ZH	Z-axis high event (over threshold). Default value: 0 (0: event not detected; 1: event (over threshold) detected)
ZL	Z-axis low event (under threshold). Default value: 0 (0: event not detected; 1: event (under threshold) detected)
YH	Y-axis high event (over threshold). Default value: 0 (0: event not detected; 1: event (over-threshold) detected)
YL	Y-axis low event (under threshold). Default value: 0 (0: event not detected; 1: event (under threshold) detected)
XH	X-axis high event (over threshold). Default value: 0 (0: event not detected; 1: event (over threshold) detected)
XL	X-axis low event (under threshold). Default value: 0 (0: event not detected; 1: event (under threshold) detected)

## 8.21 ALL\_INT\_SRC (24h)

R

**Table 62. ALL\_INT\_SRC register**

-	SLEEP_CHANGE_IA_ALL	D6D_IA_ALL	TRIPLE_TAP_ALL	DOUBLE_TAP_ALL	SINGLE_TAP_ALL	WU_IA_ALL	FF_IA_ALL
---	---------------------	------------	----------------	----------------	----------------	-----------	-----------

**Table 63. ALL\_INT\_SRC register description**

SLEEP_CHANGE_IA_ALL	Detection of change in activity/inactivity status. Default value: 0 (0: change in status not detected; 1: change in status detected)
D6D_IA_ALL	Source of change in 6D/4D orientation. Default value: 0 (0: change in orientation not detected; 1: change in orientation detected)
TRIPLE_TAP_ALL	Triple-tap event status. Default value: 0 (0: event not detected, 1: event detected)
DOUBLE_TAP_ALL	Double-tap event status. Default value: 0 (0: event not detected, 1: event detected)
SINGLE_TAP_ALL	Single-tap event status. Default value: 0 (0: event not detected, 1: event detected)
WU_IA_ALL	Wake-up event status. Default value: 0 (0: event not detected, 1: event detected)
FF_IA_ALL	Free-fall event status. Default value: 0 (0: event not detected, 1: event detected)

## 8.22 STATUS (25h)

R

**Table 64. STATUS register**

-	-	INT_GLOBAL	-	-	-	-	DRDY
---	---	------------	---	---	---	---	------

**Table 65. STATUS register description**

INT_GLOBAL	This bit is 1 if one of the following events occur: <ul style="list-style-type: none"> <li>detection of change in activity/inactivity status</li> <li>source of change in 6D/4D orientation</li> <li>single/double/triple-tap event status</li> <li>wake-up event detection status</li> <li>free-fall event detection status</li> <li>sleep event status</li> </ul>
DRDY	This bit is 1 when new accelerometer data is available and until the MSB of one of the output registers has been read.

## 8.23 FIFO\_STATUS1 (26h)

R

**Table 66. FIFO\_STATUS1 register**

FIFO_WTM_IA	FIFO_OVR_IA	-	-	-	-	-	-
-------------	-------------	---	---	---	---	---	---

**Table 67. FIFO\_STATUS1 register description**

FIFO_WTM_IA	FIFO watermark status. The watermark is set through bits FTH[6:0] in FIFO_WTM (16h). (0: FIFO filling is lower than WTM; 1: FIFO filling is equal to or higher than WTM)
FIFO_OVR_IA	FIFO overrun status: 1 if FIFO has overwritten data.

## 8.24 FIFO\_STATUS2 (27h)

R

**Table 68. FIFO\_STATUS2 register**

FSS7	FSS6	FSS5	FSS4	FSS3	FSS2	FSS1	FSS0
------	------	------	------	------	------	------	------

**Table 69. FIFO\_STATUS2 register description**

FSS[7:0]	Number of unread data stored in FIFO
----------	--------------------------------------

## 8.25 OUT\_X\_L (28h)

R

**Table 70. OUT\_X\_L register**

OUTX7	OUTX6	OUTX5	OUTX4	OUTX3	OUTX2	OUTX1	OUTX0
-------	-------	-------	-------	-------	-------	-------	-------

**Table 71. OUT\_X\_L register description**

OUTX[7:0]	LSBs of X data output
-----------	-----------------------

## 8.26 OUT\_X\_H (29h)

R

**Table 72. OUT\_X\_H register**

OUTX15	OUTX14	OUTX13	OUTX12	OUTX11	OUTX10	OUTX9	OUTX8
--------	--------	--------	--------	--------	--------	-------	-------

**Table 73. OUT\_X\_H register description**

OUTX[15:8]	MSBs of X data output
------------	-----------------------

**8.27**     **OUT\_Y\_L (2Ah)**  
R

**Table 74. OUT\_Y\_L register**

OUTY7	OUTY6	OUTY5	OUTY4	OUTY3	OUTY2	OUTY1	OUTY0
-------	-------	-------	-------	-------	-------	-------	-------

**Table 75. OUT\_Y\_L register description**

OUTY[7:0]	LSBs of Y data output
-----------	-----------------------

**8.28**     **OUT\_Y\_H (2Bh)**  
R

**Table 76. OUT\_Y\_H register**

OUTY15	OUTY14	OUTY13	OUTY12	OUTY11	OUTY10	OUTY9	OUTY8
--------	--------	--------	--------	--------	--------	-------	-------

**Table 77. OUT\_Y\_H register description**

OUTY[15:8]	MSBs of Y data output.
------------	------------------------

**8.29**     **OUT\_Z\_L (2Ch)**  
R

**Table 78. OUT\_Z\_L register**

OUTZ7	OUTZ6	OUTZ5	OUTZ4	OUTZ3	OUTZ2	OUTZ1	OUTZ0
-------	-------	-------	-------	-------	-------	-------	-------

**Table 79. OUT\_Z\_L register description**

OUTZ[7:0]	LSBs of Z data output
-----------	-----------------------

**8.30**     **OUT\_Z\_H (2Dh)**  
R

**Table 80. OUT\_Z\_H register**

OUTZ15	OUTZ14	OUTZ13	OUTZ12	OUTZ11	OUTZ10	OUTZ9	OUTZ8
--------	--------	--------	--------	--------	--------	-------	-------

**Table 81. OUT\_Z\_H register description**

OUTZ[15:8]	MSBs of Z data output
------------	-----------------------

**8.31 OUT\_T\_L (2Eh)**  
R

**Table 82. OUT\_T\_L register**

OUTT7	OUTT6	OUTT5	OUTT4	OUTT3	OUTT2	OUTT1	OUTT0
-------	-------	-------	-------	-------	-------	-------	-------

**Table 83. OUT\_T\_L register description**

OUTT[7:0]	LSBs of temperature data output. The four least significant bits are always zero since the data is in 12-bit format.
-----------	--

**8.32 OUT\_T\_H (2Fh)**  
R

**Table 84. OUT\_T\_H register**

OUTT15	OUTT14	OUTT13	OUTT12	OUTT11	OUTT10	OUTT9	OUTT8
--------	--------	--------	--------	--------	--------	-------	-------

**Table 85. OUT\_T\_H register description**

OUTT[15:8]	MSBs of temperature data output
------------	---------------------------------

### 8.33 SELF\_TEST (32h)

R/W

**Table 86. SELF\_TEST register**

-	-	ST1	ST0	-	-	-	-
---	---	-----	-----	---	---	---	---

**Table 87. SELF\_TEST register description**

ST[1:0]	These bits enable data acquisition during the self-test procedure.
---------	--

### 8.34 I3C\_IF\_CTRL (33h)

R/W

**Table 88. I3C\_IF\_CTRL register**

DIS_DRSTDAA	-	ASF_ON	-	-	-	BUS_ACT_SEL_1	BUS_ACT_SEL_0
-------------	---	--------	---	---	---	---------------	---------------

**Table 89. I3C\_IF\_CTRL register description**

DIS_DRSTDAA	If 0, direct RSTDAA is supported. If 1, direct RSTDAA is disabled.
ASF_ON	If 1, enables the anti-spike filter even if the dynamic address is assigned.
BUS_ACT_SEL_[1:0]	Bus available time selection for IBI (in-band interrupt): (00: 20 $\mu$ s; 01: 50 $\mu$ s (default); 10: 1 ms; 11: 25 ms)

### 8.35 EMB\_FUNC\_STATUS\_MAINPAGE (34h)

R

**Table 90. EMB\_FUNC\_STATUS\_MAINPAGE register**

IS_FSM_LC	0	IS_SIGMOT	IS_TILT	IS_STEP_DET	0	0	0
-----------	---	-----------	---------	-------------	---	---	---

**Table 91. EMB\_FUNC\_STATUS\_MAINPAGE register description**

IS_FSM_LC	Interrupt status bit for FSM long counter timeout interrupt event. (1: interrupt detected; 0: no interrupt)
IS_SIGMOT	Interrupt status bit for significant motion detection. (1: interrupt detected; 0: no interrupt)
IS_TILT	Interrupt status bit for tilt detection. (1: interrupt detected; 0: no interrupt)
IS_STEP_DET	Interrupt status bit for step detection. (1: interrupt detected; 0: no interrupt)

### 8.36 FSM\_STATUS\_MAINPAGE (35h)

R

**Table 92. FSM\_STATUS\_MAINPAGE register**

IS_FSM8	IS_FSM7	IS_FSM6	IS_FSM5	IS_FSM4	IS_FSM3	IS_FSM2	IS_FSM1
---------	---------	---------	---------	---------	---------	---------	---------

**Table 93. FSM\_STATUS\_MAINPAGE register description**

IS_FSM8	Interrupt status bit for FSM8 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM7	Interrupt status bit for FSM7 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM6	Interrupt status bit for FSM6 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM5	Interrupt status bit for FSM5 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM4	Interrupt status bit for FSM4 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM3	Interrupt status bit for FSM3 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM2	Interrupt status bit for FSM2 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM1	Interrupt status bit for FSM1 interrupt event. (1: interrupt detected; 0: no interrupt)

### 8.37 MLC\_STATUS\_MAINPAGE (36h)

R

**Table 94. MLC\_STATUS\_MAINPAGE register**

0	0	0	0	IS_MLC4	IS_MLC3	IS_MLC2	IS_MLC1
---	---	---	---	---------	---------	---------	---------

**Table 95. MLC\_STATUS\_MAINPAGE register description**

IS_MLC4	Interrupt status bit for MLC4 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_MLC3	Interrupt status bit for MLC3 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_MLC2	Interrupt status bit for MLC2 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_MLC1	Interrupt status bit for MLC1 interrupt event. (1: interrupt detected; 0: no interrupt)

### 8.38 SLEEP (3Dh)

R/W

**Table 96. SLEEP register**

0	0	0	0	0	0	0	DEEP_PD
---	---	---	---	---	---	---	---------

**Table 97. SLEEP register description**

DEEP_PD	If this bit is set to 1, the device enters deep a power-down state. Once the device is in a deep power-down state, the register is no longer accessible.
---------	--

### 8.39 IF\_WAKE\_UP (3Eh)

W

Table 98. IF\_WAKE\_UP register

-	-	-	-	-	-	-	SOFT_PD
---	---	---	---	---	---	---	---------

Table 99. IF\_WAKE\_UP register description

SOFT_PD	This bit allows the transition from deep power-down to soft power-down when the SPI interface is used. This bit is write only.
---------	--

### 8.40 FUNC\_CFG\_ACCESS (3Fh)

Enable embedded functions register (R/W)

Table 100. FUNC\_CFG\_ACCESS register

EMB_FUNC_REG_ACCESS	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	FSM_WR_CTRL_EN
---------------------	------------------	------------------	------------------	------------------	------------------	------------------	----------------

1. This bit must be set to 0 for the correct operation of the device.

Table 101. FUNC\_CFG\_ACCESS register description

EMB_FUNC_REG_ACCESS	Enables access to the embedded functions configuration registers <sup>(1)</sup> . Default value: 0
FSM_WR_CTRL_EN	Enables the control of the CTRL registers to FSM (FSM can change some configurations of the device autonomously). Default value: 0 (0: disabled; 1: enabled)

1. Details concerning the embedded functions configuration registers are available in [Section 9 Embedded functions register mapping](#) and [Section 10 Embedded functions register description](#)

### 8.41 FIFO\_DATA\_OUT\_TAG (40h)

This register contains the TAG values that distinguish the different kinds of data that can be batched in FIFO (R).

Table 102. FIFO\_DATA\_OUT\_TAG register

TAG_SENSOR_4	TAG_SENSOR_3	TAG_SENSOR_2	TAG_SENSOR_1	TAG_SENSOR_0	0	0	-
--------------	--------------	--------------	--------------	--------------	---	---	---

Table 103. FIFO\_DATA\_OUT\_TAG register description

TAG_SENSOR_[4:0]	FIFO tag. Identifies the sensor in FIFO_DATA_OUT_X_L (41h) and FIFO_DATA_OUT_X_H (42h), FIFO_DATA_OUT_Y_L (43h) and FIFO_DATA_OUT_Y_H (44h), and FIFO_DATA_OUT_Z_L (45h) and FIFO_DATA_OUT_Z_H (46h). For details, refer to Table 104.
------------------	--

**Table 104. Identification of sensor in FIFO**

TAG_SENSOR_[4:0]	Data in FIFO
00000	FIFO empty
00010	Accelerometer and temperature
00011	Accelerometer only data (2x depth mode)
00100	Timestamp or CFG_CHG
10010	Step counter
11010	MLC result
11011	MLC filter
11100	MLC feature
11101	FSM result

## 8.42 FIFO\_DATA\_OUT\_X\_L (41h) and FIFO\_DATA\_OUT\_X\_H (42h)

FIFO data output X (R)

**Table 105. FIFO\_DATA\_OUT\_X\_H and FIFO\_DATA\_OUT\_X\_L registers**

D15	D14	D13	D12	D11	D10	D9	D8
D7	D6	D5	D4	D3	D2	D1	D0

**Table 106. FIFO\_DATA\_OUT\_X\_H and FIFO\_DATA\_OUT\_X\_L register description**

D[15:0]	FIFO X-axis output
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## 8.43 FIFO\_DATA\_OUT\_Y\_L (43h) and FIFO\_DATA\_OUT\_Y\_H (44h)

FIFO data output Y (R)

**Table 107. FIFO\_DATA\_OUT\_Y\_H and FIFO\_DATA\_OUT\_Y\_L registers**

D15	D14	D13	D12	D11	D10	D9	D8
D7	D6	D5	D4	D3	D2	D1	D0

**Table 108. FIFO\_DATA\_OUT\_Y\_H and FIFO\_DATA\_OUT\_Y\_L register description**

D[15:0]	FIFO Y-axis output
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## 8.44 FIFO\_DATA\_OUT\_Z\_L (45h) and FIFO\_DATA\_OUT\_Z\_H (46h)

FIFO data output Z (R)

**Table 109. FIFO\_DATA\_OUT\_Z\_H and FIFO\_DATA\_OUT\_Z\_L registers**

D15	D14	D13	D12	D11	D10	D9	D8
D7	D6	D5	D4	D3	D2	D1	D0

**Table 110. FIFO\_DATA\_OUT\_Z\_H and FIFO\_DATA\_OUT\_Z\_L register description**

D[15:0]	FIFO Z-axis output
---------	--------------------

## 8.45 FIFO\_BATCH\_DEC (47h)

R/W

**Table 111. FIFO\_BATCH\_DEC register**

0	0	0	DEC_TS_BATCH_1	DEC_TS_BATCH_0	BDR_XL_2	BDR_XL_1	BDR_XL_0
---	---	---	----------------	----------------	----------	----------	----------

**Table 112. FIFO\_BATCH\_DEC register description**

DEC_TS_BATCH_[1:0]	Selects decimation for timestamp batching in FIFO. The write rate is the accelerometer BDR divided by the decimation decoder. (00: Timestamp not batched in FIFO (default); 01: Decimation 1: BDR_XL[Hz]; 10: Decimation 8: BDR_XL[Hz]/8 [Hz]; 11: Decimation 32: BDR_XL[Hz]/32 [Hz])
BDR_XL_[2:0]	Selects the batch data rate (write frequency in FIFO) for accelerometer data, see <a href="#">Table 113</a> .

**Table 113. Accelerometer batch data rate**

BDR_XL_[2:0]	Accelerometer batch frequency
000	ODR (default)
001	ODR/2
010	ODR/4
011	ODR/8
100	ODR/16
101	ODR/32
110	ODR/64
111	Accelerometer not batched in FIFO

## 8.46 TAP\_CFG0 (6Fh)

R/W

**Table 114. TAP\_CFG0 register**

AXIS1	AXIS0	INVERT_T4	INVERT_T3	INVERT_T2	INVERT_T1	INVERT_T0	-
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**Table 115. TAP\_CFG0 register description**

AXIS[1:0]	Selection of axis for tap event research: (00: no axis (default); 01: X-axis; 10: Y-axis; 11: Z-axis)
INVERT_T[4:0]	These bits enable the search of the inverted peak by selecting the maximum number of samples between the first and second (inverted) peak in tap detection. (0: disabled) 1 LSB = 1 sample (maximum 31 samples)

## 8.47 TAP\_CFG1 (70h)

R/W

**Table 116. TAP\_CFG1 register**

PRE_STILL_THS3	PRE_STILL_THS2	PRE_STILL_THS1	PRE_STILL_THS0	POST_STILL_T3	POST_STILL_T2	POST_STILL_T1	POST_STILL_T0
----------------	----------------	----------------	----------------	---------------	---------------	---------------	---------------

**Table 117. TAP\_CFG1 register description**

PRE_STILL_THS[3:0] <sup>(1)</sup>	Threshold for stationary condition before shock. 1 LSB = 62.5 mg (maximum 937.5 mg)
POST_STILL_T[3:0]	Number of samples during stationary condition after shock and wait phases. These bits are used together with POST_STILL_T[5:4] in register <a href="#">TAP_CFG2 (71h)</a> . 1 LSB = 4 samples (maximum 252 samples).

1. The PRE\_STILL\_THS[3:0] field must be set to a value greater than 0.

## 8.48 TAP\_CFG2 (71h)

R/W

**Table 118. TAP\_CFG2 register**

POST_STILL_T5	POST_STILL_T4	WAIT_T5	WAIT_T4	WAIT_T3	WAIT_T2	WAIT_T1	WAIT_T0
---------------	---------------	---------	---------	---------	---------	---------	---------

**Table 119. TAP\_CFG2 register description**

POST_STILL_T[5:4]	Number of samples during stationary condition after shock and wait phases. These bits are used together with POST_STILL_T[3:0] in register TAP_CFG1 (70h). 1 LSB = 4 samples (maximum 252 samples).
WAIT_T[5:0]	These bits program the number of samples to wait for the shock to finish. 1 LSB = 2 samples (maximum 126 samples).

## 8.49 TAP\_CFG3 (72h)

R/W

**Table 120. TAP\_CFG3 register**

POST_STILL_THS3	POST_STILL_THS2	POST_STILL_THS1	POST_STILL_THS0	LATENCY_T3	LATENCY_T2	LATENCY_T1	LATENCY_T0
-----------------	-----------------	-----------------	-----------------	------------	------------	------------	------------

**Table 121. TAP\_CFG3 register description**

POST_STILL_THS[3:0] <sup>(1)</sup>	Threshold for stationary condition after shock and wait phases. 1 LSB = 62.5 mg (maximum 937.5 mg)
LATENCY_T[3:0]	Maximum number of samples between consecutive taps event to detect double or triple tap. The default value of these bits is 0000b which corresponds to 16 samples. If the LATENCY_T[3:0] bits are set to a different value, 1LSB corresponds to 32 samples (maximum 480 samples).

1. The POST\_STILL\_THS[3:0] field must be set to a value greater than 0.

## 8.50 TAP\_CFG4 (73h)

R/W

**Table 122. TAP\_CFG4 register**

WAIT_END_LATENCY	0	PEAK_THS5	PEAK_THS4	PEAK_THS3	PEAK_THS2	PEAK_THS1	PEAK_THS0
------------------	---	-----------	-----------	-----------	-----------	-----------	-----------

**Table 123. TAP\_CFG4 register description**

WAIT_END_LATENCY	This bit enables the feature to wait for the end of the latency window to exclusively determine if the event is a single, double or triple tap.  (0: tap event flag is raised immediately for every detected tap; 1: in case of consecutive taps, only the flag for the highest level of tap is raised. The tap event flag is raised immediately if the highest level of tap enabled in TAP_CFG5 (74h) (single, double or triple) is reached, otherwise it is raised at the end of the latency window if no additional taps are detected within the window.)
PEAK_THS[5:0]	Threshold for peak detection. 1 LSB = 62.5 mg (maximum 3937.5 mg)

## 8.51 TAP\_CFG5 (74h)

R/W

**Table 124. TAP\_CFG5 register**

TRIPLE_TAP_EN	DOUBLE_TAP_EN	SINGLE_TAP_EN	REBOUND_T4	REBOUND_T3	REBOUND_T2	REBOUND_T1	REBOUND_T0
---------------	---------------	---------------	------------	------------	------------	------------	------------

**Table 125. TAP\_CFG5 register description**

TRIPLE_TAP_EN	This bit enables the triple-tap event. Default value: 0 (0: disabled; 1: enabled)
DOUBLE_TAP_EN	This bit enables the double-tap event. Default value: 0 (0: disabled; 1: enabled)
SINGLE_TAP_EN	This bit enables the single-tap event. Default value: 0 (0: disabled; 1: enabled)
REBOUND_T[4:0]	These bits program the number of samples to wait for the rebound to finish. The default value of these bits is 00000b which means that the rebound logic is disabled. If the REBOUND_T[4:0] bits are set to a different value, 1LSB corresponds to 2 samples (maximum 62 samples).

## 8.52 TAP\_CFG6 (75h)

R/W

**Table 126. TAP\_CFG6 register**

PRE_STILL_ST3	PRE_STILL_ST2	PRE_STILL_ST1	PRE_STILL_ST0	PRE_STILL_N3	PRE_STILL_N2	PRE_STILL_N1	PRE_STILL_N0
---------------	---------------	---------------	---------------	--------------	--------------	--------------	--------------

**Table 127. TAP\_CFG6 register description**

PRE_STILL_ST[3:0]	Selection of starting sample for stationary condition before shock (from the oldest sample in a buffer of 14 samples). 1 LSB = 1 sample (0: 1 <sup>st</sup> sample, 13: 14 <sup>th</sup> sample, maximum value is 13)
PRE_STILL_N[3:0]	Selection of number of samples for stationary condition before shock. 1 LSB = 1 sample (maximum 14 samples). If this field is set to 0, the stationary condition before shock is disabled.

## 8.53 **TIMESTAMP3 (7Ah), TIMESTAMP2 (7Bh), TIMESTAMP1 (7Ch), and TIMESTAMP0 (7Dh)**

R

**Table 128. TIMESTAMP output registers**

D31	D30	D29	D28	D27	D26	D25	D24
D23	D22	D21	D20	D19	D18	D17	D16
D15	D14	D13	D12	D11	D10	D9	D8
D7	D6	D5	D4	D3	D2	D1	D0

**Table 129. TIMESTAMP output register description**

D[31:0]	Timestamp output registers: 1LSB = 10 $\mu$ s (typical)
---------	---

## 9 Embedded functions register mapping

The table given below provides a list of the registers for the embedded functions available in the device and the corresponding addresses. Embedded functions registers are accessible when the EMB\_FUNC\_REG\_ACCESS bit is set to 1 in the FUNC\_CFG\_ACCESS (3Fh) register and the EMB\_FUNC\_EN bit is set to 1 in the CTRL4 (13h) register.

**Table 130. Register address map - embedded functions**

Name	Type	Register address		Default	Comment
		Hex	Binary		
PAGE_SEL	R/W	02	0000010	00000001	
RESERVED	-	03			
EMB_FUNC_EN_A	R/W	04	00000100	00000000	
EMB_FUNC_EN_B	R/W	05	00000101	00000000	
EMB_FUNC_EXEC_STATUS	R	07	00000111	output	
PAGE_ADDRESS	R/W	08	00001000	00000000	
PAGE_VALUE	R/W	09	00001001	00000000	
EMB_FUNC_INT1	R/W	0A	00001010	00000000	
FSM_INT1	R/W	0B	00001011	00000000	
RESERVED	-	0C			
MLC_INT1	R/W	0D	00001101	00000000	
EMB_FUNC_INT2	R/W	0E	00001110	00000000	
FSM_INT2	R/W	0F	00001111	00000000	
RESERVED	-	10			
MLC_INT2	R/W	11	00010001	00000000	
EMB_FUNC_STATUS	R	12	00010010	output	
FSM_STATUS	R	13	00010011	output	
RESERVED	-	14			
MLC_STATUS	R	15	00010101	output	
PAGE_RW	R/W	17	00010111	00000000	
EMB_FUNC_FIFO_EN	R/W	18	00011000		
RESERVED	-	19			
FSM_ENABLE	R/W	1A	00011010	00000000	
RESERVED	-	1B			
FSM_LONG_COUNTER_L	R/W	1C	00011100	00000000	
FSM_LONG_COUNTER_H	R/W	1D	00011101	00000000	
RESERVED	-	1E			
INT_ACK_MASK	R/W	1F	00011111	00000000	
FSM_OUTS1	R	20	00100000	output	
FSM_OUTS2	R	21	00100001	output	
FSM_OUTS3	R	22	00100010	output	
FSM_OUTS4	R	23	00100011	output	
FSM_OUTS5	R	24	00100100	output	

Name	Type	Register address		Default	Comment
		Hex	Binary		
FSM_OUTS6	R	25	00100101	output	
FSM_OUTS7	R	26	00100110	output	
FSM_OUTS8	R	27	00100111	output	
STEP_COUNTER_L	R	28	00101000	output	
STEP_COUNTER_H	R	29	00101001	output	
EMB_FUNC_SRC	R	2A	00101010	output	
RESERVED	-	2B			
EMB_FUNC_INIT_A	R/W	2C	00101100	00000000	
EMB_FUNC_INIT_B	R/W	2D	00101101	00000000	
RESERVED	-	2E-33			
MLC1_SRC	R	34	00110100	output	
MLC2_SRC	R	35	00110101	output	
MLC3_SRC	R	36	00110110	output	
MLC4_SRC	R	37	00110111	output	
FSM_ODR	R/W	39	00111001	01001000	
MLC_ODR	R/W	3A	00111010	00010001	

Reserved registers must not be changed. Writing to those registers may cause permanent damage to the device. The content of the registers that are loaded at boot should not be changed. They contain the factory calibration values. Their content is automatically restored when the device is powered up.

## 10 Embedded functions register description

### 10.1 PAGE\_SEL (02h)

Enable advanced features dedicated page (R/W)

**Table 131. PAGE\_SEL register**

PAGE_SEL3	PAGE_SEL2	PAGE_SEL1	PAGE_SEL0	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	1 <sup>(2)</sup>
-----------	-----------	-----------	-----------	------------------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.
2. This bit must be set to 1 for the correct operation of the device.

**Table 132. PAGE\_SEL register description**

PAGE_SEL[3:0]	Selects the advanced features dedicated page. Default value: 0000
---------------	---

### 10.2 EMB\_FUNC\_EN\_A (04h)

Enable embedded functions register (R/W)

**Table 133. EMB\_FUNC\_EN\_A register**

MLC_BEFORE_FSM_EN	0 <sup>(1)</sup>	SIGN_MOTION_EN	TILT_EN	PEDO_EN	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>
-------------------	------------------	----------------	---------	---------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 134. EMB\_FUNC\_EN\_A register description**

MLC_BEFORE_FSM_EN <sup>(1)</sup>	Enables machine learning core function. When the machine learning core is enabled by setting this bit to 1, the MLC algorithms are executed before the FSM programs. Default value: 0 (0: machine learning core function disabled; 1: machine learning core function enabled and executed before FSM programs)
SIGN_MOTION_EN	Enables significant motion detection function. Default value: 0 (0: significant motion detection function disabled; 1: significant motion detection function enabled)
TILT_EN	Enables tilt calculation. Default value: 0 (0: tilt algorithm disabled; 1: tilt algorithm enabled)
PEDO_EN	Enables pedometer algorithm. Default value: 0 (0: pedometer algorithm disabled; 1: pedometer algorithm enabled)

1. The MLC\_EN bit in the *EMB\_FUNC\_EN\_B (05h)* register must be set to 0 when using this bit.

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### 10.3 EMB\_FUNC\_EN\_B (05h)

Enable embedded functions register (R/W)

**Table 135. EMB\_FUNC\_EN\_B register**

0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	MLC_EN	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	FSM_EN
------------------	------------------	------------------	--------	------------------	------------------	------------------	--------

1. This bit must be set to 0 for the correct operation of the device.

**Table 136. EMB\_FUNC\_EN\_B register description**

MLC_EN <sup>(1)</sup>	Enables machine learning core function. When the machine learning core is enabled by setting this bit to 1, the MLC algorithms are executed after executing the FSM programs. Default value: 0 (0: machine learning core function disabled; 1: machine learning core function enabled and executed after FSM programs)
FSM_EN	Enables finite state machine (FSM) function. Default value: 0 (0: FSM function disabled; 1: FSM function enabled)

1. The MLC\_BEFORE\_FSM\_EN bit in the EMB\_FUNC\_EN\_A (04h) register must be set to 0 when using this bit.

### 10.4 EMB\_FUNC\_EXEC\_STATUS (07h)

Embedded functions execution status register (R)

**Table 137. EMB\_FUNC\_EXEC\_STATUS register**

0	0	0	0	0	0	EMB_FUNC_EXEC_OVR	EMB_FUNC_ENDOP
---	---	---	---	---	---	-------------------	----------------

**Table 138. EMB\_FUNC\_EXEC\_STATUS register description**

EMB_FUNC_EXEC_OVR	This bit is set to 1 when the execution of the embedded functions program exceeds maximum time (new data are generated before the end of the algorithms). Default value: 0
EMB_FUNC_ENDOP	When this bit is set to 1, no embedded function is running. Default value: 0

### 10.5 PAGE\_ADDRESS (08h)

Page address register (R/W)

**Table 139. PAGE\_ADDRESS register**

PAGE_ADDR7	PAGE_ADDR6	PAGE_ADDR5	PAGE_ADDR4	PAGE_ADDR3	PAGE_ADDR2	PAGE_ADDR1	PAGE_ADDR0
------------	------------	------------	------------	------------	------------	------------	------------

**Table 140. PAGE\_ADDRESS register description**

PAGE_ADDR[7:0]	After setting the bit PAGE_WRITE / PAGE_READ in register PAGE_RW (17h), this register is used to set the address of the register to be written/read in the advanced features page selected through the bits PAGE_SEL[3:0] in register PAGE_SEL (02h).
----------------	---

## 10.6 PAGE\_VALUE (09h)

Page value register (R/W)

**Table 141. PAGE\_VALUE register**

PAGE_VALUE7	PAGE_VALUE6	PAGE_VALUE5	PAGE_VALUE4	PAGE_VALUE3	PAGE_VALUE2	PAGE_VALUE1	PAGE_VALUE0
-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------

**Table 142. PAGE\_VALUE register description**

PAGE_VALUE[7:0]	These bits are used to write (if the bit PAGE_WRITE = 1 in register PAGE_RW (17h)) or read (if the bit PAGE_READ = 1 in register PAGE_RW (17h)) the data at the address PAGE_ADDR[7:0] of the selected advanced features page.
-----------------	--

## 10.7 EMB\_FUNC\_INT1 (0Ah)

INT1 pin control register (R/W)

Each bit in this register enables a signal to be carried over INT1. The pin's output supplies the OR combination of the selected signals.

**Table 143. EMB\_FUNC\_INT1 register**

INT1_FSM_LC	0 <sup>(1)</sup>	INT1_SIG_MOT	INT1_TILT	INT1_STEP_DET	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>
-------------	------------------	--------------	-----------	---------------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 144. EMB\_FUNC\_INT1 register description**

INT1_FSM_LC <sup>(1)</sup>	Enables routing FSM long counter timeout interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_SIG_MOT <sup>(1)</sup>	Enables routing significant motion event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_TILT <sup>(1)</sup>	Enables routing tilt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_STEP_DETECTOR <sup>(1)</sup>	Enables routing pedometer step recognition event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)

1. This bit is active if the INT1\_EMB\_FUNC bit of MD1\_CFG (1Fh) is set to 1.

## 10.8 FSM\_INT1 (0Bh)

INT1 pin control register (R/W)

Each bit in this register enables a signal to be carried over INT1. The pin's output supplies the OR combination of the selected signals.

**Table 145. FSM\_INT1 register**

INT1_FSM8	INT1_FSM7	INT1_FSM6	INT1_FSM5	INT1_FSM4	INT1_FSM3	INT1_FSM2	INT1_FSM1
-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------

**Table 146. FSM\_INT1 register description**

INT1_FSM8 <sup>(1)</sup>	Enables routing FSM8 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_FSM7 <sup>(1)</sup>	Enables routing FSM7 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_FSM6 <sup>(1)</sup>	Enables routing FSM6 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_FSM5 <sup>(1)</sup>	Enables routing FSM5 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_FSM4 <sup>(1)</sup>	Enables routing FSM4 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_FSM3 <sup>(1)</sup>	Enables routing FSM3 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_FSM2 <sup>(1)</sup>	Enables routing FSM2 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_FSM1 <sup>(1)</sup>	Enables routing FSM1 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)

1. This bit is active if the INT1\_EMB\_FUNC bit of MD1\_CFG (1Fh) is set to 1.

## 10.9 MLC\_INT1 (0Dh)

INT1 pin control register (R/W)

Each bit in this register enables a signal to be carried over INT1. The pin's output supplies the OR combination of the selected signals.

**Table 147. MLC\_INT1 register**

0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	INT1_MLC4	INT1_MLC3	INT1_MLC2	INT1_MLC1
------------------	------------------	------------------	------------------	-----------	-----------	-----------	-----------

1. This bit must be set to 0 for the correct operation of the device.

**Table 148. MLC\_INT1 register description**

INT1_MLC4 <sup>(1)</sup>	Enables routing MLC4 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_MLC3 <sup>(1)</sup>	Enables routing MLC3 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_MLC2 <sup>(1)</sup>	Enables routing MLC2 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)
INT1_MLC1 <sup>(1)</sup>	Enables routing MLC1 interrupt event to INT1. Default value: 0 (0: routing to INT1 disabled; 1: routing to INT1 enabled)

1. This bit is active if the INT1\_EMB\_FUNC bit of MD1\_CFG (1Fh) is set to 1.

## 10.10 EMB\_FUNC\_INT2 (0Eh)

INT2 pin control register (R/W)

Each bit in this register enables a signal to be carried over INT2. The pin's output supplies the OR combination of the selected signals.

**Table 149. EMB\_FUNC\_INT2 register**

INT2_FSM_LC	0 <sup>(1)</sup>	INT2_SIG_MOT	INT2_TILT	INT2_STEP_DET	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>
-------------	------------------	--------------	-----------	---------------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 150. EMB\_FUNC\_INT2 register description**

INT2_FSM_LC <sup>(1)</sup>	Enables routing FSM long counter timeout interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_SIG_MOT <sup>(1)</sup>	Enables routing significant motion event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_TILT <sup>(1)</sup>	Enables routing tilt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_STEP_DETECT <sup>(1)</sup>	Enables routing pedometer step recognition event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)

1. This bit is active if the INT2\_EMB\_FUNC bit of MD2\_CFG (20h) is set to 1.

## 10.11 FSM\_INT2 (0Fh)

INT2 pin control register (R/W)

Each bit in this register enables a signal to be carried over INT2. The pin's output supplies the OR combination of the selected signals.

**Table 151. FSM\_INT2 register**

INT2_FSM8	INT2_FSM7	INT2_FSM6	INT2_FSM5	INT2_FSM4	INT2_FSM3	INT2_FSM2	INT2_FSM1
-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------

**Table 152. FSM\_INT2 register description**

INT2_FSM8 <sup>(1)</sup>	Enables routing FSM8 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_FSM7 <sup>(1)</sup>	Enables routing FSM7 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_FSM6 <sup>(1)</sup>	Enables routing FSM6 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_FSM5 <sup>(1)</sup>	Enables routing FSM5 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_FSM4 <sup>(1)</sup>	Enables routing FSM4 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_FSM3 <sup>(1)</sup>	Enables routing FSM3 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_FSM2 <sup>(1)</sup>	Enables routing FSM2 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_FSM1 <sup>(1)</sup>	Enables routing FSM1 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)

1. This bit is active if the INT2\_EMB\_FUNC bit of MD2\_CFG (20h) is set to 1.

## 10.12 MLC\_INT2 (11h)

INT2 pin control register (R/W)

Each bit in this register enables a signal to be carried over INT2. The pin's output supplies the OR combination of the selected signals.

**Table 153. MLC\_INT2 register**

0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	INT2_MLC4	INT2_MLC3	INT2_MLC2	INT2_MLC1
------------------	------------------	------------------	------------------	-----------	-----------	-----------	-----------

1. This bit must be set to 0 for the correct operation of the device.

**Table 154. MLC\_INT2 register description**

INT2_MLC4 <sup>(1)</sup>	Enables routing MLC4 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_MLC3 <sup>(1)</sup>	Enables routing MLC3 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_MLC2 <sup>(1)</sup>	Enables routing MLC2 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)
INT2_MLC1 <sup>(1)</sup>	Enables routing MLC1 interrupt event to INT2. Default value: 0 (0: routing to INT2 disabled; 1: routing to INT2 enabled)

1. This bit is active if the INT2\_EMB\_FUNC bit of MD2\_CFG (20h) is set to 1.

## 10.13 EMB\_FUNC\_STATUS (12h)

Embedded function status register (R)

**Table 155. EMB\_FUNC\_STATUS register**

IS_FSM_LC	0	IS_SIGMOT	IS_TILT	IS_STEP_DET	0	0	0
-----------	---	-----------	---------	-------------	---	---	---

**Table 156. EMB\_FUNC\_STATUS register description**

IS_FSM_LC	Interrupt status bit for FSM long counter timeout interrupt event. (1: interrupt detected; 0: no interrupt)
IS_SIGMOT	Interrupt status bit for significant motion detection (1: interrupt detected; 0: no interrupt)
IS_TILT	Interrupt status bit for tilt detection (1: interrupt detected; 0: no interrupt)
IS_STEP_DET	Interrupt status bit for step detection (1: interrupt detected; 0: no interrupt)

## 10.14 FSM\_STATUS (13h)

Finite state machine status register (R)

**Table 157. FSM\_STATUS register**

IS_FSM8	IS_FSM7	IS_FSM6	IS_FSM5	IS_FSM4	IS_FSM3	IS_FSM2	IS_FSM1
---------	---------	---------	---------	---------	---------	---------	---------

**Table 158. FSM\_STATUS register description**

IS_FSM8	Interrupt status bit for FSM8 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM7	Interrupt status bit for FSM7 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM6	Interrupt status bit for FSM6 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM5	Interrupt status bit for FSM5 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM4	Interrupt status bit for FSM4 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM3	Interrupt status bit for FSM3 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM2	Interrupt status bit for FSM2 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_FSM1	Interrupt status bit for FSM1 interrupt event. (1: interrupt detected; 0: no interrupt)

## 10.15 MLC\_STATUS (15h)

Machine learning core status register (R)

**Table 159. MLC\_STATUS register**

0	0	0	0	IS_MLC4	IS_MLC3	IS_MLC	IS_MLC1
---	---	---	---	---------	---------	--------	---------

**Table 160. MLC\_STATUS register description**

IS_MLC4	Interrupt status bit for MLC4 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_MLC3	Interrupt status bit for MLC3 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_MLC2	Interrupt status bit for MLC2 interrupt event. (1: interrupt detected; 0: no interrupt)
IS_MLC1	Interrupt status bit for MLC1 interrupt event. (1: interrupt detected; 0: no interrupt)

## 10.16 PAGE\_RW (17h)

Enable read and write mode of advanced features dedicated page (R/W)

**Table 161. PAGE\_RW register**

EMB_FUNC_LIR	PAGE_WRITE	PAGE_READ	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>
--------------	------------	-----------	------------------	------------------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 162. PAGE\_RW register description**

EMB_FUNC_LIR	Latched interrupt mode for embedded functions. Default value: 0 (0: embedded functions interrupt request not latched; 1: embedded functions interrupt request latched)
PAGE_WRITE	Enable writes to the selected advanced features dedicated page. <sup>(1)</sup> Default value: 0 (1: enable; 0: disable)
PAGE_READ	Enable reads from the selected advanced features dedicated page. <sup>(1)</sup> Default value: 0 (1: enable; 0: disable)

1. Page selected by PAGE\_SEL[3:0] in PAGE\_SEL (02h) register.

## 10.17 EMB\_FUNC\_FIFO\_EN (18h)

Embedded functions FIFO configuration register (R/W)

**Table 163. EMB\_FUNC\_FIFO\_EN register**

0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	FSM_FIFO_EN	MLC_FILTER_FEATURE_FIFO_EN	MLC_FIFO_EN	STEP_COUNTER_FIFO_EN
------------------	------------------	------------------	------------------	-------------	----------------------------	-------------	----------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 164. EMB\_FUNC\_FIFO\_EN register description**

FSM_FIFO_EN	Enables batching in FIFO buffer of finite state machine results. Default value: 0 (0: disabled; 1: enabled)
MLC_FILTER_FEATURE_FIFO_EN	Enables batching in FIFO buffer of machine learning core filters and features. Default value: 0 (0: disabled; 1: enabled)
MLC_FIFO_EN	Enables batching in FIFO buffer of machine learning core results. Default value: 0 (0: disabled; 1: enabled)
STEP_COUNTER_FIFO_EN	Enables batching in FIFO buffer of step counter value. Default value: 0 (0: disabled; 1: enabled)

## 10.18 FSM\_ENABLE (1Ah)

Enable FSM register (R/W)

**Table 165. FSM\_ENABLE register**

FSM8_EN	FSM7_EN	FSM6_EN	FSM5_EN	FSM4_EN	FSM3_EN	FSM2_EN	FSM1_EN
---------	---------	---------	---------	---------	---------	---------	---------

**Table 166. FSM\_ENABLE register description**

FSM8_EN	Enables FSM8. Default value: 0 (0: FSM8 disabled; 1: FSM8 enabled)
FSM7_EN	Enables FSM7. Default value: 0 (0: FSM7 disabled; 1: FSM7 enabled)
FSM6_EN	Enables FSM6. Default value: 0 (0: FSM6 disabled; 1: FSM6 enabled)
FSM5_EN	Enables FSM5. Default value: 0 (0: FSM5 disabled; 1: FSM5 enabled)
FSM4_EN	Enables FSM4. Default value: 0 (0: FSM4 disabled; 1: FSM4 enabled)
FSM3_EN	Enables FSM3. Default value: 0 (0: FSM3 disabled; 1: FSM3 enabled)
FSM2_EN	Enables FSM2. Default value: 0 (0: FSM2 disabled; 1: FSM2 enabled)
FSM1_EN	Enables FSM1. Default value: 0 (0: FSM1 disabled; 1: FSM1 enabled)

## 10.19 FSM\_LONG\_COUNTER\_L (1Ch) and FSM\_LONG\_COUNTER\_H (1Dh)

FSM long counter status register (R/W)

Long counter value is an unsigned integer value (16-bit format).

**Table 167. FSM\_LONG\_COUNTER\_L register**

FSM_LC_7	FSM_LC_6	FSM_LC_5	FSM_LC_4	FSM_LC_3	FSM_LC_2	FSM_LC_1	FSM_LC_0
----------	----------	----------	----------	----------	----------	----------	----------

**Table 168. FSM\_LONG\_COUNTER\_L register description**

FSM_LC_[7:0]	Long counter current value (LSbyte). Default value: 00000000
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**Table 169. FSM\_LONG\_COUNTER\_H register**

-	FSM_LC_14	FSM_LC_13	FSM_LC_12	FSM_LC_11	FSM_LC_10	FSM_LC_9	FSM_LC_8
---	-----------	-----------	-----------	-----------	-----------	----------	----------

**Table 170. FSM\_LONG\_COUNTER\_H register description**

FSM_LC_[14:8]	Long counter current value (MSbyte). Default value: 00000000
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## 10.20 INT\_ACK\_MASK (1Fh)

Reset status register (R/W)

**Table 171. INT\_ACK\_MASK register**

IACK_MASK7	IACK_MASK6	IACK_MASK5	IACK_MASK4	IACK_MASK3	IACK_MASK2	IACK_MASK1	IACK_MASK0
------------	------------	------------	------------	------------	------------	------------	------------

**Table 172. INT\_ACK\_MASK register description**

IACK_MASK7	If set to 1, when reading the <a href="#">EMB_FUNC_STATUS (12h)</a> / <a href="#">EMB_FUNC_STATUS_MAINPAGE (34h)</a> , <a href="#">FSM_STATUS (13h)</a> / <a href="#">FSM_STATUS_MAINPAGE (35h)</a> and <a href="#">MLC_STATUS (15h)</a> / <a href="#">MLC_STATUS_MAINPAGE (36h)</a> registers in latched mode (when the <a href="#">EMB_FUNC_LIR</a> bit is set to 1 in the <a href="#">PAGE_RW (17h)</a> register), bit 7 of the status register is not reset. When this bit is set to 0, bit 7 of the status register is reset. Default value: 0
IACK_MASK6	If set to 1, when reading the <a href="#">EMB_FUNC_STATUS (12h)</a> / <a href="#">EMB_FUNC_STATUS_MAINPAGE (34h)</a> , <a href="#">FSM_STATUS (13h)</a> / <a href="#">FSM_STATUS_MAINPAGE (35h)</a> and <a href="#">MLC_STATUS (15h)</a> / <a href="#">MLC_STATUS_MAINPAGE (36h)</a> registers in latched mode (when the <a href="#">EMB_FUNC_LIR</a> bit is set to 1 in the <a href="#">PAGE_RW (17h)</a> register), bit 6 of the status register is not reset. When this bit is set to 0, bit 6 of the status register is reset. Default value: 0
IACK_MASK5	If set to 1, when reading the <a href="#">EMB_FUNC_STATUS (12h)</a> / <a href="#">EMB_FUNC_STATUS_MAINPAGE (34h)</a> , <a href="#">FSM_STATUS (13h)</a> / <a href="#">FSM_STATUS_MAINPAGE (35h)</a> and <a href="#">MLC_STATUS (15h)</a> / <a href="#">MLC_STATUS_MAINPAGE (36h)</a> registers in latched mode (when the <a href="#">EMB_FUNC_LIR</a> bit is set to 1 in the <a href="#">PAGE_RW (17h)</a> register), bit 5 of the status register is not reset. When this bit is set to 0, bit 5 of the status register is reset. Default value: 0
IACK_MASK4	If set to 1, when reading the <a href="#">EMB_FUNC_STATUS (12h)</a> / <a href="#">EMB_FUNC_STATUS_MAINPAGE (34h)</a> , <a href="#">FSM_STATUS (13h)</a> / <a href="#">FSM_STATUS_MAINPAGE (35h)</a> and <a href="#">MLC_STATUS (15h)</a> / <a href="#">MLC_STATUS_MAINPAGE (36h)</a> registers in latched mode (when the <a href="#">EMB_FUNC_LIR</a> bit is set to 1 in the <a href="#">PAGE_RW (17h)</a> register), bit 4 of the status register is not reset. When this bit is set to 0, bit 4 of the status register is reset. Default value: 0
IACK_MASK3	If set to 1, when reading the <a href="#">EMB_FUNC_STATUS (12h)</a> / <a href="#">EMB_FUNC_STATUS_MAINPAGE (34h)</a> , <a href="#">FSM_STATUS (13h)</a> / <a href="#">FSM_STATUS_MAINPAGE (35h)</a> and <a href="#">MLC_STATUS (15h)</a> / <a href="#">MLC_STATUS_MAINPAGE (36h)</a> registers in latched mode (when the <a href="#">EMB_FUNC_LIR</a> bit is set to 1 in the <a href="#">PAGE_RW (17h)</a> register), bit 3 of the status register is not reset. When this bit is set to 0, bit 3 of the status register is reset. Default value: 0
IACK_MASK2	If set to 1, when reading the <a href="#">EMB_FUNC_STATUS (12h)</a> / <a href="#">EMB_FUNC_STATUS_MAINPAGE (34h)</a> , <a href="#">FSM_STATUS (13h)</a> / <a href="#">FSM_STATUS_MAINPAGE (35h)</a> and <a href="#">MLC_STATUS (15h)</a> / <a href="#">MLC_STATUS_MAINPAGE (36h)</a> registers in latched mode (when the <a href="#">EMB_FUNC_LIR</a> bit is set to 1 in the <a href="#">PAGE_RW (17h)</a> register), bit 2 of the status register is not reset. When this bit is set to 0, bit 2 of the status register is reset. Default value: 0
IACK_MASK1	If set to 1, when reading the <a href="#">EMB_FUNC_STATUS (12h)</a> / <a href="#">EMB_FUNC_STATUS_MAINPAGE (34h)</a> , <a href="#">FSM_STATUS (13h)</a> / <a href="#">FSM_STATUS_MAINPAGE (35h)</a> and <a href="#">MLC_STATUS (15h)</a> / <a href="#">MLC_STATUS_MAINPAGE (36h)</a> registers in latched mode (when the <a href="#">EMB_FUNC_LIR</a> bit is set to 1 in the <a href="#">PAGE_RW (17h)</a> register), bit 1 of the status register is not reset. When this bit is set to 0, bit 1 of the status register is reset. Default value: 0
IACK_MASK0	If set to 1, when reading the <a href="#">EMB_FUNC_STATUS (12h)</a> / <a href="#">EMB_FUNC_STATUS_MAINPAGE (34h)</a> , <a href="#">FSM_STATUS (13h)</a> / <a href="#">FSM_STATUS_MAINPAGE (35h)</a> and <a href="#">MLC_STATUS (15h)</a> / <a href="#">MLC_STATUS_MAINPAGE (36h)</a> registers in latched mode (when the <a href="#">EMB_FUNC_LIR</a> bit is set to 1 in the <a href="#">PAGE_RW (17h)</a> register), bit 0 of the status register is not reset. When this bit is set to 0, bit 0 of the status register is reset. Default value: 0

## 10.21 FSM\_OUTS1 (20h)

FSM1 output register (R)

**Table 173. FSM\_OUTS1 register**

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V
-----	-----	-----	-----	-----	-----	-----	-----

**Table 174. FSM\_OUTS1 register description**

P_X	FSM1 output: positive event detected on the X-axis. (0: event not detected; 1: event detected)
N_X	FSM1 output: negative event detected on the X-axis. (0: event not detected; 1: event detected)
P_Y	FSM1 output: positive event detected on the Y-axis. (0: event not detected; 1: event detected)
N_Y	FSM1 output: negative event detected on the Y-axis. (0: event not detected; 1: event detected)
P_Z	FSM1 output: positive event detected on the Z-axis. (0: event not detected; 1: event detected)
N_Z	FSM1 output: negative event detected on the Z-axis. (0: event not detected; 1: event detected)
P_V	FSM1 output: positive event detected on the vector. (0: event not detected; 1: event detected)
N_V	FSM1 output: negative event detected on the vector. (0: event not detected; 1: event detected)

## 10.22 FSM\_OUTS2 (21h)

FSM2 output register (R)

**Table 175. FSM\_OUTS2 register**

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V
-----	-----	-----	-----	-----	-----	-----	-----

**Table 176. FSM\_OUTS2 register description**

P_X	FSM2 output: positive event detected on the X-axis. (0: event not detected; 1: event detected)
N_X	FSM2 output: negative event detected on the X-axis. (0: event not detected; 1: event detected)
P_Y	FSM2 output: positive event detected on the Y-axis. (0: event not detected; 1: event detected)
N_Y	FSM2 output: negative event detected on the Y-axis. (0: event not detected; 1: event detected)
P_Z	FSM2 output: positive event detected on the Z-axis. (0: event not detected; 1: event detected)
N_Z	FSM2 output: negative event detected on the Z-axis. (0: event not detected; 1: event detected)
P_V	FSM2 output: positive event detected on the vector. (0: event not detected; 1: event detected)
N_V	FSM2 output: negative event detected on the vector. (0: event not detected; 1: event detected)

## 10.23 FSM\_OUTS3 (22h)

FSM3 output register (R)

**Table 177. FSM\_OUTS3 register**

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V
-----	-----	-----	-----	-----	-----	-----	-----

**Table 178. FSM\_OUTS3 register description**

P_X	FSM3 output: positive event detected on the X-axis. (0: event not detected; 1: event detected)
N_X	FSM3 output: negative event detected on the X-axis. (0: event not detected; 1: event detected)
P_Y	FSM3 output: positive event detected on the Y-axis. (0: event not detected; 1: event detected)
N_Y	FSM3 output: negative event detected on the Y-axis. (0: event not detected; 1: event detected)
P_Z	FSM3 output: positive event detected on the Z-axis. (0: event not detected; 1: event detected)
N_Z	FSM3 output: negative event detected on the Z-axis. (0: event not detected; 1: event detected)
P_V	FSM3 output: positive event detected on the vector. (0: event not detected; 1: event detected)
N_V	FSM3 output: negative event detected on the vector. (0: event not detected; 1: event detected)

## 10.24 FSM\_OUTS4 (23h)

FSM4 output register (R)

**Table 179. FSM\_OUTS4 register**

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V
-----	-----	-----	-----	-----	-----	-----	-----

**Table 180. FSM\_OUTS4 register description**

P_X	FSM4 output: positive event detected on the X-axis. (0: event not detected; 1: event detected)
N_X	FSM4 output: negative event detected on the X-axis. (0: event not detected; 1: event detected)
P_Y	FSM4 output: positive event detected on the Y-axis. (0: event not detected; 1: event detected)
N_Y	FSM4 output: negative event detected on the Y-axis. (0: event not detected; 1: event detected)
P_Z	FSM4 output: positive event detected on the Z-axis. (0: event not detected; 1: event detected)
N_Z	FSM4 output: negative event detected on the Z-axis. (0: event not detected; 1: event detected)
P_V	FSM4 output: positive event detected on the vector. (0: event not detected; 1: event detected)
N_V	FSM4 output: negative event detected on the vector. (0: event not detected; 1: event detected)

## 10.25 FSM\_OUTS5 (24h)

FSM5 output register (R)

**Table 181. FSM\_OUTS5 register**

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V
-----	-----	-----	-----	-----	-----	-----	-----

**Table 182. FSM\_OUTS5 register description**

P_X	FSM5 output: positive event detected on the X-axis. (0: event not detected; 1: event detected)
N_X	FSM5 output: negative event detected on the X-axis. (0: event not detected; 1: event detected)
P_Y	FSM5 output: positive event detected on the Y-axis. (0: event not detected; 1: event detected)
N_Y	FSM5 output: negative event detected on the Y-axis. (0: event not detected; 1: event detected)
P_Z	FSM5 output: positive event detected on the Z-axis. (0: event not detected; 1: event detected)
N_Z	FSM5 output: negative event detected on the Z-axis. (0: event not detected; 1: event detected)
P_V	FSM5 output: positive event detected on the vector. (0: event not detected; 1: event detected)
N_V	FSM5 output: negative event detected on the vector. (0: event not detected; 1: event detected)

## 10.26 FSM\_OUTS6 (25h)

FSM6 output register (R)

**Table 183. FSM\_OUTS6 register**

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V
-----	-----	-----	-----	-----	-----	-----	-----

**Table 184. FSM\_OUTS6 register description**

P_X	FSM6 output: positive event detected on the X-axis. (0: event not detected; 1: event detected)
N_X	FSM6 output: negative event detected on the X-axis. (0: event not detected; 1: event detected)
P_Y	FSM6 output: positive event detected on the Y-axis. (0: event not detected; 1: event detected)
N_Y	FSM6 output: negative event detected on the Y-axis. (0: event not detected; 1: event detected)
P_Z	FSM6 output: positive event detected on the Z-axis. (0: event not detected; 1: event detected)
N_Z	FSM6 output: negative event detected on the Z-axis. (0: event not detected; 1: event detected)
P_V	FSM6 output: positive event detected on the vector. (0: event not detected; 1: event detected)
N_V	FSM6 output: negative event detected on the vector. (0: event not detected; 1: event detected)

## 10.27 FSM\_OUTS7 (26h)

FSM7 output register (R)

**Table 185. FSM\_OUTS7 register**

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V
-----	-----	-----	-----	-----	-----	-----	-----

**Table 186. FSM\_OUTS7 register description**

P_X	FSM7 output: positive event detected on the X-axis. (0: event not detected; 1: event detected)
N_X	FSM7 output: negative event detected on the X-axis. (0: event not detected; 1: event detected)
P_Y	FSM7 output: positive event detected on the Y-axis. (0: event not detected; 1: event detected)
N_Y	FSM7 output: negative event detected on the Y-axis. (0: event not detected; 1: event detected)
P_Z	FSM7 output: positive event detected on the Z-axis. (0: event not detected; 1: event detected)
N_Z	FSM7 output: negative event detected on the Z-axis. (0: event not detected; 1: event detected)
P_V	FSM7 output: positive event detected on the vector. (0: event not detected; 1: event detected)
N_V	FSM7 output: negative event detected on the vector. (0: event not detected; 1: event detected)

## 10.28 FSM\_OUTS8 (27h)

FSM8 output register (R)

**Table 187. FSM\_OUTS8 register**

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V
-----	-----	-----	-----	-----	-----	-----	-----

**Table 188. FSM\_OUTS8 register description**

P_X	FSM8 output: positive event detected on the X-axis. (0: event not detected; 1: event detected)
N_X	FSM8 output: negative event detected on the X-axis. (0: event not detected; 1: event detected)
P_Y	FSM8 output: positive event detected on the Y-axis. (0: event not detected; 1: event detected)
N_Y	FSM8 output: negative event detected on the Y-axis. (0: event not detected; 1: event detected)
P_Z	FSM8 output: positive event detected on the Z-axis. (0: event not detected; 1: event detected)
N_Z	FSM8 output: negative event detected on the Z-axis. (0: event not detected; 1: event detected)
P_V	FSM8 output: positive event detected on the vector. (0: event not detected; 1: event detected)
N_V	FSM8 output: negative event detected on the vector. (0: event not detected; 1: event detected)

## 10.29 STEP\_COUNTER\_L (28h) and STEP\_COUNTER\_H (29h)

Step counter output register (R)

**Table 189. STEP\_COUNTER\_L register**

STEP_7	STEP_6	STEP_5	STEP_4	STEP_3	STEP_2	STEP_1	STEP_0
--------	--------	--------	--------	--------	--------	--------	--------

**Table 190. STEP\_COUNTER\_L register description**

STEP_[7:0]	Step counter output (LSbyte)
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**Table 191. STEP\_COUNTER\_H register**

STEP_15	STEP_14	STEP_13	STEP_12	STEP_11	STEP_10	STEP_9	STEP_8
---------	---------	---------	---------	---------	---------	--------	--------

**Table 192. STEP\_COUNTER\_H register description**

STEP_[15:8]	Step counter output (MSbyte)
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## 10.30 EMB\_FUNC\_SRC (2Ah)

Embedded function source register (R/W)

**Table 193. EMB\_FUNC\_SRC register**

PEDO_RST_STEP	0 <sup>(1)</sup>	STEP_DETECTED	STEP_COUNT_DELTA_IA	STEP_OVERFLOW	STEP_COUNTER_BIT_SET	0 <sup>(1)</sup>	0 <sup>(1)</sup>
---------------	------------------	---------------	---------------------	---------------	----------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 194. EMB\_FUNC\_SRC register description**

PEDO_RST_STEP	Reset pedometer step counter. Read/write bit. (0: disabled; 1: enabled)
STEP_DETECTED	Step detector event detection status. Read-only bit. (0: step detection event not detected; 1: step detection event detected)
STEP_COUNT_DELTA_IA	Pedometer step recognition on delta time status. Read-only bit. (0: no step recognized during delta time; 1: at least one step recognized during delta time)
STEP_OVERFLOW	Step counter overflow status. Read-only bit. (0: step counter value < 2 <sup>16</sup> ; 1: step counter value reached 2 <sup>16</sup> )
STEP_COUNTER_BIT_SET	This bit is equal to 1 when the step count is increased. If a timer period is programmed in PEDO_SC_DELTAT_L (AAh) and PEDO_SC_DELTAT_H (ABh) embedded advanced features (page 1) registers, this bit is kept to 0. Read-only bit.

### 10.31 EMB\_FUNC\_INIT\_A (2Ch)

Embedded functions initialization register (R/W)

**Table 195. EMB\_FUNC\_INIT\_A register**

MLC_BEFORE_FSM_INIT	0 <sup>(1)</sup>	SIG_MOT_INIT	TILT_INIT	STEP_DET_INIT	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>
---------------------	------------------	--------------	-----------	---------------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 196. EMB\_FUNC\_INIT\_A register description**

MLC_BEFORE_FSM_INIT	Machine learning core initialization request (MLC executed before FSM). Default value: 0
SIG_MOT_INIT	Significant motion detection algorithm initialization request. Default value: 0
TILT_INIT	Tilt algorithm initialization request. Default value: 0
STEP_DET_INIT	Pedometer step counter/detector algorithm initialization request. Default value: 0

### 10.32 EMB\_FUNC\_INIT\_B (2Dh)

Embedded functions initialization register (R/W)

**Table 197. EMB\_FUNC\_INIT\_B register**

0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	MLC_INIT	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	FSM_INIT
------------------	------------------	------------------	----------	------------------	------------------	------------------	----------

1. This bit must be set to 0 for the correct operation of the device.

**Table 198. EMB\_FUNC\_INIT\_B register description**

MLC_INIT	Machine learning core initialization request (MLC executed after FSM). Default value: 0
FSM_INIT	FSM initialization request. Default value: 0

### 10.33 MLC1\_SRC (34h)

Machine learning core source register (R)

**Table 199. MLC1\_SRC register**

MLC1_SRC_7	MLC1_SRC_6	MLC1_SRC_5	MLC1_SRC_4	MLC1_SRC_3	MLC1_SRC_2	MLC1_SRC_1	MLC1_SRC_0
------------	------------	------------	------------	------------	------------	------------	------------

**Table 200. MLC1\_SRC register description**

MLC1_SRC_[7:0]	Output value of MLC1 decision tree
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### 10.34 MLC2\_SRC (35h)

Machine learning core source register (R)

**Table 201. MLC2\_SRC register**

MLC2_SRC_7	MLC2_SRC_6	MLC2_SRC_5	MLC2_SRC_4	MLC2_SRC_3	MLCS2_SRC_2	MLC2_SRC_1	MLC2_SRC_0
------------	------------	------------	------------	------------	-------------	------------	------------

**Table 202. MLC2\_SRC register description**

MLC2_SRC_[7:0]	Output value of MLC2 decision tree
----------------	------------------------------------

### 10.35 MLC3\_SRC (36h)

Machine learning core source register (R)

**Table 203. MLC3\_SRC register**

MLC3_SRC_7	MLC3_SRC_6	MLC3_SRC_5	MLC3_SRC_4	MLC3_SRC_3	MLC3_SRC_2	MLC3_SRC_1	MLC3_SRC_0
------------	------------	------------	------------	------------	------------	------------	------------

**Table 204. MLC3\_SRC register description**

MLC3_SRC_[7:0]	Output value of MLC3 decision tree
----------------	------------------------------------

### 10.36 MLC4\_SRC (37h)

Machine learning core source register (R)

**Table 205. MLC4\_SRC register**

MLC4_SRC_7	MLC4_SRC_6	MLC4_SRC_5	MLC4_SRC_4	MLC4_SRC_3	MLC4_SRC_2	MLC4_SRC_1	MLC4_SRC_0
------------	------------	------------	------------	------------	------------	------------	------------

**Table 206. MLC4\_SRC register description**

MLC4_SRC_[7:0]	Output value of MLC4 decision tree
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### 10.37 FSM\_ODR (39h)

Finite state machine output data rate configuration register (R/W)

**Table 207. FSM\_ODR register**

0 <sup>(1)</sup>	1 <sup>(2)</sup>	FSM_ODR_2	FSM_ODR_1	FSM_ODR_0	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>
------------------	------------------	-----------	-----------	-----------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.
2. This bit must be set to 1 for the correct operation of the device.

**Table 208. FSM\_ODR register description**

FSM_ODR_[2:0]	Finite state machine ODR configuration: (000: 12.5 Hz; 001: 25 Hz (default); 010: 50 Hz; 011: 100 Hz; 100: 200 Hz; 101: 400 Hz; 110: 800 Hz)
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### 10.38 MLC\_ODR (3Ah)

Machine learning core output data rate configuration register (R/W)

**Table 209. MLC\_ODR register**

0 <sup>(1)</sup>	MLC_ODR_2	MLC_ODR_1	MLC_ODR_0	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	1 <sup>(2)</sup>
------------------	-----------	-----------	-----------	------------------	------------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.
2. This bit must be set to 1 for the correct operation of the device.

**Table 210. MLC\_ODR register description**

MLC_ODR_[2:0]	Machine learning core ODR configuration: (000: 12.5 Hz; 001: 25 Hz (default); 010: 50 Hz; 011: 100 Hz; 100: 200 Hz)
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## 11 Embedded advanced features pages

The table given below provides a list of the registers for the embedded advanced features page 0. These registers are accessible when PAGE\_SEL[3:0] are set to 0000 in PAGE\_SEL (02h).

*Note:* The content of these registers is loaded when the embedded functions are enabled by setting the EMB\_FUNC\_EN bit to 1 in the CTRL4 (13h) register. The embedded functions must be enabled in order for these registers to become accessible.

**Table 211. Register address map - embedded advanced features page 0**

Name	Type	Register address		Default	Comment
		Hex	Binary		
FSM_LC_TIMEOUT_L	R/W	54	01010100	00000000	
FSM_LC_TIMEOUT_H	R/W	55	01010101	00000000	
FSM_PROGRAMS	R/W	56	01010110	00000000	
FSM_START_ADD_L	R/W	58	01011000	00000000	
FSM_START_ADD_H	R/W	59	01011001	00000000	
PEDO_CMD_REG	R/W	5D	01011101	00000000	
PEDO_DEB_STEPS_CONF	R/W	5E	01011110	00001010	
PEDO_SC_DELTAT_L	R/W	AA	10101010	00000000	
PEDO_SC_DELTAT_H	R/W	AB	10101011	00000000	
T_SENSITIVITY_L	R/W	B6	10110110	11010001	
T_SENSITIVITY_H	R/W	B7	10110111	00011001	

Reserved registers must not be changed. Writing to those registers may cause permanent damage to the device. The content of the registers that are loaded at boot should not be changed. They contain the factory calibration values. Their content is automatically restored when the device is powered up.

**Write procedure example:** write value 06h in register at address 5Eh (PEDO\_DEB\_STEPS\_CONF) in Page 0

1. Write bit EMB\_FUNC\_REG\_ACCESS = 1 in FUNC\_CFG\_ACCESS (3Fh) // Enable access to embedded functions registers
2. Write bit PAGE\_WRITE = 1 in PAGE\_RW (17h) register // Select write operation mode
3. Write 0000 in PAGE\_SEL[3:0] field of register PAGE\_SEL (02h) // Select page 0
4. Write 5Eh in PAGE\_ADDRESS (08h) register // Set address
5. Write 06h in PAGE\_VALUE (09h) register // Set value to be written
6. Write bit PAGE\_WRITE = 0 in PAGE\_RW (17h) register // Write operation disabled
7. Write bit EMB\_FUNC\_REG\_ACCESS = 0 in FUNC\_CFG\_ACCESS (3Fh) // Disable access to embedded functions registers

**Read procedure example:** read value of register at address 5Eh (PEDO\_DEB\_STEPS\_CONF) in Page 0

1. Write bit EMB\_FUNC\_REG\_ACCESS = 1 in FUNC\_CFG\_ACCESS (3Fh) // Enable access to embedded functions registers
2. Write bit PAGE\_READ = 1 in PAGE\_RW (17h) register // Select read operation mode
3. Write 0000 in PAGE\_SEL[3:0] field of register PAGE\_SEL (02h) // Select page 0
4. Write 5Eh in PAGE\_ADDRESS (08h) register // Set address
5. Read value of PAGE\_VALUE (09h) register // Get register value
6. Write bit PAGE\_READ = 0 in PAGE\_RW (17h) register // Read operation disabled
7. Write bit EMB\_FUNC\_REG\_ACCESS = 0 in FUNC\_CFG\_ACCESS (3Fh) // Disable access to embedded functions registers

*Note: Steps 1 and 2 of both procedures are intended to be performed at the beginning of the procedure. Steps 6 and 7 of both procedures are intended to be performed at the end of the procedure. If the procedure involves multiple operations, only steps 3, 4 and 5 must be repeated for each operation. If, in particular, the multiple operations involve consecutive registers, only step 5 can be performed.*

## 12 Embedded advanced features register description

### 12.1 Page 0 - embedded advanced features registers

#### 12.1.1 FSM\_LC\_TIMEOUT\_L (54h) and FSM\_LC\_TIMEOUT\_H (55h)

FSM long counter timeout register (R/W)

The long counter timeout value is an unsigned integer value (16-bit format). When the long counter value reached this value, the FSM generates an interrupt.

**Table 212. FSM\_LC\_TIMEOUT\_L register**

FSM_LC_TIMEOUT7	FSM_LC_TIMEOUT6	FSM_LC_TIMEOUT5	FSM_LC_TIMEOUT4	FSM_LC_TIMEOUT3	FSM_LC_TIMEOUT2	FSM_LC_TIMEOUT1	FSM_LC_TIMEOUT0
-----------------	-----------------	-----------------	-----------------	-----------------	-----------------	-----------------	-----------------

**Table 213. FSM\_LC\_TIMEOUT\_L register description**

FSM_LC_TIMEOUT[7:0]	FSM long counter timeout value (LSbyte). Default value: 00000000
---------------------	--

**Table 214. FSM\_LC\_TIMEOUT\_H register**

FSM_LC_TIMEOUT15	FSM_LC_TIMEOUT14	FSM_LC_TIMEOUT13	FSM_LC_TIMEOUT12	FSM_LC_TIMEOUT11	FSM_LC_TIMEOUT10	FSM_LC_TIMEOUT9	FSM_LC_TIMEOUT8
------------------	------------------	------------------	------------------	------------------	------------------	-----------------	-----------------

**Table 215. FSM\_LC\_TIMEOUT\_H register description**

FSM_LC_TIMEOUT[15:8]	FSM long counter timeout value (MSbyte). Default value: 00000000
----------------------	--

#### 12.1.2 FSM\_PROGRAMS (56h)

FSM number of programs register (R/W)

**Table 216. FSM\_PROGRAMS register**

FSM_N_PROG7	FSM_N_PROG6	FSM_N_PROG5	FSM_N_PROG4	FSM_N_PROG3	FSM_N_PROG2	FSM_N_PROG1	FSM_N_PROG0
-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------

**Table 217. FSM\_PROGRAMS register description**

FSM_N_PROG[7:0]	Number of FSM programs; must be less than or equal to 8. Default value: 00000000
-----------------	---

**12.1.3 FSM\_START\_ADD\_L (58h) and FSM\_START\_ADD\_H (59h)**

FSM start address register (R/W). First available address is 0x35C.

**Table 218. FSM\_START\_ADD\_L register**

FSM_START7	FSM_START6	FSM_START5	FSM_START4	FSM_START3	FSM_START2	FSM_START1	FSM_START0
------------	------------	------------	------------	------------	------------	------------	------------

**Table 219. FSM\_START\_ADD\_L register description**

FSM_START[7:0]	FSM start address value (LSbyte). Default value: 00000000
----------------	---

**Table 220. FSM\_START\_ADD\_H register**

FSM_START15	FSM_START14	FSM_START13	FSM_START12	FSM_START11	FSM_START10	FSM_START9	FSM_START8
-------------	-------------	-------------	-------------	-------------	-------------	------------	------------

**Table 221. FSM\_START\_ADD\_H register description**

FSM_START[15:8]	FSM start address value (MSbyte). Default value: 00000000
-----------------	---

**12.1.4 PEDO\_CMD\_REG (5Dh)**

Pedometer configuration register (R/W)

**Table 222. PEDO\_CMD\_REG register**

0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	0 <sup>(1)</sup>	CARRY_COUNT_EN	FP_REJECTION_EN	0 <sup>(1)</sup>	0 <sup>(1)</sup>
------------------	------------------	------------------	------------------	----------------	-----------------	------------------	------------------

1. This bit must be set to 0 for the correct operation of the device.

**Table 223. PEDO\_CMD\_REG register description**

CARRY_COUNT_EN	Set when user wants to generate interrupt only on count overflow event.
FP_REJECTION_EN <sup>(1)</sup>	Enables the false-positive rejection feature

1. This bit is active if the MLC\_EN bit of EMB\_FUNC\_EN\_B (05h) or the MLC\_BEFORE\_FSM\_EN bit in the EMB\_FUNC\_EN\_A (04h) register is set to 1.

**12.1.5 PEDO\_DEB\_STEPS\_CONF (5Eh)**

Pedometer debounce configuration register (R/W)

**Table 224. PEDO\_DEB\_STEPS\_CONF register**

DEB_STEP7	DEB_STEP6	DEB_STEP5	DEB_STEP4	DEB_STEP3	DEB_STEP2	DEB_STEP1	DEB_STEP0
-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------

**Table 225. PEDO\_DEB\_STEPS\_CONF register description**

DEB_STEP[7:0]	Debounce threshold. Minimum number of steps to increment the step counter (debounce). Default value: 00001010
---------------	--

**12.1.6 PEDO\_SC\_DELTAT\_L (AAh) and PEDO\_SC\_DELTAT\_H (ABh)**

Time period register for step detection on delta time (R/W)

**Table 226. PEDO\_SC\_DELTAT\_L register**

PD_SC_7	PD_SC_6	PD_SC_5	PD_SC_4	PD_SC_3	PD_SC_2	PD_SC_1	PD_SC_0
---------	---------	---------	---------	---------	---------	---------	---------

**Table 227. PEDO\_SC\_DELTAT\_H register**

PD_SC_15	PD_SC_14	PD_SC_13	PD_SC_12	PD_SC_11	PD_SC_10	PD_SC_9	PD_SC_8
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**Table 228. PEDO\_SC\_DELTAT\_H/L register description**

PD_SC_[15:0]	Time period value (1LSB = 6.4 ms)
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**12.1.7 T\_SENSITIVITY\_L (B6h) and T\_SENSITIVITY\_H (B7h)**

Temperature sensor sensitivity value register (R/W)

This sensitivity value is also applied to the data processed in the finite state machine (FSM) and machine learning core (MLC) blocks.

This register corresponds to the conversion value of the embedded temperature sensor. The register value is expressed as half-precision floating-point format: S EEEEEEEEEEEEEEE (S: 1 sign bit; E: 5 exponent bits; F: 10 fraction bits).

The default value of T\_S\_[15:0] is 0x19D1, this value corresponds to 0.045 °C/LSB with 12-bit resolution.

**Table 229. T\_SENSITIVITY\_L register**

T_S_7	T_S_6	T_S_5	T_S_4	T_S_3	T_S_2	T_S_1	T_S_0
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**Table 230. T\_SENSITIVITY\_L register description**

T_S_[7:0]	Temperature sensor sensitivity (LSbyte). Default value: 11010001
-----------	--

**Table 231. T\_SENSITIVITY\_H register**

T_S_15	T_S_14	T_S_13	T_S_12	T_S_11	T_S_10	T_S_9	T_S_8
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**Table 232. T\_SENSITIVITY\_H register description**

T_S_[15:8]	Temperature sensor sensitivity (MSbyte). Default value: 00011001
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## 13 Package information

In order to meet environmental requirements, ST offers these devices in different grades of **ECOPACK** packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

### 13.1 Soldering information

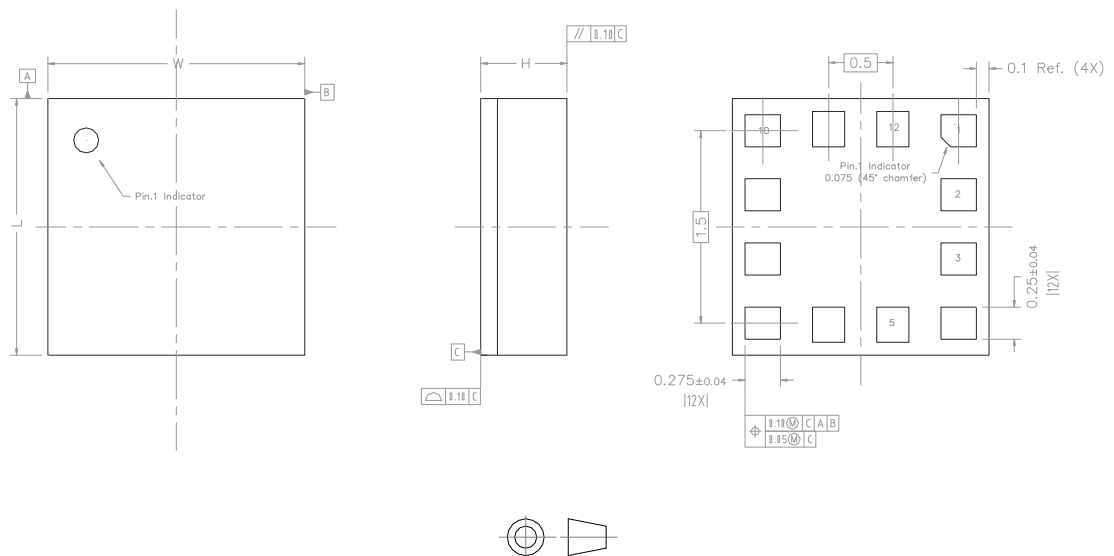
The LGA package is compliant with the **ECOPACK** and RoHS standard.

It is qualified for soldering heat resistance according to JEDEC J-STD-020.

For the land pattern and soldering recommendations, consult technical note **TN0018** available on [www.st.com](http://www.st.com).

### 13.2 LGA-12 package information

Figure 18. LGA-12 2.0 x 2.0 x 0.74 mm package outline and mechanical data



Dimensions are in millimeter unless otherwise specified  
General Tolerance is +/-0.15mm unless otherwise specified

#### OUTER DIMENSIONS

ITEM	DIMENSION [mm]	TOLERANCE [mm]
Length [L]	2	±0.1
Width [W]	2	±0.1
Height [H]	0.74 MAX	/

DM00170568

## Revision history

**Table 233. Document revision history**

Date	Version	Changes
09-Nov-2022	2	Minor textual updates

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