

## Ultra-compact high-performance eCompass module: ultra-low-power 3D accelerometer and 3D magnetometer

Datasheet - production data



LGA-12 (2.0x2.0x1.0 mm)

### Features

- 3 magnetic field channels and 3 acceleration channels
- $\pm 50$  gauss magnetic dynamic range
- $\pm 2/\pm 4/\pm 8/\pm 16$  g selectable acceleration full scales
- Anti-aliasing filter
- 16-bit data output
- SPI / I<sup>2</sup>C serial interfaces
- Analog supply voltage 1.71 V to 1.98 V
- Programmable interrupt generators for free-fall, motion and magnetic field detection
- Embedded self-test
- Embedded 256-level FIFO
- Embedded temperature sensor
- Embedded digital functions: step detector, step counter, significant motion and tilt
- ECOPACK®, RoHS and "Green" compliant

### Applications

- Tilt-compensated compasses
- Map rotation
- Position and free-fall detection
- Motion-activated functions
- Click/double-click recognition
- Pedometers
- Intelligent power saving for handheld devices
- Display orientation
- Gaming and virtual reality input devices
- Impact recognition and logging
- Vibration monitoring and compensation

### Description

The LSM303AH is an ultra-low-power high-performance system-in-package featuring a 3D digital linear acceleration sensor and a 3D digital magnetic sensor.

The LSM303AH has user-selectable linear acceleration full scales of  $\pm 2g/\pm 4g/\pm 8g/\pm 16$  g and is capable of measuring accelerations with output data rates from 1 Hz to 6400 Hz. The device has a magnetic field dynamic range of  $\pm 50$  gauss with output data rates from 10 Hz to 100 Hz. The LSM303AH includes an I<sup>2</sup>C serial bus interface that supports standard, fast mode, fast mode plus, and high-speed (100 kHz, 400 kHz, 1 MHz, and 3.4 MHz) and an SPI serial standard interface.

The LSM303AH has an integrated 256-level first-in, first-out (FIFO) buffer allowing the user to store data in order to limit intervention by the host processor. The FIFO buffer applies only to the accelerometer.

The embedded self-test capability allows the user to check the functioning of the sensor in the final application.

The system can be configured to generate an interrupt signal for free-fall, motion detection and magnetic field detection. The magnetic and accelerometer blocks can be enabled or put into power-down mode separately.

The LSM303AH is available in a plastic land grid array package (LGA) and is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

**Table 1. Device summary**

Part number	Temp. range [°C]	Package	Packaging
LSM303AH	-40 to +85	LGA-12	Tray
LSM303AHTR	-40 to +85	LGA-12	Tape and reel

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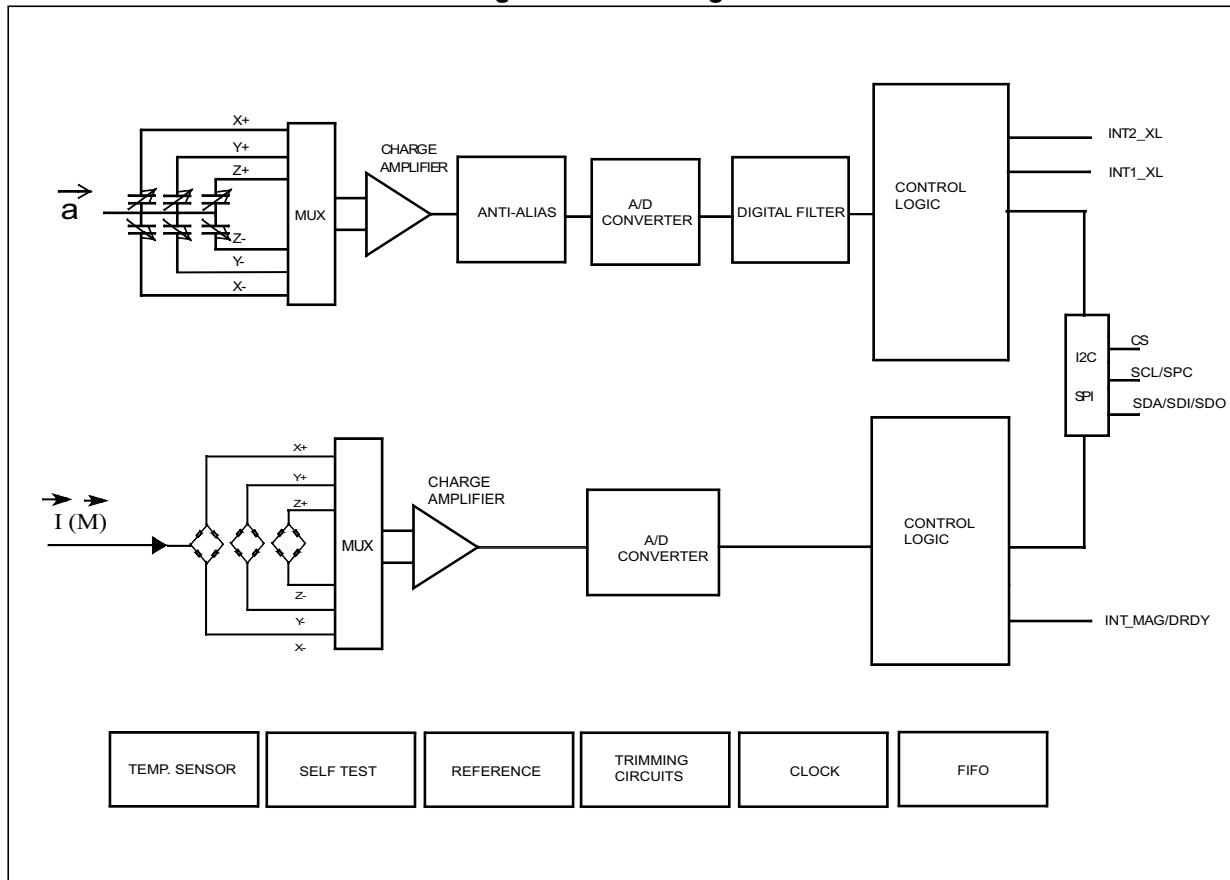
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# 1 Block diagram and pin description

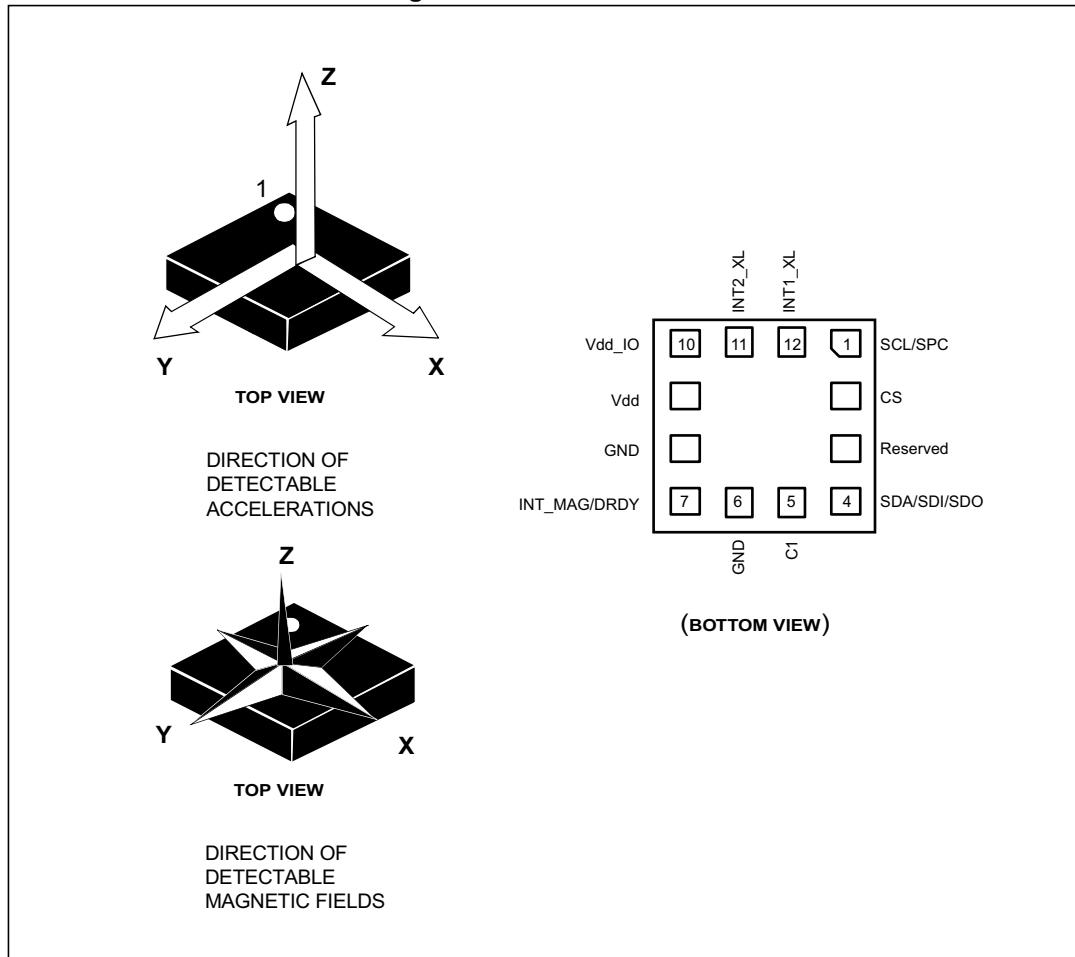
## 1.1 Block diagram

Figure 1. Block diagram



## 1.2 Pin description

Figure 2. Pin connections



**Table 2. Pin description**

Pin#	Name	Function
1	SCL SPC	I <sup>2</sup> C serial clock (SCL) SPI serial port clock (SPC)
2	CS	SPI enable I <sup>2</sup> C/SPI mode selection 1: SPI idle mode / I <sup>2</sup> C communication enabled; 0: SPI communication mode / I <sup>2</sup> C disabled
3	Reserved	Reserved, connected to GND
4	SDA SDI SDO	I <sup>2</sup> C serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)
5	C1	Capacitor connection (C1 = 220 nF)
6	GND	0 V
7	INT_MAG/DRDY	Magnetometer interrupt/data-ready signal
8	GND	0 V
9	Vdd	Power supply
10	Vdd_IO	Power supply for I/O pins
11	INT2_XL	Accelerometer interrupt 2
12	INT1_XL	Accelerometer interrupt 1

## 2 Module specifications

### 2.1 Sensor characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted <sup>(a)</sup>.

**Table 3. Sensor characteristics**

Symbol	Parameter	Test conditions	Min.	Typ. <sup>(1)</sup>	Max.	Unit
LA_FS	Linear acceleration measurement range			±2		<i>g</i>
				±4		
				±8		
				±16		
M_FS	Magnetic dynamic range			±49.152		gauss
LA_So	Sensitivity 16-bit <sup>(2)</sup>	@ FS ±2 <i>g</i>		0.061		mg/digit
		@ FS ±4 <i>g</i>		0.122		
		@ FS ±8 <i>g</i>		0.244		
		@ FS ±16 <i>g</i>		0.488		
M_So	Magnetic sensitivity			1.5		mgauss/ LSB
LA_TCSo	Linear acceleration sensitivity change vs. temperature <sup>(3)</sup>			0.01		%/°C
M_TCSo	Magnetic sensitivity change vs. temperature <sup>(3)</sup>			±0.03		%/°C
LA_TyOff	Typical zero- <i>g</i> level offset accuracy <sup>(4)(5)</sup>			±30		mg
M_TyOff	Magnetic sensor offset	With offset cancellation <sup>(6)(7)</sup>		0		mgauss
LA_TCOff	Zero- <i>g</i> level change vs. temp. <sup>(3)</sup>	Max. delta from 25 °C		±0.2		mg/°C
M_TCOff	Magnetic sensor offset change vs. temp.	With offset cancellation <sup>(6)</sup>	-0.3		+0.3	mgauss/ °C
LA_An	Linear acceleration RMS noise	ODR = 50 Hz, High-Resolution mode, FS = ±2 <i>g</i>		0.6		mg (RMS)
M_R	Magnetic RMS noise <sup>(8)</sup>	High-performance mode		3		mgauss (RMS)
ST	Self-test positive difference <sup>(9)</sup> (accelerometer only)		70		1500	mg
M_ST	Magnetic self-test <sup>(10)</sup>		15		500	mgauss
Top	Operating temperature range		-40		+85	°C

1. Typical specifications are not guaranteed.

a. The product is factory calibrated at 1.8 V. The operational power supply range is from 1.71 V to 1.98 V.

2. Sensitivity calculated at 16-bit.
3. Measurements are performed in a uniform temperature setup and they are based on characterization data in a limited number of samples, not measured during final test for production.
4. Typical zero-g level offset value after MSL3 preconditioning.
5. Offset can be eliminated by enabling the slope filter.
6. Based on characterization data on a limited number of samples, not measured during final test for production.
7. Excluding drift due to magnetic shock.
8. With low-pass filter or offset cancellation enabled.
9. “Self-test positive difference” is defined as:  $\text{OUTPUT[mg]}_{(\text{CTRL3 ST2, ST1 bits=01})} - \text{OUTPUT[mg]}_{(\text{CTRL3 ST2, ST1 bits=00})}$ .
10. Magnetic “self-test” is defined as  $\text{OUTPUT[gauss]}_{(\text{self-test enabled})} - \text{OUTPUT[gauss]}_{(\text{self-test disabled})}$ .

## 2.2 Temperature sensor characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted <sup>(b)</sup>.

**Table 4. Temperature sensor characteristics**

Symbol	Parameter	Test conditions	Min.	Typ. <sup>(1)</sup>	Max.	Unit
TSDr	Temperature sensor output change vs. temp.			1		digit/°C <sup>(2)</sup>
TODR	Temperature refresh rate			12.5		Hz
Top	Operating temperature range		-40		+85	°C

1. Typical specifications are not guaranteed.

2. 8-bit resolution.

## 2.3 Electrical characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted <sup>(b)</sup>

**Table 5. Electrical characteristics**

Symbol	Parameter	Test conditions	Min.	Typ. <sup>(1)</sup>	Max.	Unit
Vdd	Supply voltage		1.71		1.98	V
Vdd_IO	Module power supply for I/O <sup>(2)</sup>		1.71	1.8	Vdd+0.1	V
LA_Idd_HR	Accelerometer current consumption in high-resolution mode. Magnetic sensor in power-down.	12.5Hz-6400Hz ODR range		162		µA
LA_Idd_LP	Accelerometer current consumption in low-power mode. Magnetic sensor in power-down.	100 Hz ODR		16		µA
		50 Hz ODR		10		µA
		12.5 Hz ODR		6		µA
		1 Hz ODR		4.5		µA
M_Idd_HR	Magnetic current consumption in high-resolution mode. Accelerometer in power-down mode.	ODR = 20 Hz		200		µA
M_Idd_LP	Magnetic current consumption in low-power mode. Linear accel. in power-down mode.	ODR = 20 Hz		50		µA
Idd_PD	Current consumption in power-down			2.5		µA
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>	High-level output voltage	I <sub>OH</sub> = 4 mA <sup>(3)</sup>	Vdd_IO - 0.2			V
V <sub>OL</sub>	Low-level output voltage	I <sub>OL</sub> = 4 mA <sup>(3)</sup>			0.2	V
Top	Operating temperature range		-40		+85	°C

1. Typical specifications are not guaranteed.

2. It is possible to remove Vdd maintaining Vdd\_IO without blocking the communication bus, in this condition the measurement chain is powered off.

3. 4 mA is the maximum driving capability, i.e. 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>.

b. The product is factory calibrated at 1.8 V. The operational power supply range is from 1.71 V to 1.98 V.

## 2.4 Communication interface characteristics

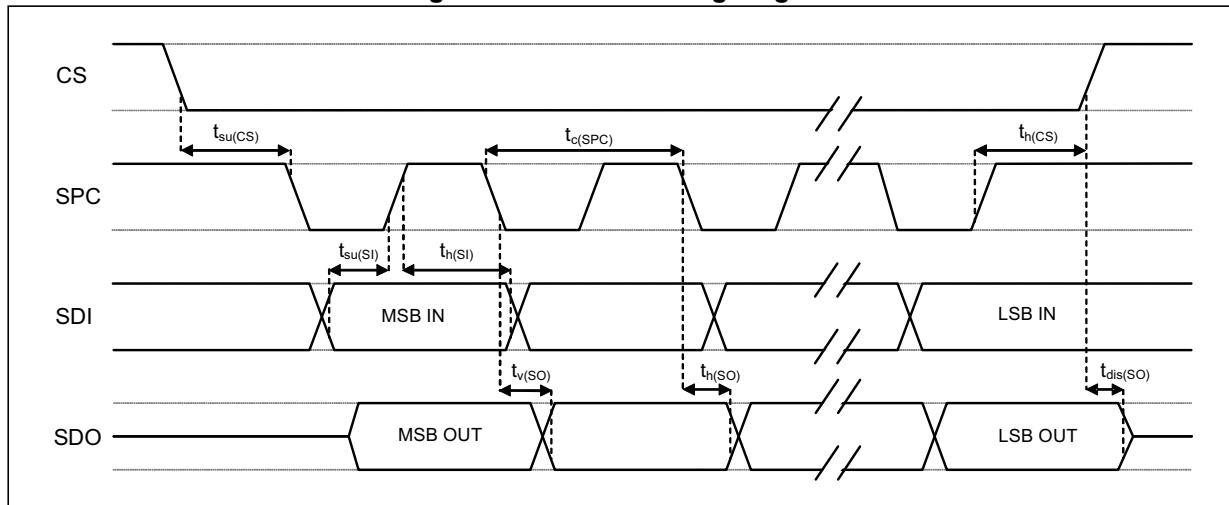
### 2.4.1 SPI - serial peripheral interface

Subject to general operating conditions for Vdd and Top.

**Table 6. SPI slave timing values**

Symbol	Parameter	Value <sup>(1)</sup>		Unit
		Min	Max	
$t_c(\text{SPC})$	SPI clock cycle	100		ns
$f_c(\text{SPC})$	SPI clock frequency		10	MHz
$t_{su(\text{CS})}$	CS setup time	5		ns
$t_h(\text{CS})$	CS hold time	20		
$t_{su(\text{SI})}$	SDI input setup time	5		
$t_h(\text{SI})$	SDI input hold time	15		
$t_v(\text{SO})$	SDO valid output time		50	
$t_h(\text{SO})$	SDO output hold time	5		
$t_{dis(\text{SO})}$	SDO output disable time		50	

**Figure 3. SPI slave timing diagram**



Note: Values are guaranteed at 10 MHz clock frequency for SPI with 3 wires, based on characterization results, not tested in production.

Measurement points are done at  $0.2 \cdot Vdd\_IO$  and  $0.8 \cdot Vdd\_IO$ , for both input and output ports.

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

Subject to general operating conditions for Vdd and Top.

**Table 7. I<sup>2</sup>C slave timing values (standard and fast mode)**

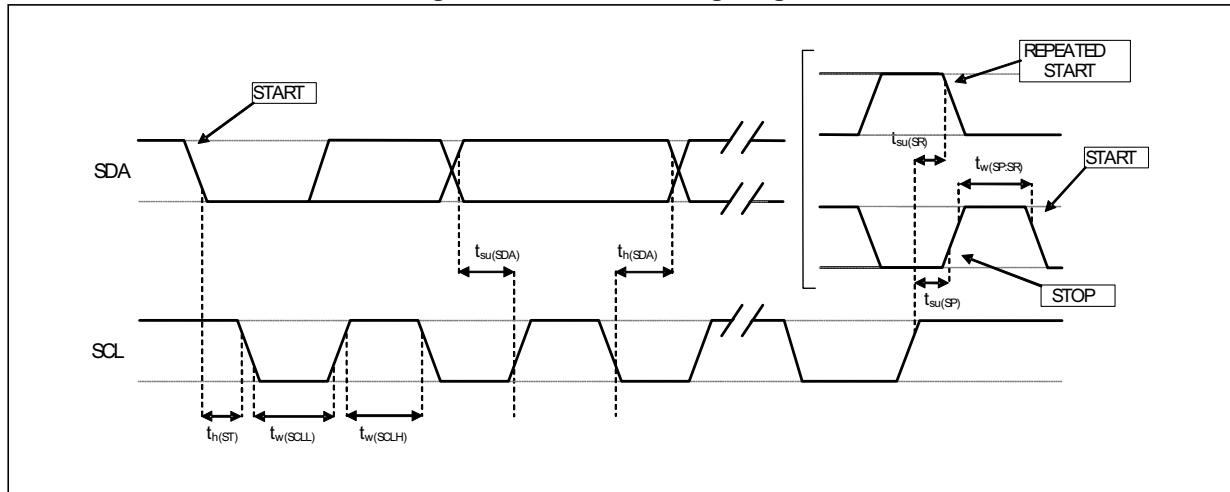
Symbol	Parameter	I <sup>2</sup> C standard mode <sup>(1)</sup>		I <sup>2</sup> C fast mode <sup>(1)</sup>		Unit
		Min	Max	Min	Max	
f <sub>(SCL)</sub>	SCL clock frequency	0	100	0	400	kHz
t <sub>w(SCLL)</sub>	Low period of the SCL clock	4.7		1.3		$\mu$ s
t <sub>w(SCLH)</sub>	High period of the SCL clock	4.0		0.6		
t <sub>su(SDA)</sub>	Data setup time	250		100		
t <sub>h(SDA)</sub>	Data hold time	0	3.45	0	0.9	
t <sub>h(ST)</sub>	START condition hold time	4		0.6		
t <sub>su(SR)</sub>	Setup time for a repeated START condition	4.7		0.6		
t <sub>su(SP)</sub>	Setup time for STOP condition	4		0.6		
t <sub>w(SP:SR)</sub>	Bus free time between STOP and START condition	4.7		1.3		

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

**Table 8. I<sup>2</sup>C slave timing values (fast mode plus and high speed)**

Symbol	Parameter	I <sup>2</sup> C fast mode plus <sup>(1)</sup>		I <sup>2</sup> C high speed <sup>(1)</sup>		Unit
		Min	Max	Min	Max	
f <sub>(SCL)</sub>	SCL clock frequency	0	1	0	3.4	MHz
t <sub>w(SCLL)</sub>	Low period of the SCL clock	0.5		0.16		$\mu$ s
t <sub>w(SCLH)</sub>	High period of the SCL clock	0.26		0.06		
t <sub>su(SDA)</sub>	Data setup time	50		10		
t <sub>h(SDA)</sub>	Data hold time	0		0	0.07	
t <sub>h(ST)</sub>	START condition hold time	0.26		0.16		
t <sub>su(SR)</sub>	Setup time for a repeated START condition	0.26		0.16		
t <sub>su(SP)</sub>	Setup time for STOP condition	0.26		0.16		
t <sub>w(SP:SR)</sub>	Bus free time between STOP and START condition	0.5				

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

**Figure 4. I<sup>2</sup>C slave timing diagram**

Note: Measurement points are done at  $0.2 \cdot V_{dd\_IO}$  and  $0.8 \cdot V_{dd\_IO}$ , 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 9. Absolute maximum ratings**

Symbol	Ratings	Maximum value	Unit
Vdd	Supply voltage	-0.3 to 2.2	V
Vdd_IO	I/O pins supply voltage	-0.3 to 2.2	V
Vin	Input voltage on any control pin (CS, SCL/SPC, SDA/SDI/SDO)	-0.3 to Vdd_IO +0.3	V
A <sub>POW</sub>	Acceleration (any axis, powered, Vdd = 1.8 V)	3000 for 0.5 ms	g
		10000 for 0.2 ms	g
A <sub>UNP</sub>	Acceleration (any axis, unpowered)	3000 for 0.5 ms	g
		10000 for 0.2 ms	g
M <sub>EF</sub>	Maximum exposed field	10000	gauss
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 (HBM)	2	kV

*Note:* Supply voltage on any pin should never exceed 2.2 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

### 3.1 Sensitivity

#### 3.1.1 Linear acceleration sensor 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,  $\pm 1 \text{ g}$  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 Magnetic sensor sensitivity

Sensitivity describes the ratio of the output digital data expressed in LSB units and the applied magnetic field expressed in mG (milligauss). It can be measured, for example, by applying a known magnetic field along one axis and measuring the digital output of the device.

### 3.2 Zero-g level

The zero-g level offset (LA\_TyOff) 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 will measure 0 g on the X-axis and 0 g on the Y-axis whereas the Z-axis will measure 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 the ideal value in this case is called zero-g offset. Offset is to some extent a result of stress to 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 with temperature, see [Table 3](#) "Zero-g level change vs. temperature" (LA\_TCOFF). The zero-g level tolerance (TyOff) describes the standard deviation of the range of zero-g levels of a population of sensors.

### 3.3 Zero-gauss level

Zero-gauss level offset (M\_TyOff) describes the deviation of an actual output signal from the ideal output if no magnetic field is present.

### 3.4 Magnetic dynamic range

The magnetic dynamic range is defined as the magnetic field driven along one sensitive axis, giving the maximum digital output value.

## 4      Functionality

### 4.1    Magnetometer

#### 4.1.1    Magnetometer power modes

The LSM303AH magnetometer provides two different power modes: high-resolution and low-power modes.

The tables below summarize the magnetometer RMS noise values and current consumption in different product configurations.

When the low-pass filter is enabled, the bandwidth is reduced while noise performance is improved without any increase in power consumption.

**Table 10. RMS noise of operating modes**

CFG_REG_B_M[LPF] or CFG_REG_B_M[OFF_CANC]	(CFG_REG_A_M [LP = 0]) high-resolution mode		(CFG_REG_A_M [LP = 1]) low-power mode	
	BW [Hz]	Noise RMS [mg]	BW [Hz]	Noise RMS [mg]
0 (disable)	ODR/2	4.5	ODR/2	9
1 (enable)	ODR/4	3	ODR/4	6

**Table 11. Current consumption of operating modes**

ODR (Hz)	Current consumption ( $\mu$ A) (CFG_REG_A_M [LP] = 0) high-resolution CFG_REG_B_M [OFF_CANC] = 0	Current consumption ( $\mu$ A) (CFG_REG_A_M [LP] = 1) low-power CFG_REG_B_M [OFF_CANC] = 0	Current consumption ( $\mu$ A) (CFG_REG_A_M [LP] = 0) high-resolution CFG_REG_B_M [OFF_CANC] = 1	Current consumption ( $\mu$ A) (CFG_REG_A_M [LP] = 1) low-power CFG_REG_B_M [OFF_CANC] = 1
10	100	25	125	55
20	200	50	240	105
50	475	125	590	255
100	950	250	1180	505

The following table summarizes the turn-on time of the magnetometer in the two different power modes with the offset cancellation function enabled or disabled (see [Section 4.1.2: Magnetometer offset cancellation](#)).

**Table 12. Operating mode and turn-on time**

Operating mode	Turn-on time	
CFG_REG_A_M[LP]	CFG_REG_A_M[OFF_CANC = 0]	CFG_REG_A_M[OFF_CANC = 1]
0 (high-resolution)	9.4 ms	9.4 ms + 1/ODR
1 (low-power)	6.4 ms	6.4 ms + 1/ODR

The LSM303AH offers single measurement mode in both high-resolution and low-power modes.

Single measurement mode is enabled by writing bits MD[1:0] to '01' in [CFG\\_REG\\_A\\_M \(60h\)](#).

In single measurement mode, once the measurement has been performed, the DRDY pin is set to high, data is available in the output register and the LSM303AH is automatically configured in idle mode by setting the MD[1] bit to '1'.

Single measurement is independent of the programmed ODR but depends on the frequency at which the MD[1:0] bits are written by the microcontroller/application processor.

Maximum ODR frequency achievable in single mode measurement is given in the following table.

**Table 13. Maximum ODR in single measurement mode (HR and LP modes)**

Maximum ODR	Power mode (CFG_REG_A_M[LP])
100 Hz	High resolution (LP = '0')
150 Hz	Low power (LP = '1')

In single measurement mode, for ODR < 10 Hz, current consumption can be calculated with the following formula:

$$(\text{Current_consumption}_\text{10Hz} - \text{Current_consumption}_\text{in_power_down}) / (10 \text{ Hz} / \text{ODR}) + \text{Current_consumption}_\text{in_power_down}$$

Where Current\_consumption\_in\_power\_down and Current\_consumption\_10Hz can be found, respectively, in [Table 5](#) and [Table 11](#).

#### 4.1.2 Magnetometer offset cancellation

Offset cancellation is the result of performing a set and reset in the magnetic sensor.

The offset cancellation technique is defined as follows:

$$H_{out} = \frac{H_n + H_{n-1}}{2}$$

where  $H_n$  and  $H_{n-1}$  are two consecutive magnetic field measurements, one after a set pulse, the other after a reset pulse.

Considering a magnetic offset ( $H_{off}$ ), the two magnetic field measurements are:

- Set:  $H_n = H + H_{off}$
- Reset:  $H_{n-1} = H - H_{off}$

The offset is cancelled according to the offset cancellation technique:

$$H_{out} = \frac{H_n + H_{n-1}}{2} = \frac{2H + H_{off} - H_{off}}{2} = H$$

In the LSM303AH offset cancellation is enabled by setting bit OFF\_CANC = 1 (and bit OFF\_CANC\_ONE\_SHOT = 1 in single measurement mode) in [CFG\\_REG\\_B\\_M \(61h\)](#).

Offset cancellation is automatically managed by the device in continuous mode.

Offset cancellation has to be managed by the user in single measurement mode averaging two consecutive measurements  $H_n$  and  $H_{n-1}$ .

If offset cancellation is disabled, a set of the magnetic sensor is performed anyway.

The set pulse frequency can be configured by setting the Set\_FREQ bit in [CFG\\_REG\\_B\\_M \(61h\)](#).

#### 4.1.3 Magnetometer interrupt

In LSM303AH magnetometer interrupt signal generation is based on the comparison between data and a programmable threshold.

To enable the interrupt function, in INT\_CTRL\_REG\_M register (63h) the "IEN" bit must be set to '1'.

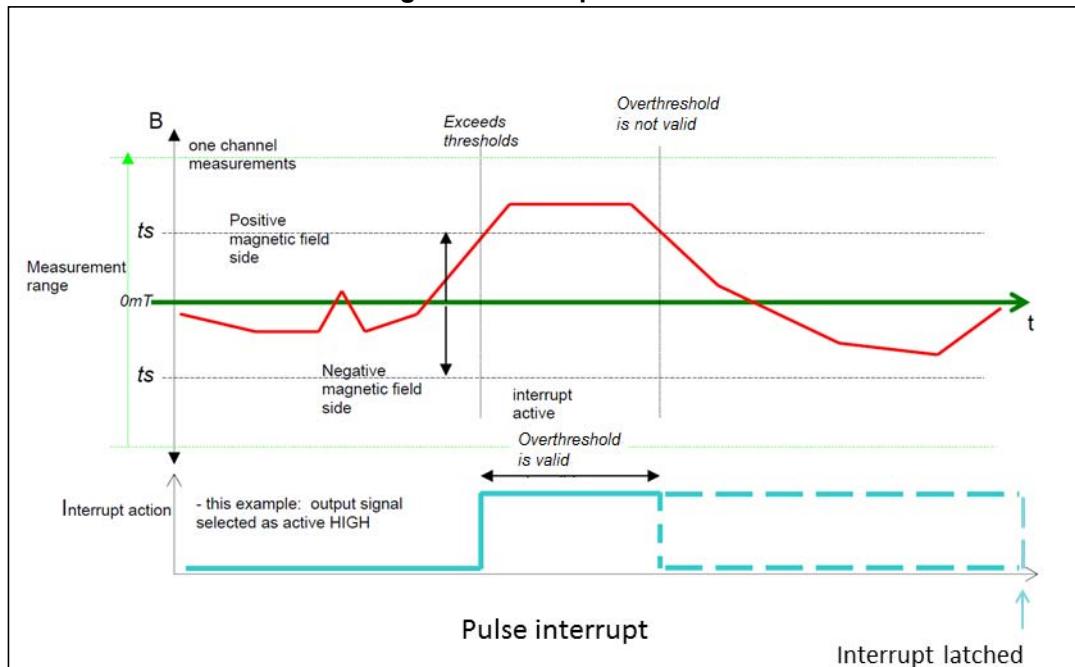
In the LSM303AH the user can select the axis/axes in which the interrupt function can be enabled. In order to do this, the XIEN, YIEN, and ZIEN bits in [INT\\_CTRL\\_REG\\_M \(63h\)](#) need be set properly.

The threshold value can be programmed by setting the [INT\\_THS\\_L\\_REG\\_M \(65h\)](#) and [INT\\_THS\\_H\\_REG\\_M \(66h\)](#) registers.

The threshold is expressed in absolute value as a 15-bit unsigned number. The threshold has the same sensitivity as the magnetic data.

When magnetic data exceeds the positive or the negative threshold, the interrupt signal is generated and the information about the type of interrupt is stored in the [INT\\_SOURCE\\_REG\\_M \(64h\)](#) register. In particular, when magnetic data exceeds the positive threshold the P\_TH\_S\_axis bit is set to '1', while if data exceeds the negative threshold the N\_TH\_S\_axis bit is set to '1'. If magnetic data lay between the positive and the negative thresholds, no interrupt signal is released.

Figure 5. Interrupt function



Two different approaches for the interrupt function are available:

- Typical: comparison is between magnetic data read by the sensor and the programmable threshold;
- Advanced: comparison is made between magnetic data after hard-iron correction and the programmable threshold.

These approaches are configurable by setting the INT\_on\_DataOFF bit in [CFG\\_REG\\_B\\_M \(61h\)](#).

If INT\_on\_DataOFF is set to '0' the typical approach is selected, otherwise if it is set to '1' the advanced approach is selected.

Two different interrupts are available:

- Pulsed interrupt signal: it goes high when the magnetic data exceed one of the two thresholds and goes low when the magnetic data are between the two thresholds. This kind of interrupt is selected by setting the IEL bit in [INT\\_CTRL\\_REG\\_M \(63h\)](#) to '0'.
- Latched interrupt signal: it goes high when the data exceed one of the two thresholds but is reset only once the source register is read and not when the magnetic data returns between the two thresholds. This kind of interrupt is selected by setting the IEL bit in [INT\\_CTRL\\_REG\\_M \(63h\)](#) to '1'.

The interrupt signal polarity can be set using the IEA bit in [INT\\_CTRL\\_REG\\_M \(63h\)](#).

If IEA is set to '1' then the interrupt signal is active high, while if it is set to '0' the interrupt signal is active low.

In order to drive the interrupt signal from the DRDY pad, the INT\_MAG\_PIN bit in [CFG\\_REG\\_C\\_M \(62h\)](#) must be set to '1'.

#### 4.1.4 Magnetometer hard-iron compensation

Hard-iron distortion occurs when a magnetic object is placed near the magnetometer and appears as a permanent bias in the sensor's outputs.

The hard-iron correction consists of compensating magnetic data from hard-iron distortion.

The operation is defined as follows:

$$H_{\text{out}} = H_{\text{read}} - H_{\text{HI}}$$

where:

- $H_{\text{read}}$  is the generic uncompensated magnetic field data, as read by the sensor;
- $H_{\text{HI}}$  is the hard-iron distortion field;
- $H_{\text{out}}$  is the compensated magnetic data.

The computation of the hard-iron distortion field should be performed by an external processor. After the computation of the hard iron-distortion field has been performed, the measured magnetic data can be compensated.

The LSM303AH offers the possibility of storing hard-iron data inside six dedicated registers from 45h to 4Ah.

Each register contains eight bits so that the hard-iron data can be expressed as a 16-bit two's complement number. The OFFSET\_axis\_REG\_H registers contain the MSBs of the hard-iron data, while the OFFSET\_axis\_REG\_L registers contain the LSBs.

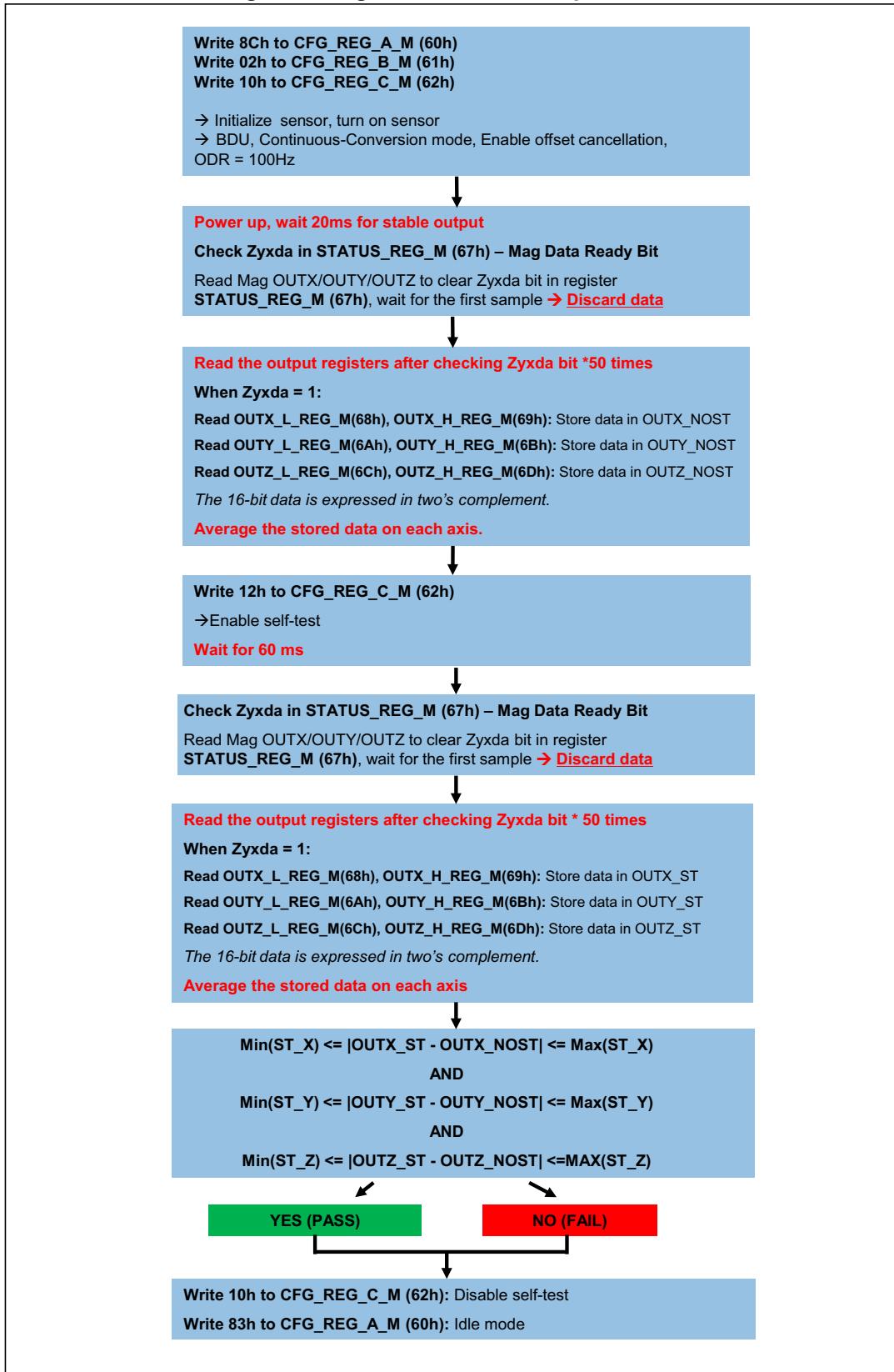
Hard-iron data have the same format and weight of the magnetic output data. The hard-iron values stored in dedicated registers are automatically subtracted from the output data.

#### 4.1.5 Magnetometer self-test

The self-test function is available for the magnetic sensor. When the magnetic self-test is enabled, a current is forced into a coil inside the device. This current will generate a magnetic field that will produce a variation of the magnetometer output signals. If the output signals change within the amplitude limits specified in [Table 3](#) then the sensor is working properly and the parameters of the interface chip are within the defined specifications.

The self-test procedure is described in the following figure.

Figure 6. Magnetometer self-test procedure



## 4.2 Accelerometer

### 4.2.1 Accelerometer power modes

The LSM303AH accelerometer provides two different power modes: high-resolution (including high-frequency mode) and low-power modes.

The following tables summarize the selection of the different operating modes as well as the low-pass filter and current consumption.

**Table 14. Accelerometer operating modes**

CTRL1_A(ODR[3:1])	CTRL1_A(HF_ODR)	ODR selection [Hz]	Bit resolution	Mode
<b>Accelerometer low-power mode</b>				
0000	-	-	10	PD
1000	-	1		LP
1001	-	12.5		
1010	-	25		
1011	-	50		
1100	-	100		
1101	-	200		
1110	-	400		
1111	-	800		
<b>Accelerometer high-resolution mode</b>				
0001	-	12.5	14	HR
0010	-	25		
0011	-	50		
0100	-	100		
0101	0	200		
0110	0	400		
0111	0	800		
0101	1	1600	12	HF
0110	1	3200		
0111	1	6400		

**Table 15. Low-pass filter in low-power, high-resolution and high-frequency modes**

ODR [Hz]	LPF cutoff [Hz]
<b>Low-power mode</b>	
800	3200
400	
200	
100	
50	
25	
12.5	
1	
<b>High-resolution mode</b>	
800	355
400	177
200	88
100	44
50	22
25	11
12.5	5.5
<b>High-frequency mode</b>	
6400	2840
3200	1420
1600	710

**Table 16. Current consumption of operating modes**

ODR (Hz)	Typical current consumption in high-resolution/high-frequency mode [µA]	Typical current consumption in low-power mode [µA]
1	-	4.5
12.5	162	6
25		7.5
50		10
100		16
200		26.5
400		48.5
800		92.5
1600		
3200		
6400		

#### 4.2.2 Accelerometer 6D / 4D orientation detection

The LSM303AH includes 6D / 4D orientation detection which applies only to the accelerometer.

In this configuration the interrupt is generated when the device is stable in a known direction. In 4D configuration, detection of the position of the Z-axis is disabled.

#### 4.2.3 Accelerometer activity/inactivity function

The Activity/Inactivity recognition function allows reducing the power consumption of the system in order to develop new smart applications and is applicable only to the accelerometer block of the device.

When the Activity/Inactivity recognition function is activated, the LSM303AH is able to automatically go to 12.5 Hz sampling rate and to wake up as soon as the interrupt event has been detected, increasing the output data rate and bandwidth.

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 Activity/Inactivity recognition function is activated by writing the desired threshold in the [WAKE\\_UP\\_THS\\_A \(33h\)](#) register. The high-pass filter is automatically enabled.

If the device is in Sleep (Inactivity) mode, when at least one of the axes exceeds the threshold in the [WAKE\\_UP\\_THS\\_A \(33h\)](#) the device goes into Sleep-to-Wake (as Wake-Up).

Activity/Inactivity threshold and duration can be configured in the control registers:

[WAKE\\_UP\\_THS\\_A \(33h\)](#)

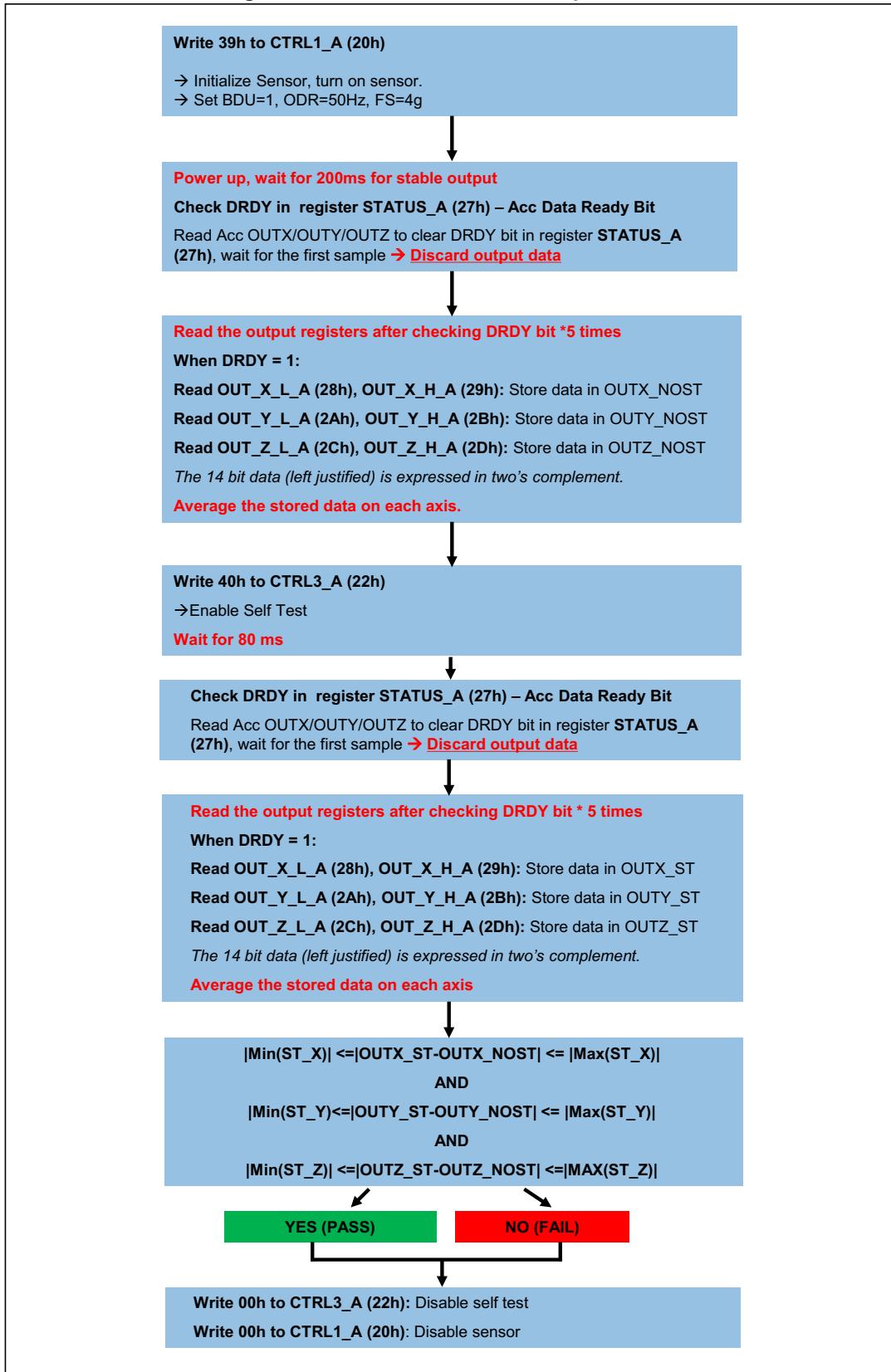
[WAKE\\_UP\\_DUR\\_A \(34h\)](#)

#### 4.2.4 Accelerometer self-test

The self-test allows the user to check the sensor functionality without moving it. When the self-test is enabled, an actuation force is applied to the sensor, simulating a definite input acceleration. In this case the sensor outputs will exhibit a change in their DC levels which are related to the selected full scale through the device sensitivity. When the self-test is activated, the device output level is given by the algebraic sum of the signals produced by the acceleration acting on the sensor and by the electrostatic test-force. If the output signals change within the amplitude specified inside [Table 3](#), then the sensor is working properly and the parameters of the interface chip are within the defined specifications.

The self-test procedure is described in the following figure.

Figure 7. Accelerometer self-test procedure



#### 4.2.5 Accelerometer data stabilization time vs. ODR setting

The data stabilization time required when an ODR change is applied in order to have valid usable data depends on the ODR selected and accelerometer setting.

The table below provides the number of samples to be discarded in order to obtain valid usable data for the accelerometer.

**Table 17. Number of samples to be discarded**

ODR [Hz]	HF	HR	LP
6400	6	-	-
3200	2	-	-
1600	1	-	-
800	-	1	0
400	-	1	0
200	-	1	0
100	-	1	0
50	-	0	0
25	-	0	0
12.5	-	0	0
1	-	-	0

#### 4.2.6 Accelerometer anti-aliasing filter

The anti-aliasing filter reveals a robustness against external signal disturbance, maintaining the best accelerometer signal integrity.

The anti-aliasing bandwidth has a bandwidth of ODR/2 in high-resolution (HR) and high-frequency (HF) modes. Refer to [Table 15](#) for additional details on filtering.

### 4.3 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 and magnetic data may be accessed through an I<sup>2</sup>C/SPI interface, thus making the device particularly suitable for direct interfacing with a microcontroller.

The LSM303AH features a data-ready signal which indicates when new sets of measured acceleration and magnetic data are available, thus simplifying data synchronization in the digital system that uses the device.

## 4.4 FIFO

The FIFO buffer applies only to the accelerometer. The LSM303AH embeds 256 slots of 14-bit data FIFO for each of the three output channels, X, Y and Z of the acceleration module. 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.

The internal FIFO allows collecting 256 samples (14-bit size data) for each axis or storing the output of the module computation up to 768 samples (14-bit size data).

This buffer can work according to the following 5 different modes:

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

Each mode is selected by the FIFO\_MODE bits in the [FIFO\\_CTRL\\_A \(25h\)](#) register.

Programmable FIFO threshold status, FIFO overrun events and the number of unread samples stored are available in the [FIFO\\_SRC\\_A \(2Fh\)](#) and [FIFO\\_SAMPLES\\_A \(30h\)](#) registers and can be set to generate dedicated interrupts on the INT1 and INT2 pins using the [CTRL4\\_A \(23h\)](#) and [CTRL5\\_A \(24h\)](#) registers.

[FIFO\\_SRC\\_A \(2Fh\)](#) (FIFO\_FTH) goes to '1' when the number of unread samples [FIFO\\_SRC\\_A \(2Fh\)](#) and [FIFO\\_SAMPLES\\_A \(30h\)](#) (Diff[8:0]) is greater than or equal to FTH [7:0] in [FIFO\\_THS\\_A \(2Eh\)](#).

If FTH [7:0] is equal to '0', [FIFO\\_SRC\\_A \(2Fh\)](#) (FIFO\_FTH) goes to '0'.

[FIFO\\_SRC\\_A \(2Fh\)](#) (FIFO\_OVRN) is equal to '1' if a FIFO slot is overwritten.

[FIFO\\_SRC\\_A \(2Fh\)](#) and [FIFO\\_SAMPLES\\_A \(30h\)](#) (Diff[8:0]) contain stored data levels of unread samples. When Diff[8:0] is equal to '000000000', FIFO is empty. When Diff[8:0] is equal to '100000000', FIFO is full and the unread samples are 256.

To guarantee the correct acquisition of data during the switching into and out of FIFO mode, the first sample acquired must be discarded.

When the FIFO threshold status flag is '0'-logic, FIFO filling is lower than the threshold level and when '1'-logic, FIFO filling is equal to or higher than the threshold level.

### 4.4.1 Bypass mode

In Bypass mode ([FIFO\\_CTRL\\_A \(25h\)](#) (FMODE [2:0]= 000), the FIFO is not operational, no data is collected in FIFO memory, and it remains empty with the only actual sample available in the output registers.

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

For each channel only the first address is used. When new data is available, the old data is overwritten.

#### 4.4.2 FIFO mode

In FIFO mode ([FIFO\\_CTRL\\_A \(25h\)](#) (FMODE [2:0])= 001) data from the X, Y and Z channels are stored in the FIFO until it is full, when 256 unread samples are stored in memory, data collecting is stopped.

To reset the FIFO content, Bypass mode should be written in the [FIFO\\_CTRL\\_A \(25h\)](#) register, setting the FMODE [2:0] bits to '000'. After this reset command, it is possible to restart FIFO mode, writing the value '001' in [FIFO\\_CTRL\\_A \(25h\)](#) (FMODE [2:0]).

The FIFO buffer can memorize 256 slots of X, Y and Z data.

#### 4.4.3 Continuous mode

Continuous mode ([FIFO\\_CTRL\\_A \(25h\)](#) (FMODE[2:0] = 110) provides a continuous FIFO update: when 256 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\\_CTRL\\_A \(25h\)](#) (FIFO\_FTH) is asserted when the number of unread samples in FIFO is greater than or equal to [FIFO\\_THS\\_A \(2Eh\)](#) (FTH[7:0]).

It is possible to route [FIFO\\_CTRL\\_A \(25h\)](#)(FTH) to the INT1 pin by writing the INT1\_FTH bit to '1' in register [CTRL4\\_A \(23h\)](#) or to the INT2 pin by writing the INT2\_FTH bit to '1' in register [CTRL5\\_A \(24h\)](#).

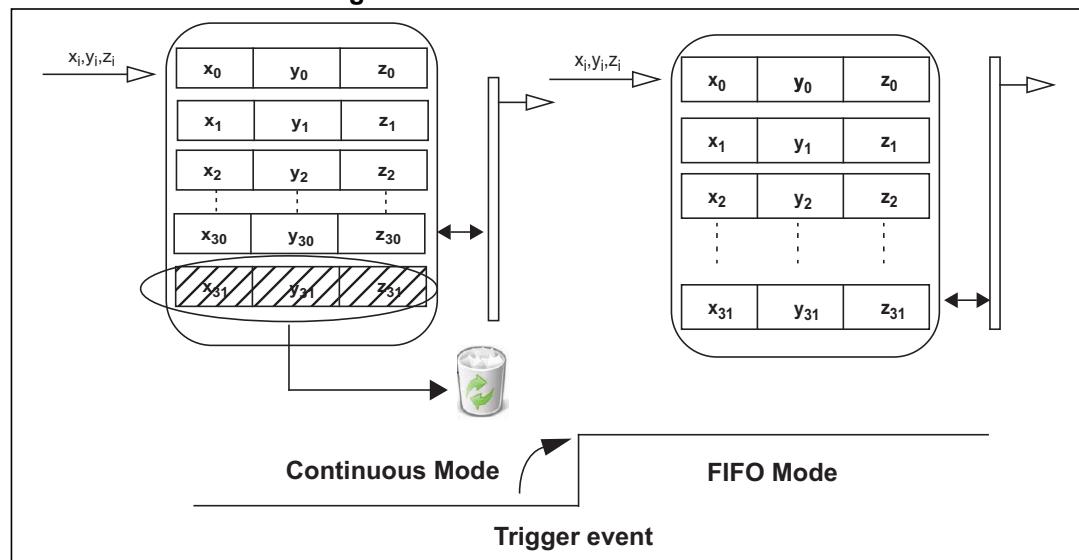
If an overrun occurs, the oldest sample in FIFO is overwritten and the FIFO\_OVR flag in [FIFO\\_SRC\\_A \(2Fh\)](#) is asserted.

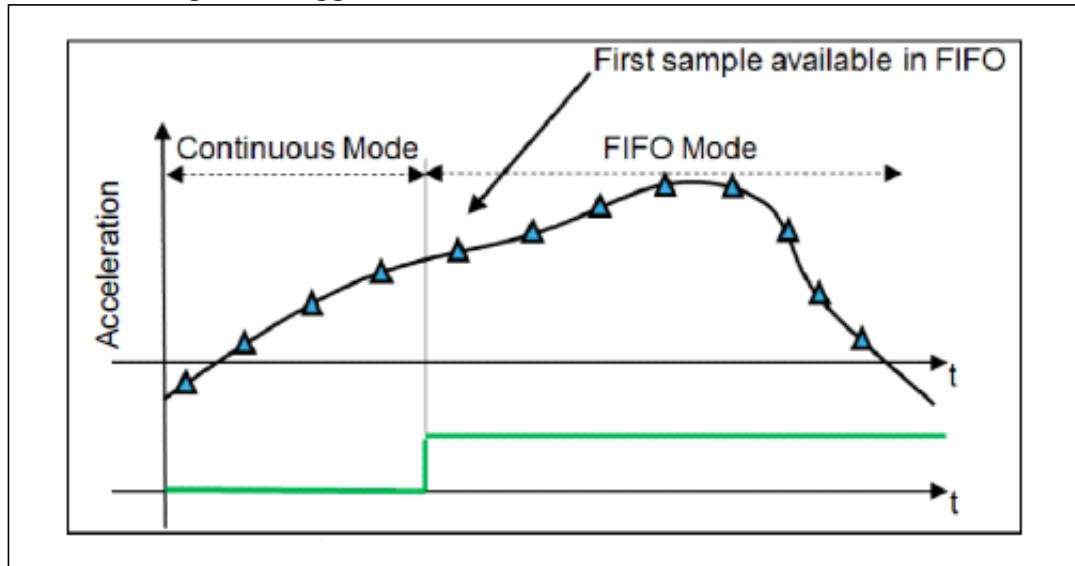
In order to empty the FIFO before it is full, it is also possible to pull from FIFO the number of unread samples available in [FIFO\\_SRC\\_A \(2Fh\)](#) and [FIFO\\_SAMPLES\\_A \(30h\)](#) (Diff[8:0]).

#### 4.4.4 Continuous-to-FIFO mode

In Continuous-to-FIFO mode [FIFO\\_CTRL\\_A \(25h\)](#) (FMODE [2:0] = 011), FIFO operates in Continuous mode and FIFO mode starts upon an internal trigger event. When the FIFO is full, data collecting is stopped.

**Figure 8. Continuous-to-FIFO mode**

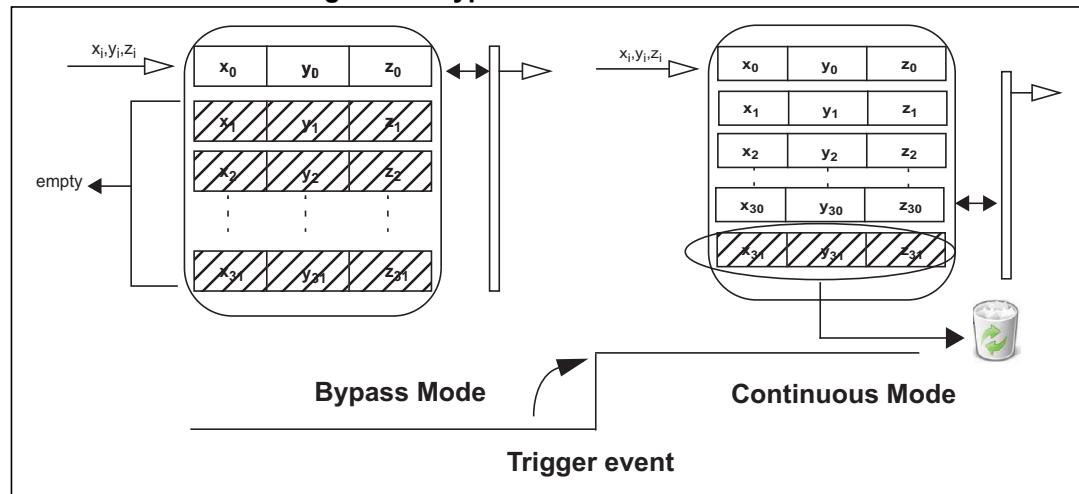


**Figure 9. Trigger event to FIFO for Continuous-to-FIFO mode**

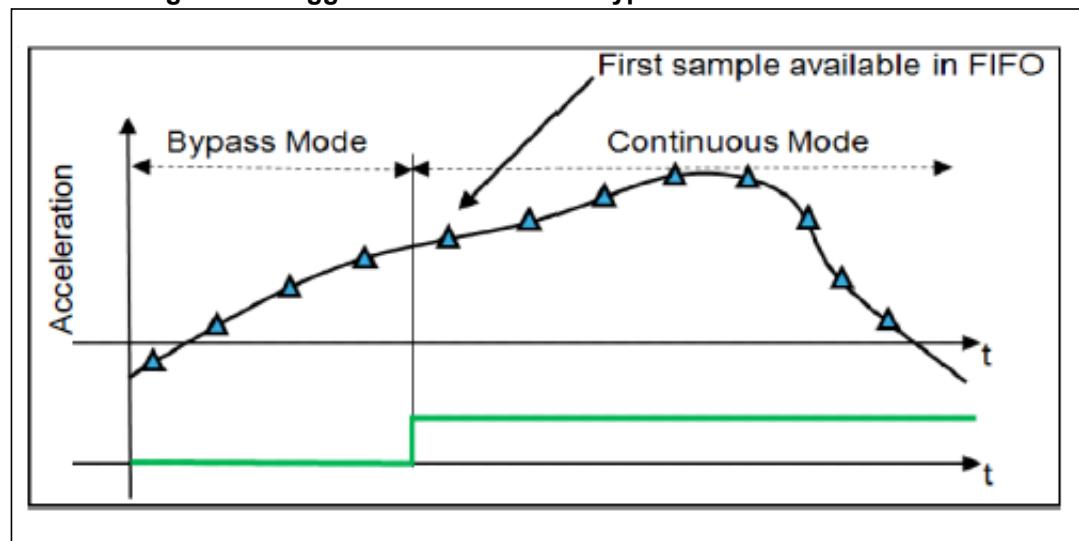
#### 4.4.5 Bypass-to-Continuous mode

In Bypass-to-Continuous mode ([FIFO\\_CTRL\\_A \(25h\)](#)(FMODE[2:0] = '100'), data measurement storage inside FIFO starts in Continuous mode upon an internal trigger event, then the sample that follows the trigger is available in FIFO.

**Figure 10. Bypass-to-Continuous mode**



**Figure 11. Trigger event to FIFO for Bypass-to-Continuous mode**



#### 4.4.6 Module-to-FIFO

When the MODULE\_TO\_FIFO bit in the [FIFO\\_CTRL\\_A \(25h\)](#) register is set to '1', the 14-bit magnitude of the vector of the current axes is sent as FIFO input instead of axes data. X-, Y- and Z-axis data are replaced with 3 times the adjacent data generated by the module routine, as shown in [Figure 12](#), so a row of FIFO is written every 3 axes data ready.

The module routine must be previously enabled by writing to the [FUNC\\_CTRL\\_A \(3Fh\)](#) register.

The module data in FIFO can be read as output data in the registers 28h-2Dh.

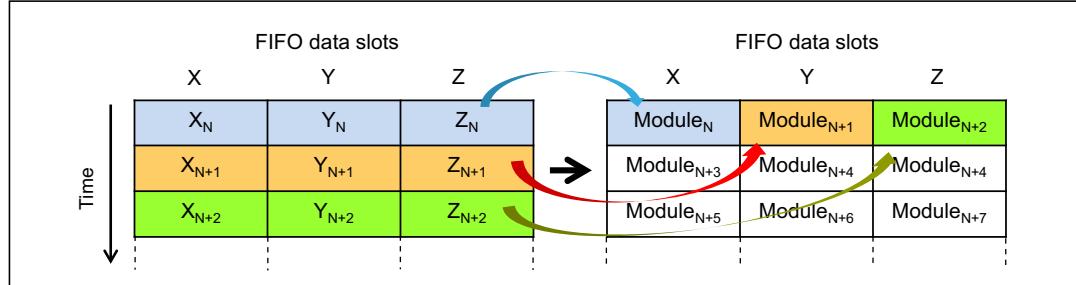
The LSM303AH calculates the vector sum of the acceleration of the X-, Y-, Z-axis using the following formula:

$$\text{module (14-bit)} = \text{Sqrt}(x^2+y^2+z^2)$$

The implementation is based on an approximation of this formula (error below noise level).

As shown in [Figure 12](#), when module-to-FIFO is enabled, each row of FIFO contains 3 values of the module, related to 3 consecutive ODR.

**Figure 12. Module-to-FIFO mode example**



#### 4.5 Embedded functions

The LSM303AH embeds internal logic able to implement the following functions which are applicable to the accelerometer only:

- Step detector
- Step counter
- Significant motion function
- Tilt function

Pedometer, significant motion, and tilt functions can work in parallel. Step detector, step counter, tilt function, and significant motion function work at 25 Hz, so the user can configure ODR at 25 Hz or higher.

**Table 18. ODR function settings**

	Pedometer	Tilt function	Event recognition
ODR ≥ 1600 Hz	Y	Y	X
ODR < 1600 Hz	Y	Y	Y
ODR 25-50 Hz	Y	Y	Y
ODR 12.5 Hz	X	X	Y

#### 4.5.1 Step detector/Step counter

The step detector function generates an interrupt when a step is recognized, the step counter (automatically enabled when step detector is on) counts the number of the steps detected.

Step Detector/Step Counter (SD/SC) are enabled by setting to '1'-logic the STEP\_CNT\_ON bit in the [FUNC\\_CTRL\\_A \(3Fh\)](#) register. Additional pedometer advanced configurations can be used if the FUNC\_CFG\_EN bit in [CTRL2\\_A \(21h\)](#) is set to "1". Details of the pedometer advanced configuration registers are available in [Section 9: Advanced configuration register mapping](#) and [Section 10: Advanced configuration registers description](#).

To disable the pedometer advanced configurations, the FUNC\_CFG\_EN bit in CTRL2 (3Fh) must be set to '0'. Refer to [Section 10.4: CTRL2\\_A \(3Fh\)](#).

The "step detected" interrupt can be read in the [FUNC\\_CK\\_GATE\\_A \(3Dh\)](#) register and by writing the INT2 STEP DET bit to '1'-logic in the [CTRL5\\_A \(24h\)](#) register it can be routed on INT2. The number of steps detected can be read from [STEP\\_COUNTER\\_L\\_A \(3Bh\)](#) and [STEP\\_COUNTER\\_H\\_A \(3Ch\)](#) registers (65535 steps max).

- As default, SD/SC operates with data scaled at 2 g of full scale (device full-scale independent), but it is possible to make it work with a FS of 4 g by setting the PEDO4g bit to '1'-logic.
- The number of steps can be reset by writing the bit RST nSTEP to '1'-logic in [STEP\\_COUNTER\\_MINTHS\\_A \(3Ah\)](#): this is a synchronous reset activated at the first data valid and before the algorithm execution. The bit is auto-reset once the counter has been successfully set to 0000h.

*Note:*

*This bit does not reset the algorithm and its variables.*

The algorithm and its variables can be reset just by writing the STEP\_CNT\_ON bit to '0'-logic, i.e. turning off the SD/SC routine. The RST PEDO bit in the [FUNC\\_CK\\_GATE\\_A \(3Dh\)](#) register signals that a SD/SC reset has to be done, so it goes high and remains at '1'-logic value until the algorithm ends the reset procedure, which is carried out at first execution after the SD/SC routine has been re-enabled, before the algorithm starts.

#### 4.5.2 Significant motion

The significant motion functionality can be used in location-based applications in order to receive a notification indicating when the user is changing location. This function has been implemented in hardware using only the accelerometer and works at 25 Hz, so the accelerometer ODR must be set at 25 Hz or higher values.

The significant motion interrupt signal can be driven to the interrupt pin by setting to 1 the INT2\_SIG\_MOT bit of the [CTRL5\\_A \(24h\)](#) register; it can also be checked by reading the SIG\_MOT\_DET bit of the [FUNC\\_CK\\_GATE\\_A \(3Dh\)](#) register.

The significant motion function generates an interrupt when the difference between the number of steps from its initialization is higher or equal than a threshold. The threshold value corresponds to the number of steps to be performed by the user upon a change of location before the significant motion interrupt is generated.

The threshold has a default value equal to 6. This threshold is configurable in the [SM\\_THS\\_A \(34h\)](#) register in the advanced configuration registers (refer to [Section 9: Advanced configuration register mapping](#) and [Section 10: Advanced configuration registers description](#)). The significant motion threshold can be used if the FUNC\_CFG\_EN bit in [CTRL2\\_A \(21h\)](#) is set to "1".

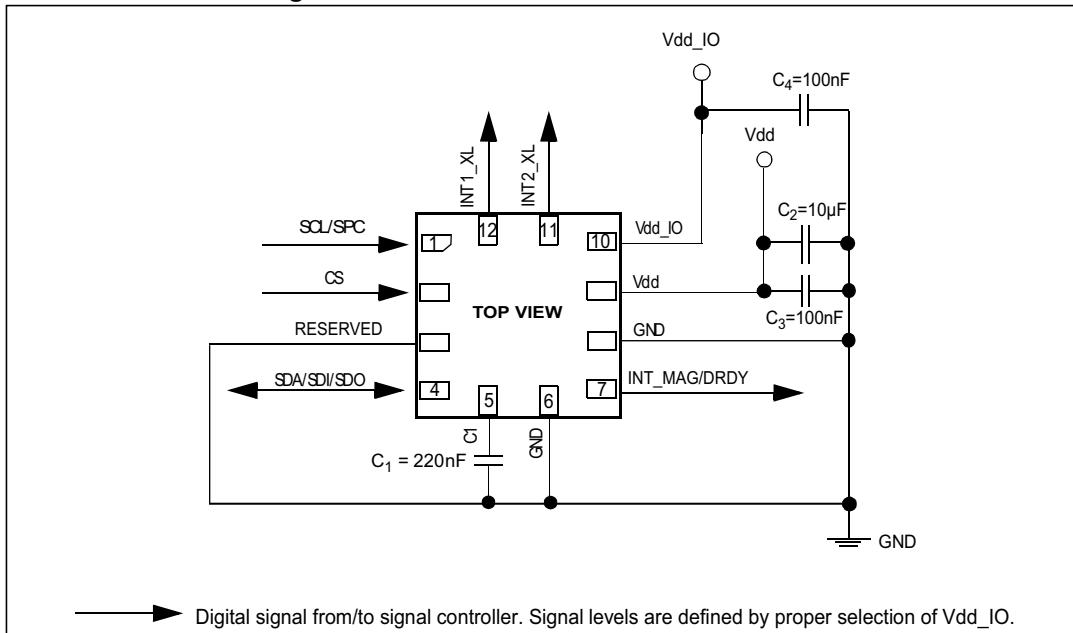
## 4.6 Factory calibration

The IC interface is factory calibrated for sensitivity (LA\_So, M\_GN), Zero-g level (LA\_TyOff) and Zero-gauss level (M\_TyOff).

The trim values are stored inside the device in nonvolatile memory. Anytime the device is turned on, the trim parameters are downloaded into the registers to be used during active operation. This allows using the device without further calibration.

## 5 Application hints

Figure 13. LSM303AH electrical connections



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

It is possible to remove Vdd, maintaining Vdd\_IO, without blocking the communication bus, in this condition the measurement chain is powered off.

The following recommendations apply to capacitor C1:

- It must be connected as close as possible to pins 5 and 6 since very high current pulses flow from C1 to pin 5 and 6. This avoid problems caused by inductive effects due to the length of the copper strips.
- It is highly recommended to use low ESR (max 200 mOhm)

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

The functions, the threshold and the timing of the three interrupt pins (INT1\_XL, INT2\_XL, and INT\_MAG/DRDY) can be completely programmed by the user through the I<sup>2</sup>C/SPI interface.

**Table 19. Pin status**

<b>Pin#</b>	<b>Name</b>	<b>Function</b>	<b>Status</b>
1	SCL SPC	I <sup>2</sup> C serial clock (SCL) SPI serial port clock (SPC)	Default: input without pull-up
2	CS	SPI enable I <sup>2</sup> C/SPI mode selection 1: SPI idle mode / I <sup>2</sup> C communication enabled; 0: SPI communication mode / I <sup>2</sup> C disabled	Default: input without pull-up
3	Reserved	Reserved, connected to GND	
4	SDA SDI SDO	I <sup>2</sup> C serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)	Default: (SDA) input without pull-up
5	C1	Capacitor connection (C1 = 220 nF)	External cap, voltage forced by the device
6	GND	0 V	
7	INT_MAG/DRDY	Magnetometer interrupt/data-ready signal	Default: output high impedance
8	GND	0 V	
9	Vdd	Power supply	
10	Vdd_IO	Power supply for I/O pins	
11	INT2_XL	Accelerometer interrupt 2	Default: output forced to ground
12	INT1_XL	Accelerometer interrupt 1	Default: output forced to ground

**Note:** *In order to program INT\_MAG/DRDY as a push-pull output, write the INT\_MAG bit to 1 in CFG\_REG\_C\_M (62h).*

## 5.1 Soldering information

The LGA package is compliant with the ECOPACK® , RoHS and “Green” standards.  
It is qualified for soldering heat resistance according to JEDEC J-STD-020.

Leave “Pin 1 Indicator” unconnected during soldering.

Land pattern and soldering recommendations are available at [www.st.com](http://www.st.com).

## 5.2 High-current wiring effects

High current in wiring and printed circuit traces can be culprits in causing errors in magnetic field measurements for compassing.

Conductor-generated magnetic fields will add to the Earth’s magnetic field, leading to errors in compass heading computation.

Keep currents higher than 10 mA a few millimeters away from the sensor IC.

## 6 Digital interfaces

The registers embedded inside the LSM303AH may be accessed through both the I<sup>2</sup>C and SPI serial interfaces. The latter may be SW-configured to operate in 3-wire interface mode.

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

**Table 20. Serial interface pin description**

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

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

The LSM303AH 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 21. I<sup>2</sup>C terminology**

Term	Description
Transmitter	The device which sends data to the bus
Receiver	The device which receives data from the bus
Master	The device which 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 the 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) I<sup>2</sup>C standards as well as with the 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.

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 magnetometer block of the LSM303AH 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 sub-address (SUB) is transmitted: the 7 LSb represent the actual register address.

The I<sup>2</sup>C embedded inside the accelerometer block of the LSM303AH 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 sub-address (SUB) is transmitted: the 7 LSb represent the actual register address while the IF\_ADD\_INC bit in [CTRL2\\_A \(21h\)](#) defines the increase in the address.

The slave address is completed with a Read/Write bit. If the bit was '1' (Read), a repeated START (SR) condition must be issued after the two sub-address bytes; if the bit is '0' (Write) the master will transmit to the slave with direction unchanged. [Table 26](#) explains how the SAD+read/write bit pattern is composed, listing all the possible configurations.

**Table 22. Transfer when master is writing one byte to slave**

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

**Table 23. Transfer when master is writing multiple bytes to slave**

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

**Table 24. 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 25. 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	DAT A	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 receiver can't receive another complete byte of data until it has performed some other function, it can hold the clock line SCL low to force the transmitter into a wait state. Data transfer only continues when the receiver is ready for another byte and releases the data line. If a slave receiver doesn't acknowledge the slave address (i.e. 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.

#### Default address:

The accelerometer sensor slave address is 0011101b while magnetic sensor slave address is 0011110b.

The slave addresses are completed with a Read/Write bit. If the bit was '1' (Read), a repeated START (SR) condition must be issued after the two sub-address bytes. If the bit is '0' (Write) the master will transmit to the slave with direction unchanged. [Table 26](#) and [Table 27](#) explain how the SAD+Read/Write bit patterns are composed, listing all the possible configurations.

**Linear acceleration sensor: the default (factory setting) 7-bit slave address is 0011101b.**

**Table 26. SAD+Read/Write patterns**

Command	SAD[6:0]	R/W	SAD+R/W
Read	0011101	1	00111011
Write	0011101	0	00111010

**Magnetic field sensor: the default (factory setting) 7-bit slave address is 0011110b.**

**Table 27. SAD + Read/Write patterns**

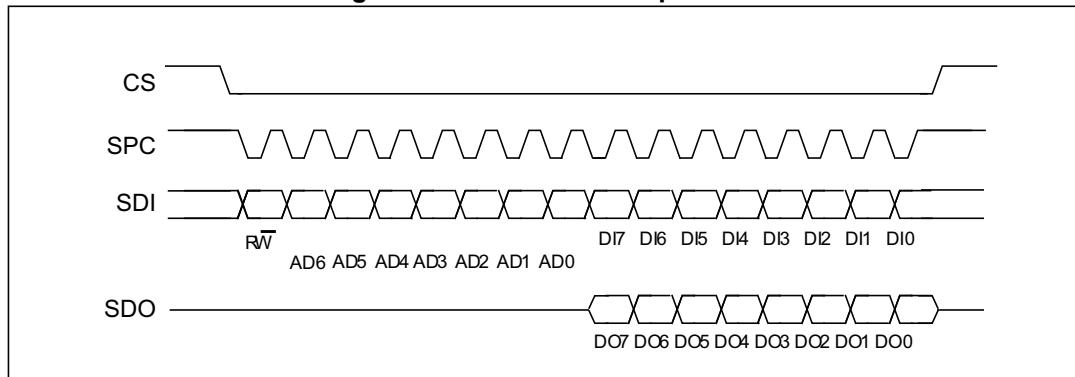
Command	SAD[6:0]	R/W	SAD + R/W
Read	0011110	1	00111101 (3Dh)
Write	0011110	0	00111100 (3Ch)

## 6.2 SPI bus interface

The LSM303AH 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 3 wires: **CS**, **SPC**, **SDI** and **SDO** (refer to [Table 20](#)).

**Figure 14. Read and write protocol**



**CS** is the serial port enable 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:** **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 will drive **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).

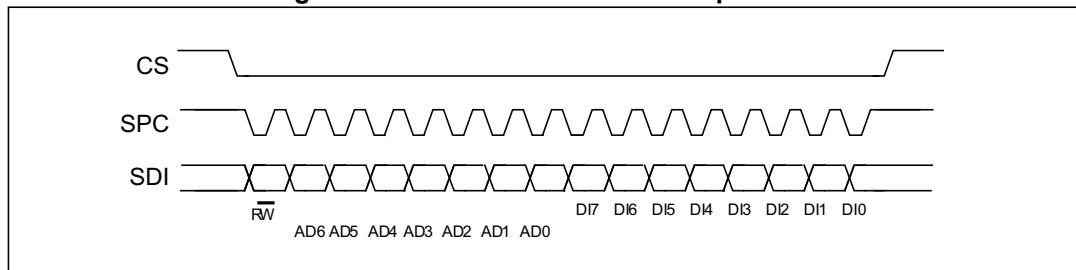
**bit 8-15:** data DO(7:0) (read mode). This is the data that is read from the device (MSb first).

In multiple read/write commands additional blocks of 8 clock periods will be added. For the accelerometer when the [\*\*CTRL2\\_A \(21h\)\*\*](#) (IF\_ADD\_INC) bit is '0', the address used to read/write data remains the same for every block. When the [\*\*CTRL2\\_A \(21h\)\*\*](#) (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 Accelerometer SPI write

**Figure 15. Accelerometer 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.

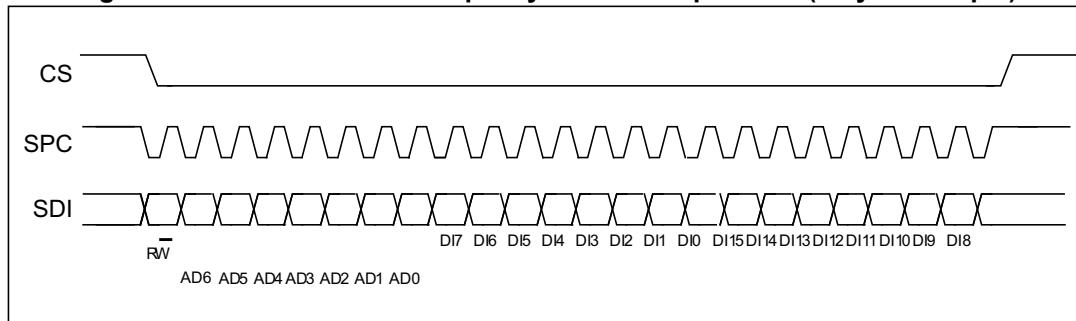
**bit 1 -7:** address AD(6:0). This is the address field of the indexed register.

**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.

The accelerometer address auto increment is enabled by default (volatile bit IF\_ADD\_INC in [CTRL2\\_A \(21h\)](#) must be set to '0' to disable).

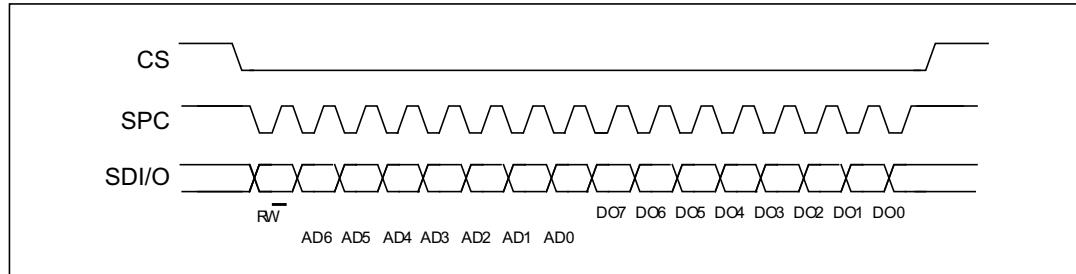
**Figure 16. Accelerometer multiple byte SPI write protocol (2-byte example)**



### 6.2.2 Accelerometer SPI read in 3-wire mode

3-wire mode is entered by setting the [CTRL2\\_A \(21h\)](#) (SPI\_ENABLE) bit equal to '1' (SPI serial interface read enable).

**Figure 17. Accelerometer 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.

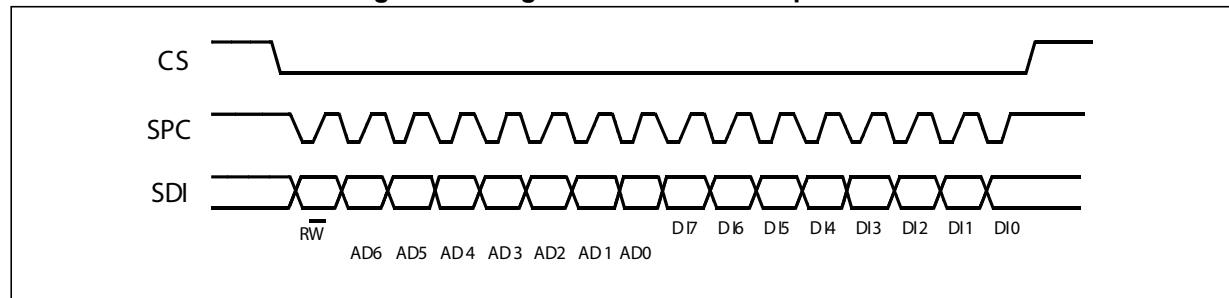
**bit 8-15:** data DO(7:0) (read mode). This is the data that is read from the device (MSb first).

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

The accelerometer address auto increment is enabled by default (volatile bit IF\_ADD\_INC in [CTRL2\\_A \(21h\)](#) must be set to '0' to disable).

### 6.2.3 Magnetometer SPI write

**Figure 18. Magnetometer SPI write protocol**



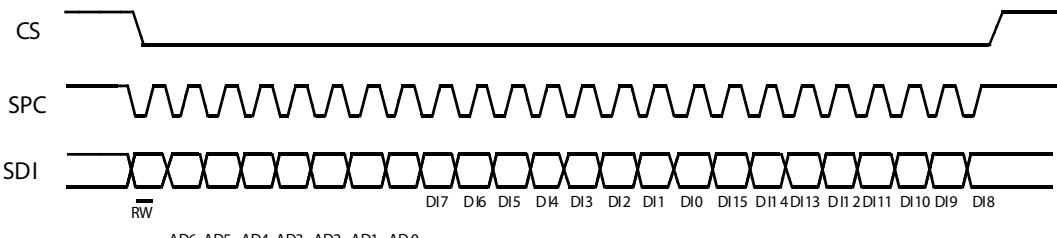
The SPI write command is performed with 16 clock pulses. The multiple byte write command is performed by adding blocks of 8 clock pulses to the previous one.

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

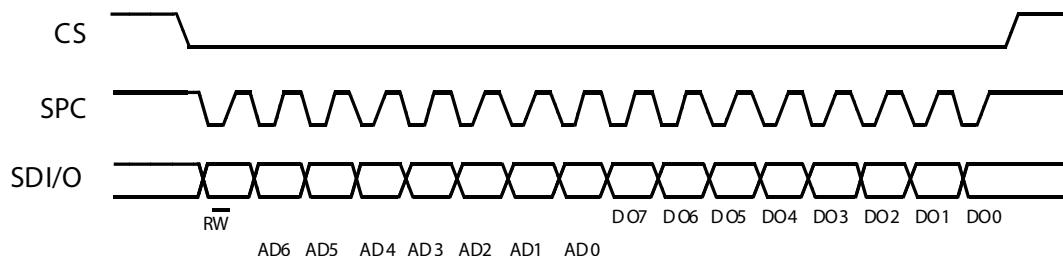
**bit 1-7:** address AD(6:0). This is the address field of the indexed register.

**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). Further data in multiple byte writes.

**Figure 19. Magnetometer multiple byte SPI write protocol (2-byte example)**

#### 6.2.4 Magnetometer SPI read in 3-wire mode

**Figure 20. Magnetometer SPI read protocol in 3-wire mode**

The SPI read command is performed with 16 clock pulses:

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

The multiple read command is available in 3-wire mode.

## 7 Register mapping

The table given below provides a list of the 8-bit registers embedded in the device and the corresponding addresses. Registers 00h through 3Fh are dedicated to the accelerometer while registers 40h through 6Fh are dedicated to the magnetometer.

**Table 28. Register map**

Name	Type <sup>(1)</sup>	Register address		Default	Comment
		Hex	Binary		
RESERVED	-	00-0B		-	RESERVED
Module_8bit_A	R	0C	00001100	output	
RESERVED	-	0D-0E		-	RESERVED
WHO_AM_I_A	R	0F	00001111	01000011	Who I am ID
RESERVED	-	10-1F		-	RESERVED
CTRL1_A	R/W	20	00100000	00000000	Control registers
CTRL2_A	R/W	21	00100001	00000100	
CTRL3_A	R/W	22	00100010	00000000	
CTRL4_A	R/W	23	00100011	00000000	
CTRL5_A	R/W	24	00100100	00000000	
FIFO_CTRL_A	R/W	25	00100101	00000000	FIFO control reg
OUT_T_A	R	26	00100110	output	Temp sensor output
STATUS_A	R	27	00100111	output	Status data register
OUT_X_L_A	R	28	00101000	output	Output registers
OUT_X_H_A	R	29	00101001		
OUT_Y_L_A	R	2A	00101010		
OUT_Y_H_A	R	2B	00101011		
OUT_Z_L_A	R	2C	00101100		
OUT_Z_H_A	R	2D	00101101		
FIFO_THS_A	R/W	2E	00101110	00000000	FIFO registers
FIFO_SRC_A	R	2F	00101111	output	FIFO SRC
FIFO_SAMPLES_A	R/W	30	00110000	00000000	Unread samples stored in FIFO
TAP_6D_THS_A	R/W	31	00110001	00000000	TAP, 4D, 6D threshold
INT_DUR_A	R/W	32	00110010	00000000	Interrupt duration
WAKE_UP_THS_A	R/W	33	00110011	00000000	TAP/D-TAP selection, Inactivity EN, Wakeup threshold

Table 28. Register map (continued)

Name	Type <sup>(1)</sup>	Register address		Default	Comment
		Hex	Binary		
WAKE_UP_DUR_A	R/W	34	00110100	00000000	Wakeup duration
FREE_FALL_A	R/W	35	00110101	00000000	Free-fall config.
STATUS_DUP_A	R	36	00110110	output	Status register
WAKE_UP_SRC_A	R	37	00110111	output	Wakeup SRC
TAP_SRC_A	R	38	00111000	output	TAP SRC
6D_SRC_A	R	39	00111001	output	6D SRC
STEP_COUNTER_MINTHS_A	R/W	3A	00111010	00010000	STEP C config
STEP_COUNTER_L_A	R	3B	00111011	output	Steps detected LSB
STEP_COUNTER_H_A	R	3C	00111100	output	Steps detected MSB
FUNC_CK_GATE_A	R	3D	00111110	output	ST FUNCTION setting
FUNC_SRC_A	R	3E	00000100	output	FUNCTION SRC
FUNC_CTRL_A	R/W	3F	00000100	00000000	FUNCTION CTRL
RESERVED		40-44			
OFFSET_X_REG_L_M	R/W	45	01000101	00000000	Magnetometer hard-iron registers
OFFSET_X_REG_H_M	R/W	46	01000110	00000000	
OFFSET_Y_REG_L_M	R/W	47	01000111	00000000	
OFFSET_Y_REG_H_M	R/W	48	01001000	00000000	
OFFSET_Z_REG_L_M	R/W	49	01001001	00000000	
OFFSET_Z_REG_H_M	R/W	4A	01001010	00000000	
RESERVED		4B-4C			
WHO_AM_I_M	R	4F	01001111	01000000	Who I am ID
RESERVED		50-5F			
CFG_REG_A_M	R/W	60	01100000	00000011	Magnetometer configuration registers
CFG_REG_B_M	R/W	61	01100001	00000000	
CFG_REG_C_M	R/W	62	01100010	00000000	
INT_CRTL_REG_M	R/W	63	01100011	11100000	Magnetometer interrupt configuration registers
INT_SOURCE_REG_M	R	64	01100100		
INT_THS_L_REG_M	R/W	65	01100101	00000000	
INT_THS_H_REG_M	R/W	66	01100110	00000000	
STATUS_REG_M	R	67	01100111		

**Table 28. Register map (continued)**

Name	Type <sup>(1)</sup>	Register address		Default	Comment
		Hex	Binary		
OUTX_L_REG_M	R	68	01101000	output	Magnetometer output registers
OUTX_H_REG_M	R	69	01101001	output	
OUTY_L_REG_M	R	6A	01101010	output	
OUTY_H_REG_M	R	6B	01101010	output	
OUTZ_L_REG_M	R	6C	01101100	output	
OUTZ_H_REG_M	R	6D	01101101	output	
RESERVED		6E-6F			

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

Registers marked as *Reserved* 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 Module\_8bit\_A (0Ch)

Module out value (r). This register is a read-only register.

**Table 29. Module\_8bit\_A register**

Module_7	Module_6	Module_5	Module_4	Module_3	Module_2	Module_1	Module_0
----------	----------	----------	----------	----------	----------	----------	----------

**Table 30. Module\_8bit\_A register description**

Module [7:0]	Module output value (8-bit). Default value: 0
--------------	---

### 8.2 WHO\_AM\_I\_A (0Fh)

Who\_AM\_I register (r). This register is a read-only register. Its value is fixed at 43h.

**Table 31. WHO\_AM\_I\_A register default values**

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

### 8.3 CTRL1\_A (20h)

Control register 1 (r/w)

**Table 32. CTRL1\_A register**

ODR3	ODR2	ODR1	ODR0	FS1	FS0	HF_ODR	BDU
------	------	------	------	-----	-----	--------	-----

**Table 33. CTRL1\_A register description**

ODR [3:0]	Output data rate & power mode selection. Default value: 0000 (see <a href="#">Table 34</a> )
FS [1:0]	Full-scale selection. Default value: 00 (00: $\pm 2\text{ g}$ ; 01: $\pm 16\text{ g}$ ; 10: $\pm 4\text{ g}$ ; 11: $\pm 8\text{ g}$ )
HF_ODR	High-frequency ODR mode enable. Default value: 0
BDU	Block data update. Default value: 0 (0: continuous update; 1: output registers not updated until MSB and LSB read)

ODR [3:0] is used to set the power mode and ODR selection. The following table lists the bit settings for power-down mode and each available frequency.

**Table 34. ODR register setting: power down (PD) and low power (LP)**

ODR[3:0]	HF_ODR	ODR selection [Hz]	Bit resolution	Mode
0000	-	-	-	PD
1000	-	1	10	LP
1001	-	12.5	10	LP
1010	-	25	10	LP

**Table 34. ODR register setting: power down (PD) and low power (LP) (continued)**

ODR[3:0]	HF_ODR	ODR selection [Hz]	Bit resolution	Mode
1011	-	50	10	LP
1100	-	100	10	LP
1101	-	200	10	LP
1110	-	400	10	LP
1111	-	800	10	LP

**Table 35. ODR register setting: high resolution (HR) and high frequencies (HF)**

ODR[3:0]	HF_ODR	ODR selection [Hz]	Bit resolution	Mode
0001	-	12.5	14	HR
0010	-	25	14	HR
0011	-	50	14	HR
0100	-	100	14	HR
0101	0	200	14	HR
0110	0	400	14	HR
0111	0	800	14	HR
0101	1	1600	12	HF
0110	1	3200	12	HF
0111	1	6400	12	HF

The BDU bit is used to inhibit the update of the output registers until both upper and lower register parts are read. In default mode (BDU = '0') the output register values are updated continuously. When the BDU is activated (BDU = '1'), the content of the output registers is not updated until both MSB and LSB are read which avoids reading values related to different sample times.

## 8.4 CTRL2\_A (21h)

Control register 2 (r/w)

**Table 36. CTRL2\_A register**

BOOT	SOFT_RESET	0 <sup>(1)</sup>	FUNC_CFG_EN <sup>(2)(3)(4)</sup>	FDS_SLOPE	IF_ADD_INC	I2C_DISABLE	SPI_ENABLE
------	------------	------------------	----------------------------------	-----------	------------	-------------	------------

1. This bit must be set to '0' for the correct operation of the device.
2. When this bit is enabled, only advanced configuration registers can be written. For proper functionality of the device, all the other registers must not be modified.
3. Details of advanced configuration registers are available in [Section 9: Advanced configuration register mapping](#) and [Section 10: Advanced configuration registers description](#).
4. To disable the advanced configuration, bit FUNC\_CFG\_EN in [CTRL2\\_A \(3Fh\)](#) must be set to '0'. Refer to [Section 10.4: CTRL2\\_A \(3Fh\)](#)

**Table 37. CTRL2\_A register description**

BOOT	Reboot memory content. Default value: 0 (0: normal mode; 1: reboot memory content)
SOFT_RESET	Soft reset acts as reset for all control registers, then goes to 0. Default value: 0 (0: disabled; 1: enabled)
FUNC_CFG_EN	Access to advanced configuration registers from address 2Bh to 3Fh. Default value: 0 (0: disable the access to advanced configuration registers; 1: enable the access to advanced configuration registers)
FDS_SLOPE	High-pass filter data selection on output register and FIFO. Default value: 0 (0: internal filter bypassed; 1: internal filter enabled on output register and FIFO)
IF_ADD_INC	Register address automatically incremented during multiple byte access with a serial interface ( $I^2C$ or SPI). Default value: 1 (0: disabled; 1: enabled)
I2C_DISABLE	Disable $I^2C$ communication protocol. Default value: 0 (0: SPI and $I^2C$ interfaces enabled; 1: $I^2C$ mode disabled)
SPI_ENABLE	3-wire SPI interface read enable. Default value: 0 0: SPI read disabled 1: SPI read enabled

## 8.5 CTRL3\_A (22h)

Control register 3 (r/w)

**Table 38. CTRL3\_A register**

ST2	ST1	TAP_X_EN	TAP_Y_EN	TAP_Z_EN	LIR	H_LACTIVE	PP_OD

**Table 39. CTRL3\_A register description**

ST [2:1]	Self-test enable. Default value: 00 (00: Self-test disabled; Other: see <a href="#">Table 40</a> )
TAP_X_EN	Tap recognition on X direction enable. Default value: 0 (0: disabled; 1: enabled)
TAP_Y_EN	Tap recognition on Y direction enable. Default value: 0 (0: disabled; 1: enabled)
TAP_Z_EN	Tap recognition on Z direction enable. Default value: 0 (0: disabled; 1: enabled)
LIR	Latched Interrupt. Switches between latched ('1'-logic) and pulsed ('0'-logic) mode for function source signals and interrupts routed to pins (wakeup, tap, double-tap, tilt, pedometer, significant motion). Default value: 0 (0: interrupt request not latched; 1: interrupt request latched)
H_LACTIVE	Interrupt active high, low. Default value: 0 (0: active high; 1: active low)
PP_OD	Push-pull/open-drain selection on interrupt pad. Default value: 0 (0: push-pull; 1: open-drain)

**Table 40. Self-test mode selection**

<b>ST2</b>	<b>ST1</b>	<b>Self-test mode</b>
0	0	Normal mode
0	1	Positive sign self-test
1	0	Negative sign self-test
1	1	Not allowed

## 8.6 CTRL4\_A (23h)

Control register 4 (r/w): interrupt 1 configuration

**Table 41. CTRL4\_A register**

0 <sup>(1)</sup>	INT1_S_TAP	INT1_WU	INT1_FF	INT1_TAP	INT1_6D	INT1_FTH	INT1_DRDY
------------------	------------	---------	---------	----------	---------	----------	-----------

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

**Table 42. CTRL4\_A register description**

INT1_S_TAP	Single-tap recognition is routed on INT1 pad. Default value: 0 (0: disabled; 1: enabled)
INT1_WU	Wakeup recognition is routed on INT1 pad. Default value: 0 (0: disabled; 1: enabled)
INT1_FF	Free-fall recognition is routed on INT1 pad. Default value: 0 (0: disabled; 1: enabled)
INT1_TAP	Double-tap recognition is routed on INT1 pad. Default value: 0 (0: disabled; 1: enabled)
INT1_6D	6D recognition is routed on INT1 pad. Default value: 0 (0: disabled; 1: enabled)
INT1_FTH	FIFO threshold interrupt is routed on INT1 pad. Default value: 0 (0: disabled; 1: enabled)
INT1_DRDY	Data-Ready is routed on INT1 pad. Default value: 0 (0: disabled; 1: enabled)

## 8.7 CTRL5\_A (24h)

Control register 5 (r/w): interrupt 2 configuration

**Table 43. CTRL5\_A register**

DRDY_PULSED	INT2_BOOT	INT2_ON_INT1	INT2_TILT	INT2_SIG_MOT	INT2_STEP	INT2_FTH	INT2_DRDY
-------------	-----------	--------------	-----------	--------------	-----------	----------	-----------

**Table 44. CTRL5\_A register description**

DRDY_PULSED	Data-ready interrupt mode selection: latched mode / pulsed mode. Default value: 0 (0: latched mode; 1: pulsed mode for data-ready)
INT2_BOOT	Boot state routed on INT2 pad. Default value: 0 (0: disabled; 1: enabled)
INT2_ON_INT1	All signals routed on INT2 are also routed on INT1. Default value: 0 (0: disabled; 1: enabled)
INT2_TILT	Tilt event is routed on INT2 pad. Default value: 0 (0: disabled; 1: enabled)
INT2_SIG_MOT	Significant motion detection is routed on INT2 pad. Default value: 0 (0: disabled; 1: enabled)
INT2_STEP	Step detection is routed on INT2 pad. Default value: 0 (0: disabled; 1: enabled)
INT2_FTH	FIFO threshold interrupt is routed on INT2 pad. Default value: 0 (0: disabled; 1: enabled)
INT2_DRDY	Data-Ready is routed on INT2 pad. Default value: 0 (0: disabled; 1: enabled)

## 8.8 FIFO\_CTRL\_A (25h)

FIFO control register 5 (r/w).

**Table 45. FIFO\_CTRL\_A register**

FMODE2	FMODE1	FMODE0	INT2_STEP_COUNTOV	MODULE_TO_FIFO	0 <sup>(1)</sup>	0 <sup>(1)</sup>	IF_CS_PUDIS
--------	--------	--------	-------------------	----------------	------------------	------------------	-------------

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

**Table 46. FIFO\_CTRL\_A register description**

FMODE [2:0]	FIFO mode selection bits. Default: 000. For further details refer to <a href="#">Table 47</a> .
INT2_STEP_COUNTOV	Step counter overflow interrupt enable on INT2 pad. Default value: 0 (0: disabled; 1: enabled)
MODULE_TO_FIFO	When set to '1'-logic, module routine result is send to FIFO instead of X,Y,Z acceleration data
IF_CS_PUDIS	When '1'-logic disconnects pull-up in if_cs pad. Default: 0

When the FIFO has been enabled, data acquired has been stored at the accelerometer ODR and the trigger signal of FIFO writing is the accelerometer internal data-ready.

FIFO data can be stored in default configuration where inertial data as been stored as X, Y, Z data or in module configuration:

Default configuration: 256-level inertial data (14-bit stored data for X, Y, Z)

User-selectable: 768 module data (14-bit each module)

**Table 47. FIFO mode selection**

FMODE2	FMODE1	FMODE0	Mode
0	0	0	Bypass mode: FIFO turned off
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 FIFO mode
1	0	1	Reserved
1	1	0	Continuous mode: data If the FIFO is full, the new sample overwrites the older sample.
1	1	1	Reserved

## 8.9 OUT\_T\_A (26h)

Temperature output register (r).

**Table 48. OUT\_T\_A register**

TEMP7	TEMP6	TEMP5	TEMP4	TEMP3	TEMP2	TEMP1	TEMP0
-------	-------	-------	-------	-------	-------	-------	-------

**Table 49. OUT\_T\_A register description**

Temp [7:0]	Temperature sensor output data. The value is expressed as two's complement sign. Sensitivity = 1 °C/LSB 0 LSB represents T=25 °C ambient.
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## 8.10 STATUS\_A (27h)

Status register (r)

**Table 50. STATUS\_A register**

FIFO_THS	WU_IA	SLEEP_STATE	DOUBLE_TAP	SINGLE_TAP	6D_IA	FF_IA	DRDY
----------	-------	-------------	------------	------------	-------	-------	------

**Table 51. STATUS\_A register description**

FIFO_THS	FIFO threshold status flag. (0: FIFO filling is lower than threshold level; 1: FIFO filling is equal to or higher than the threshold level.)
WU_IA	Wakeup event detection status. (0: WU event not detected; 1: Wakeup event detected)
SLEEP_STATE	Sleep event status. (0: Sleep event not detected; 1: Sleep event detected)
DOUBLE_TAP	Double-tap event status (0: Double-tap event not detected; 1: Double-tap event detected)
SINGLE_TAP	Single-tap event status (0: Single-tap event not detected; 1: Single-tap event detected)
6D_IA	Source of change in position portrait/landscape/face-up/face-down. (0: no event detected; 1: a change in position detected)
FF_IA	Free-fall event detection status. (0: free-fall event not detected; 1: free-fall event detected)
DRDY	Data-ready status. (0: not ready; 1: X-, Y- and Z-axis new data available)

## 8.11 OUT\_X\_L\_A (28h)

X-axis LSB output register (r)

**Table 52. OUT\_X\_L\_A register default values**

X_L7	X_L6	X_L5 <sup>(2)</sup>	X_L4 <sup>(2)</sup>	X_L3 <sup>(1)(2)</sup>	X_L2 <sup>(1)(2)</sup>	0	0
------	------	---------------------	---------------------	------------------------	------------------------	---	---

1. If 12-bit mode is enabled, this bit is set to 0.
2. If 10-bit mode is enabled, this bit is set to 0.

The 8 least significant bits of linear acceleration sensor X-axis output. Together with the [OUT\\_X\\_H\\_A \(29h\)](#) register it forms the output value expressed as a 16-bit word in 2's complement.

## 8.12 OUT\_X\_H\_A (29h)

X-axis MSB output register (r)

**Table 53. OUT\_X\_H\_A register default values**

X_H7	X_H6	X_H5	X_H4	X_H3	X_H2	X_H1	X_H0
------	------	------	------	------	------	------	------

The 8 most significant bits of linear acceleration sensor X-axis output. Together with the [OUT\\_X\\_L\\_A \(28h\)](#) register it forms the output value expressed as a 16-bit word in 2's complement.

## 8.13 OUT\_Y\_L\_A (2Ah)

Y-axis LSB output register (r)

**Table 54. OUT\_Y\_L\_A register default values**

Y_L7	Y_L6	Y_L5 <sup>(2)</sup>	Y_L4 <sup>(2)</sup>	Y_L3 <sup>(1)(2)</sup>	Y_L2 <sup>(1)(2)</sup>	0	0
------	------	---------------------	---------------------	------------------------	------------------------	---	---

1. If 12-bit mode is enabled, this bit is set to 0.
2. If 10-bit mode is enabled, this bit is set to 0.

The 8 least significant bits of linear acceleration sensor Y-axis output. Together with the [OUT\\_Y\\_H\\_A \(2Bh\)](#) register it forms the output value expressed as a 16-bit word in 2's complement.

## 8.14 OUT\_Y\_H\_A (2Bh)

Y-axis MSB output register (r)

**Table 55. OUT\_Y\_H\_A register default values**

Y_H7	Y_H6	Y_H5	Y_H4	Y_H3	Y_H2	Y_H1	Y_H0
------	------	------	------	------	------	------	------

The 8 most significant bits of linear acceleration sensor Y-axis output. Together with the [OUT\\_Y\\_L\\_A \(2Ah\)](#) register it forms the output value expressed as a 16-bit word in 2's complement.

## 8.15 OUT\_Z\_L\_A (2Ch)

Z-axis LSB output register (r)

**Table 56. OUT\_Z\_L\_A register default values**

Z_L7	Z_L6	Z_L5 <sup>(2)</sup>	Z_L4 <sup>(2)</sup>	Z_L3 <sup>(1)(2)</sup>	Z_L2 <sup>(1)(2)</sup>	0	0
------	------	---------------------	---------------------	------------------------	------------------------	---	---

1. If 12-bit mode is enabled, this bit is set to 0.
2. If 10-bit mode is enabled, this bit is set to 0.

The 8 least significant bits of linear acceleration sensor Z-axis output. Together with the [OUT\\_Z\\_H\\_A \(2Dh\)](#) register it forms the output value expressed as a 16-bit word in 2's complement.

## 8.16 OUT\_Z\_H\_A (2Dh)

Z-axis MSB output register (r)

**Table 57. OUT\_Z\_H\_A register default values**

Z_H7	Z_H6	Z_H5	Z_H4	Z_H3	Z_H2	Z_H1	Z_H0
------	------	------	------	------	------	------	------

The 8 most significant bits of linear acceleration sensor Z-axis output. Together with the [OUT\\_Z\\_L\\_A \(2Ch\)](#) register it forms the output value expressed as a 16-bit word in 2's complement.

## 8.17 FIFO\_THS\_A (2Eh)

FIFO threshold level setting (r/w).

**Table 58. FIFO\_THS\_A register**

FTH7	FTH6	FTH5	FTH4	FTH3	FTH2	FTH1	FTH0
------	------	------	------	------	------	------	------

## 8.18 FIFO\_SRC\_A (2Fh)

FIFO\_SRC register (r)

**Table 59. FIFO\_SRC\_A register**

FTH	FIFO OVR	DIFF8	-	-	-	-	-
-----	----------	-------	---	---	---	---	---

**Table 60. FIFO\_SRC register description**

FTH	FIFO threshold status. (0: FIFO filling is lower than FTH level; 1: FIFO filling is equal to or higher than threshold level)
OVR	FIFO overrun status. (0: FIFO is not completely filled; 1: FIFO is completely filled and at least one sample has been overwritten)
DIFF8	Concatenated with <a href="#">FIFO_SAMPLES_A (30h)</a> register, it represents the number of unread samples stored in FIFO. (000000000 = FIFO empty; 100000000 = FIFO full, 256 unread samples).

## 8.19 FIFO\_SAMPLES\_A (30h)

FIFO\_SAMPLES control register (r)

**Table 61. FIFO\_SAMPLES\_A register**

DIFF7	DIFF6	DIFF5	DIFF4	DIFF3	DIFF2	DIFF1	DIFF0
-------	-------	-------	-------	-------	-------	-------	-------

**Table 62. FIFO\_SAMPLES\_A register description**

DIFF [7:0]	Concatenated with DIFF8 bit in <a href="#">FIFO_SRC_A (2Fh)</a> register, it represents the number of unread samples stored in FIFO. (000000000 = FIFO empty; 100000000 = FIFO full, 256 unread samples).
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## 8.20 TAP\_6D\_THS\_A (31h)

4D configuration enable and TAP threshold configuration (r/w)

**Table 63. TAP\_6D\_THS\_A register**

4D_EN	6D_THS1	6D_THS0	TAP_THS4	TAP_THS3	TAP_THS2	TAP_THS1	TAP_THS0
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**Table 64. TAP\_6D\_THS\_A register description**

4D_EN	4D detection portrait/landscape position enable. (0: no position detected; 1: portrait/landscape detection and face-up/face-down position enabled).
6D_THS [1:0]	Thresholds for 4D/6D function @ FS=2 g (refer to <a href="#">Table 65</a> )
TAP_THS [4:0]	Threshold for TAP recognition @FS=2 g

**Table 65. 4D/6D threshold setting FS @ 2 g**

6D_THS1	6D_THS0	Threshold decoding (degrees)
0	0	6 (80 degrees)
0	1	11 (70 degrees)
1	0	16 (60 degrees)
1	1	21 (50 degrees)

## 8.21 INT\_DUR\_A (32h)

Interrupt duration register (r/w)

**Table 66. INT\_DUR\_A register**

LAT3	LAT2	LAT1	LAT0	QUIET1	QUIET0	SHOCK1	SHOCK0
------	------	------	------	--------	--------	--------	--------

**Table 67. INT\_DUR\_A register description**

LAT [3:1]	Duration of maximum time gap for double-tap recognition. When double-tap recognition is enabled, this register expresses the maximum time between two successive detected taps to determine a double-tap event. 1 LSB = 32 TODR.
QUIET [1:0]	Expected quiet time after a tap detection: this register represents the time after the first detected tap in which there must not be any over-threshold event. 1 LSB = 4 TODR.
SHOCK [4:0]	Maximum duration of over-threshold event: this register represents the maximum time of an over-threshold signal detection to be recognized as a tap event. 1 LSB = 8 TODR

## 8.22 WAKE\_UP\_THS\_A (33h)

Wakeup threshold register (r/w)

**Table 68. WAKE\_UP\_THS\_A register**

SINGLE_DOUBLE_TAP	SLEEP_ON	WU_THS_5	WU_THS_4	WU_THS_3	WU_THS_2	WU_THS_1	WU_THS_0
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**Table 69. WAKE\_UP\_THS\_A register description**

SINGLE_DOUBLE_TAP	Double/single-tap event detection: (0: double-tap event detection; 1: single-tap event detection)
SLEEP_ON	Sleep (inactivity) enable (0: sleep disabled; 1: sleep enabled)
WU_THS [5:0]	Wakeup threshold

## 8.23 WAKE\_UP\_DUR\_A (34h)

Wakeup and sleep duration configuration register (r/w)

**Table 70. WAKE\_UP\_DUR\_A register**

FF_DUR5	WU_DUR1	WU_DUR0	INT1_FSS7	SLEEP_DUR3	SLEEP_DUR2	SLEEP_DUR1	SLEEP_DUR0
---------	---------	---------	-----------	------------	------------	------------	------------

**Table 71. WAKE\_UP\_DUR\_A register description**

FF DUR5	Free-fall duration. In conjunction with FF_DUR [4:0] bit in <a href="#">FREE_FALL_A (35h)</a> register. 1 LSB = 1 TODR
WU_DUR [1:0]	Wakeup duration. 1 LSB = 1 TODR
INT1_FSS7	FF interrupt is routed on INT1 pad (0: disabled; 1: enabled)
SLEEP_DUR[5:0]	Duration to go in sleep mode. 1 LSB = 512 TODR

## 8.24 FREE\_FALL\_A (35h)

Free-fall duration and threshold configuration register (r/w)

**Table 72. FREE\_FALL\_A register**

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

**Table 73. FREE\_FALL\_A register description**

FF_DUR [4:0]	Free-fall duration. In conjunction with FF_DUR5 bit in <a href="#">WAKE_UP_DUR_A (34h)</a> register. 1 LSB = 1 TODR.
FF_THS [2:0]	Free-fall threshold @ FS = 2 g (refer to <a href="#">Table 74</a> )

**Table 74. FREE\_FALL\_A threshold decoding @ 2 g FS**

FF_THS1	FF_THS1	FF_THS0	Threshold decoding (degrees)
0	0	0	5
0	0	1	7
0	1	0	8
0	1	1	10
1	0	0	11
1	0	1	13
1	1	0	15
1	1	1	16

## 8.25 STATUS\_DUP\_A (36h)

Event detection status register (r)

**Table 75. STATUS\_DUP\_A register**

OVR	WU_IA	SLEEP_STATE	DOUBLE_TAP	SINGLE_TAP	6D_IA	FF_IA	DRDY
-----	-------	-------------	------------	------------	-------	-------	------

**Table 76. STATUS\_DUP\_A register description**

OVR	FIFO overrun status flag. (0: FIFO filling is not completely filled; 1: FIFO is completely filled and at least one sample has been overwritten)
WU_IA	Wakeup event detection status. (0: WU event not detected; 1: Wake up event detected)
SLEEP_STATE	Sleep event status. (0: Sleep event not detected; 1: Sleep event detected)
DOUBLE_TAP	Double-tap event status: (0: Double-tap event not detected; 1: Double-tap event detected)
SINGLE_TAP	Single-tap event status: (0: Single-tap event not detected; 1: Single-tap event detected)
6D_IA	Source of change in position portrait/landscape/face-up/face-down. (0: no event detected; 1: a change in position is detected)
FF_IA	Free-fall event detection status. (0: free-fall event not detected; 1: free-fall event detected)
DRDY	Data-ready status. (0: not ready; 1: X-, Y- and Z-axis new data available)

## 8.26 WAKE\_UP\_SRC\_A (37h)

Wakeup source register (r)

**Table 77. WAKE\_UP\_SRC\_A register**

-	-	FF_IA	SLEEP STATE IA	WU_IA	X_WU	Y_WU	Z_WU
---	---	-------	----------------	-------	------	------	------

**Table 78. WAKE\_UP\_SRC\_A register description**

FF_IA	Free-fall event detection status. (0: FF event not detected; 1: FF event detected)
SLEEP STATE IA	Sleep event status. (0: Sleep event not detected; 1: Sleep event detected)
WU_IA	Wakeup event detection status. (0: Wakeup event not detected; 1: Wakeup event is detected)
X_WU	Wakeup event detection status on X-axis. (0: Wakeup event on X not detected; 1: Wakeup event on X-axis is detected)
Y_WU	Wakeup event detection status on Y-axis. (0: Wakeup event on Y not detected; 1: Wake up event on Y-axis is detected)
Z_WU	Wakeup event detection status on Z-axis. (0: Wakeup event on Z not detected; 1: Wake up event on Z-axis is detected)

## 8.27 TAP\_SRC\_A (38h)

TAP source register (r)

**Table 79. TAP\_SRC\_A register**

-	TAP_IA	SINGLE TAP	DOUBLE TAP	TAP SIGN	X_TAP	Y_TAP	Z_TAP
---	--------	------------	------------	----------	-------	-------	-------

**Table 80. TAP\_SRC\_A register description**

TAP_IA	TAP event status. (0: Tap event not detected; 1: Tap event detected)
SINGLE TAP	Single-tap event status. (0: Single-tap event not detected; 1: Single-tap event detected)
DOUBLE TAP	Double-tap event status. (0: Double-tap event not detected; 1: Double-tap event detected)
TAP_SIGN	Sign of acceleration detected by tap event. (0: positive sign of acceleration detected; 1: negative sign of acceleration detected).
X_TAP	Tap event detection status on X-axis. (0: Tap event on X not detected; 1: Tap event on X-axis is detected)
Y_TAP	Tap event detection status on Y-axis. (0: Tap event on Y not detected; 1: TAP event on Y-axis is detected)
Z_TAP	Tap event detection status on Z-axis. (0: Tap event on Z not detected; 1: Tap event on Z-axis is detected)

## 8.28 6D\_SRC\_A (39h)

6D source register (r)

**Table 81. 6D\_SRC\_A register**

-	6D_IA	ZH	ZL	YH	YL	XH	XL
---	-------	----	----	----	----	----	----

**Table 82. 6D\_SRC\_A register description**

6D_IA	Source of change in position portrait/landscape/face-up/face-down. (0: no event detected; 1: a change in position is detected)
ZH	ZH over threshold (0: ZH does not exceed the threshold; 1: ZH is over the threshold)
ZL	ZL over threshold (0: ZL does not exceed the threshold; 1: ZL is over the threshold)
YH	YH over threshold (0: YH does not exceed the threshold; 1: YH is over the threshold)
YL	YL over threshold (0: YL does not exceed the threshold; 1: YL is over the threshold)
XH	XH over threshold: (0: XH does not exceed the threshold; 1: XH is over the threshold)
XL	XL over threshold (0: XL does not exceed the threshold; 1: XL is over the threshold)

## 8.29 STEP\_COUNTER\_MINTHS\_A (3Ah)

Step counter configuration register (r/w).

**Table 83. STEP\_COUNTER\_MINTHS\_A configuration register**

RST_nSTEP	PEDO4g	SC_MTHS5	SC_MTHS4	SC_MTHS3	SC_MTHS2	SC_MTHS1	SC_MTHS0
-----------	--------	----------	----------	----------	----------	----------	----------

**Table 84. STEP\_COUNTER\_MINTHS\_A configuration register description**

RST_nSTEP	Step number synchronous reset bit: when '1'-logic forces pedometer to reset the number of steps in <a href="#">STEP_COUNTER_L_A (3Bh)</a> and <a href="#">STEP_COUNTER_H_A (3Ch)</a> registers. Default value: 0
PEDO4g	4 g operation mode for pedometer routines enable. Default: 0 (0: 4 g operation mode for pedometer routines disabled; 1: 4 g operation mode for pedometer routines enabled)
SC_MTHS [5:0]	Minimum threshold value for step counter routine. Default: 01 0000

### 8.30 STEP\_COUNTER\_L\_A (3Bh)

Step counter register (r)

**Table 85. STEP\_COUNTER\_L\_A configuration register**

nSTEP_L7	nSTEP_L6	nSTEP_L5	nSTEP_L4	nSTEP_L3	nSTEP_L2	nSTEP_L1	nSTEP_L0
----------	----------	----------	----------	----------	----------	----------	----------

**Table 86. STEP\_COUNTER\_L\_A configuration register description**

nSTEP_L [7:0]	Least significant part of number of steps detected by step counter routine. Unsigned representation.
---------------	---

### 8.31 STEP\_COUNTER\_H\_A (3Ch)

Step counter register (r)

**Table 87. STEP\_COUNTER\_H\_A register**

nSTEP_H7	nSTEP_H6	nSTEP_H5	nSTEP_H4	nSTEP_H3	nSTEP_H2	nSTEP_H1	nSTEP_H0
----------	----------	----------	----------	----------	----------	----------	----------

**Table 88. STEP\_COUNTER\_H\_A register description**

nSTEP_H [7:0]	Most significant part of number of steps detected by step counter routine. Unsigned representation.
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### 8.32 FUNC\_CK\_GATE\_A (3Dh)

Functional source register (r)

**Table 89. FUNC\_CK\_GATE\_A register**

TILT_INT	FS_SRC_1	FS_SRC_0	SIG_MOT_DETECT	RST_SIGN_MOT	RST_PEDO	STEP_DETECT	CK_GATE_FUNC
----------	----------	----------	----------------	--------------	----------	-------------	--------------

**Table 90. FUNC\_CK\_GATE\_A register description**

TILT_INT	Tilt event detection status. (0: tilt event not detected; 1: tilt event detected)
FS_SRC [1:0]	Full-scale SRC bit. (00: Same as <i>CTRL1_A (20h)</i> - no scaling; 01: 2 g; 10: 4 g; 11: same as <i>CTRL1_A (20h)</i> - no scaling)
SIGN_MOT_DETECT	Significant motion event detection status. (0: significant motion event not detected; 1: significant motion event detected)
RST_SIGN_MOT	Significant motion initialization reset. (0: disabled; 1: pedometer significant motion initialization has to be executed at the next routine execution or is actually ongoing)
RST_PEDO	Pedometer reset. (0: disabled; 1: indicates that pedometer step counter initialization has to be executed at the next routine execution or is actually ongoing)
STEP_DETECT	Step detection status. (0: Step not detected; 1: Step detected)
CK_GATE_FUNC	Function clocking gate signal. (0: Power down; 1: FUNC is in power mode)

### 8.33 FUNC\_SRC\_A (3Eh)

Functional source register (r)

**Table 91. FUNC\_SRC\_A register**

-	-	-	-	-	RST_TILT	MODULE_READY	-
---	---	---	---	---	----------	--------------	---

**Table 92. FUNC\_SRC\_A register description**

RST_TILT	Tilt reset. (0: disabled; 1: indicates that tilt initialization has to be executed at the next routine execution or is actually ongoing)
MODULE_READY	Module status. (0: new module data not available, 1: new module data available)

## 8.34 FUNC\_CTRL\_A (3Fh)

Functional control register (r/w)

**Table 93. FUNC\_CTRL\_A register**

0 <sup>(1)</sup>	0 <sup>(1)</sup>	MODULE_ON	TILT_ON	0 <sup>(1)</sup>	0 <sup>(1)</sup>	SIGN_MOT_ON	STEP_CNT_ON
------------------	------------------	-----------	---------	------------------	------------------	-------------	-------------

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

**Table 94. FUNC\_CTRL\_A register description**

MODULE_ON	Module processing enable. Default value: 0 (0: disabled; 1: module)
TILT_ON	Tilt on. Default value: 0 (0: new module data not available; 1: new module data available)
SIGN_MOT_ON	Pedometer significant motion routine enable. Default value: 0 (0: disabled, 1: pedometer significant motion routine enabled)
STEP_CNT_ON	Step counter routine enable. Default value: 0 (0: disabled, 1: pedometer step counter routine enabled)

## 8.35 OFFSET\_X\_REG\_L\_M (45h) and OFFSET\_X\_REG\_H\_M (46h)

These registers comprise a 16-bit register and represent X hard-iron offset in order to compensate environmental effects (data in two's complement). These values act on the magnetic output data value in order to delete the environmental offset.

## 8.36 OFFSET\_Y\_REG\_L\_M (47h) and OFFSET\_Y\_REG\_H\_M (48h)

These registers comprise a 16-bit register and represent Y hard-iron offset in order to compensate environmental effects (data in two's complement). These values act on the magnetic output data value in order to delete the environmental offset.

## 8.37 OFFSET\_Z\_REG\_L\_M (49h) and OFFSET\_Z\_REG\_H\_M (4Ah)

These registers comprise a 16-bit register and represent Z hard-iron offset in order to compensate environmental effects (data in two's complement). These values act on the magnetic output data value in order to delete the environmental offset.

## 8.38 WHO\_AM\_I\_M (4Fh)

The identification register is used to identify the device (read-only register).

0	1	0	0	0	0	0	0
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## 8.39 CFG\_REG\_A\_M (60h)

The configuration register is used to configure the output data rate and the measurement configuration.

**Table 95. CFG\_REG\_A\_M register**

COMP_TEMP_EN	REBOOT	SOFT_RST	LP	ODR1	ODR0	MD1	MD0
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**Table 96. CFG\_REG\_A\_M register description**

COMP_TEMP_EN <sup>(1)</sup>	Enable the magnetometer temperature compensation. Default value: 0 (0: temperature compensation disabled; 1: temperature compensation enabled)
REBOOT	Reboot magnetometer memory content. Default value: 0 (0: normal mode; 1: reboot memory content)
SOFT_RST	When this bit is set, the configuration registers and user registers are reset. Flash registers keep their values.
LP	Low-power mode enable. Default: 0 0: high-resolution mode 1: low-power mode enabled
ODR[1:0]	Output data rate configuration (see <a href="#">Table 97: Output data rate configuration</a> )
MD[1:0]	Mode select bit. These bits select the mode of operation of the device (see <a href="#">Table 98: System mode</a> )

- For proper operation, this bit must be set to '1'.

**Table 97. Output data rate configuration**

ODR1	ODR0	ODR (Hz)
0	0	10 (default)
0	1	20
1	0	50
1	1	100

**Table 98. System mode**

MD1	MD0	Mode
0	0	Continuous mode. In continuous mode the device continuously performs measurements and places the result in the data register. The data-ready signal is generated when a new data set is ready to be read. This signal can be available on the external pin by setting the INT_MAG bit in <a href="#">CFG_REG_C_M (62h)</a> .
0	1	Single mode. When single mode is selected, the device performs a single measurement, sets DRDY high and returns to idle mode. Mode register return to idle mode bit values.
1	0	Idle mode. Device is placed in idle mode. I <sup>2</sup> C and SPI active.
1	1	Idle mode. Device is placed in idle mode. I <sup>2</sup> C and SPI active.

## 8.40 CFG\_REG\_B\_M (61h)

**Table 99. CFG\_REG\_B\_M register**

0	0	0	OFF_CANC_ONE_SHOT	INT_on_DataOFF	Set_FREQ	OFF_CANC	LPF
---	---	---	-------------------	----------------	----------	----------	-----

**Table 100. CFG\_REG\_B\_M register description**

OFF_CANC_ONE_SHOT	Enables offset cancellation in single measurement mode. The OFF_CANC bit must be set to 1 when enabling offset cancellation in single measurement mode. 0: offset cancellation in single measurement mode disabled; 1: offset cancellation in single measurement mode enabled.
INT_on_DataOFF	If '1', the interrupt block recognition checks data after the hard-iron correction to discover the interrupt.
Set_FREQ	Selects the frequency of the set pulse. 0: set pulse is released every 63 ODR; 1: set pulse is released only at power-on after PD condition.
OFF_CANC	Enables offset cancellation.
LPF	Low-pass filter enable (see <a href="#">Table 101</a> ) 0: digital filter disabled; 1: digital filter enabled

**Table 101. Digital low-pass filter**

CFG_REG_B[LPF]	BW [Hz]
0 (disable)	ODR/2
1 (enable)	ODR/4

## 8.41 CFG\_REG\_C\_M (62h)

**Table 102. CFG\_REG\_C\_M register**

0	INT_MAG_PIN	I2C_DIS	BDU	BLE	0 <sup>(1)</sup>	Self_test	INT_MAG
---	-------------	---------	-----	-----	------------------	-----------	---------

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

**Table 103. CFG\_REG\_C\_M register description**

INT_MAG_PIN	If '1', the INTERRUPT signal (INT bit inside <i>INT_SOURCE_REG_M (64h)</i> ) is driven on INT_MAG_PIN.
I2C_DIS	If '1', the I <sup>2</sup> C interface is inhibited. Only the SPI interface can be used.
BDU	If enabled, reading of incorrect data is avoided when the user reads asynchronously. In fact if the read request arrives during an update of the output data, a latch is possible, reading incoherent high and low parts of the same register. Only one part is updated and the other one remains old.
BLE	If '1', an inversion of the low and high parts of the data occurs.
Self_test	If '1', the self-test is enabled.
INT_MAG	If '1', the DRDY pin is configured as a digital output.

## 8.42 INT\_CTRL\_REG\_M (63h)

The interrupt control register is used to enable and to configure the interrupt recognition.

**Table 104. INT\_CTRL\_REG\_M register**

XIEN	YIEN	ZIEN	0 <sup>(1)</sup>	0 <sup>(1)</sup>	IEA	IEL	IEN
------	------	------	------------------	------------------	-----	-----	-----

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

**Table 105. INT\_CTRL\_REG\_M register description**

XIEN	Enables the interrupt recognition for the X-axis. Default: 0 1: enabled; 0: disabled.
YIEN	Enables the interrupt recognition for the Y-axis. Default: 0 1: enabled; 0: disabled.
ZIEN	Enables the interrupt recognition for the Z-axis. Default: 0 1: enabled; 0: disabled.
IEA	Controls the polarity of the INT bit ( <i>INT_SOURCE_REG_M (64h)</i> ) when an interrupt occurs. Default: 0 If IEA = 0, then INT = 0 signals an interrupt If IEA = 1, then INT = 1 signals an interrupt
IEL	Controls whether the INT bit ( <i>INT_SOURCE_REG_M (64h)</i> ) is latched or pulsed. Default: 0 If IEL = 0, then INT is pulsed. If IEL = 1, then INT is latched. Once latched, INT remains in the same state until <i>INT_SOURCE_REG_M (64h)</i> is read.
IEN	Interrupt enable. When set, enables the interrupt generation. The INT bit is in <i>INT_SOURCE_REG_M (64h)</i> . Default: 0

## 8.43 INT\_SOURCE\_REG\_M (64h)

When interrupt latched is selected, reading this register resets all the bits in this register.

**Table 106. INT\_SOURCE\_REG\_M register**

P_TH_S_X	P_TH_S_Y	P_TH_S_Z	N_TH_S_X	N_TH_S_Y	N_TH_S_Z	MROI	INT
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**Table 107. INT\_SOURCE\_REG\_M register description**

P_TH_S_X	X-axis value exceeds the threshold positive side
P_TH_S_Y	Y-axis value exceeds the threshold positive side
P_TH_S_Z	Z-axis value exceeds the threshold positive side
N_TH_S_X	X-axis value exceeds the threshold negative side
N_TH_S_Y	Y-axis value exceeds the threshold negative side
N_TH_S_Z	Z-axis value exceeds the threshold negative side
MROI	MROI flag generation is always enabled. This flag is reset by reading <a href="#">INT_SOURCE_REG_M (64h)</a> .
INT	This bit signals when the interrupt event occurs.

## 8.44 INT\_THS\_L\_REG\_M (65h)

This register contains the least significant bits of the threshold value chosen for the interrupt.

**Table 108. INT\_THS\_L\_REG\_M register**

TH7	THS6	TH5	TH4	TH3	TH2	TH1	TH0
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**Table 109. INT\_THS\_L\_REG\_M register description**

TH[7:0]	Threshold value for the interrupt.
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## 8.45 INT\_THS\_H\_REG\_M (66h)

This register contains the most significant bits of the threshold value chosen for the interrupt.

**Table 110. INT\_THS\_H\_REG\_M register**

TH15	THS14	TH13	TH12	TH11	TH10	TH9	TH8
------	-------	------	------	------	------	-----	-----

**Table 111. INT\_THS\_H\_REG\_M register description**

TH[15:8]	Threshold value for the interrupt.
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These registers set the threshold value for the output to generate the interrupt (INT bit in [INT\\_SOURCE\\_REG\\_M \(64h\)](#)). This threshold is common to all three (axes) output values and is unsigned unipolar. The threshold value is correlated to the current gain and it is unsigned because the threshold is considered as an absolute value but crossing the threshold is detected for both positive and negative sides.

## 8.46 STATUS\_REG\_M (67h)

The status register is an 8-bit read-only register. This register is used to indicate device status. SR0 through SR7 indicate bit locations, with SR denoting the bits that are in the status register. SR7 denotes the first bit of the data stream.

**Table 112. STATUS\_REG\_M register**

Zyxor	zor	yor	xor	Zyxda	zda	yda	xda
-------	-----	-----	-----	-------	-----	-----	-----

**Table 113. STATUS\_REG\_M register description**

Zyxor	X-, Y- and Z-axis data overrun. Default value: 0 (0: no overrun has occurred; 1: a new set of data has overwritten the previous set).
zor	Z-axis data overrun. Default value: 0 (0: no overrun has occurred; 1: new data for the Z-axis has overwritten the previous data).
yor	Y-axis data overrun. Default value: 0 (0: no overrun has occurred; 1: new data for the Y-axis has overwritten the previous data).
xor	X-axis data overrun. Default value: 0 (0: no overrun has occurred; 1: new data for the X-axis has overwritten the previous data).
Zyxda	X-, Y- and Z-axis new data available. Default value: 0 (0: a new set of data is not yet available; 1: a new set of data is available).
zda	Z-axis new data available. Default value: 0 (0: a new data for the Z-axis is not yet available; 1: a new data for the Z-axis is available)
yda	Y-axis new data available. Default value: 0 (0: a new data for the Y-axis is not yet available; 1: a new data for the Y-axis is available)
xda	X-axis new data available. Default value: 0 (0: a new data for the X-axis is not yet available; 1: a new data for the X-axis is available)

## 8.47 OUTX\_L\_REG\_M, OUTX\_H\_REG\_M (68h - 69h)

The data output X registers are two 8-bit registers, data output ch1 MSB register (69h) and output X LSB register (68h).

The output data represents the raw magnetic data only if OFFSET\_X\_REG is equal to zero, otherwise hard-iron calibration is included.

**Table 114. OUTX\_L\_REG\_M register**

0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---

**Table 115. OUTX\_H\_REG\_M register**

0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---

The value of the magnetic field is expressed in two's complement. This register contains the X component of the magnetic data.

## 8.48 OUTY\_L\_REG\_M, OUTY\_H\_REG\_M (6Ah - 6Bh)

The data output Y registers are two 8-bit registers, data output ch1 MSB register (6Bh) and output Y LSB register (6Ah).

The output data represents the raw magnetic data only if OFFSET\_Y\_REG is equal to zero, otherwise hard-iron calibration is included.

**Table 116. OUTY\_L\_REG\_M register**

0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---

**Table 117. OUTY\_H\_REG\_M register**

0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---

The value of the magnetic field is expressed in two's complement. This register contains the Y component of the magnetic data.

## 8.49 OUTZ\_L\_REG\_M, OUTZ\_H\_REG\_M (6Ch - 6Dh)

The data output Z registers are two 8-bit registers, data output ch1 MSB register (6Bh) and output Z LSB register (6Ah).

The output data represents the raw magnetic data only if OFFSET\_Z\_REG is equal to zero, otherwise hard-iron calibration is included.

**Table 118. OUTZ\_L\_REG\_M register**

0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---

**Table 119. OUTZ\_H\_REG\_M register**

0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---

The value of the magnetic field is expressed in two's complement. This register contains the Z component of the magnetic data.

## 9 Advanced configuration register mapping

The table below provides a list of the registers for advanced configuration functions available in the device and the corresponding addresses.

Advanced configuration registers are accessible when FUNC\_CFG\_EN is set to '1' in [CTRL2\\_A \(21h\)](#). Once enabled, access to the advanced configuration registers can be disabled by setting the FUNC\_CFG\_EN bit to '1' in [CTRL2\\_A \(3Fh\)](#).

**Table 120. Register map - advanced configuration functions**

Name	Type	Register address		Default	Comment
		Hex	Binary		
RESERVED	R/W	00-2A			
PEDO_DEB_REG_A	R/W	2B	00101011	01101110	
RESERVED	R/W	2C-33			
SM_THS_A	R/W	34	00110100	00000110	
RESERVED	R/W	35-39			
STEP_COUNT_DELTA_A	R/W	3A	00111010	00000000	
RESERVED	R/W	3B-3E			
CTRL2_A (3Fh)	R/W	3F	00111111	00010100	

Registers marked as *Reserved* 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 Advanced configuration registers description

### 10.1 PEDO\_DEB\_REG\_A (2Bh)

**Table 121. PEDO\_DEB\_REG\_A register default values**

DEB_TIME4	DEB_TIME3	DEB_TIME2	DEB_TIME1	DEB_TIME0	DEB_STEP2	DEB_STEP1	DEB_STEP0
-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------

**Table 122. PEDO\_DEB\_REG\_A register description**

DEB_TIME[4:0]	Debounce time. If the time between two consecutive steps is greater than DEB_TIME*80ms, the debouncer is reactivated. Default value: 01101
DEB_STEP[2:0]	Debounce threshold. Minimum number of steps to increment step counter (debounce). Default value: 110

### 10.2 SM\_THS\_A (34h)

Defines the threshold value (r/w).

**Table 123. SM\_THS\_A configuration register**

SM_THS_7	SM_THS_6	SM_THS_5	SM_THS_4	SM_THS_3	SM_THS_2	SM_THS_1	SM_THS_0
----------	----------	----------	----------	----------	----------	----------	----------

**Table 124. SM\_THS\_A configuration register description**

SM_THS_[7:0]	These bits define the threshold value which corresponds to the number of steps to be performed by the user upon a change of location before the significant motion interrupt is generated. It is expressed as an 8-bit unsigned value. The default value of this field is equal to 6 (= 00000110b).
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### 10.3 STEP\_COUNT\_DELTA\_A (3Ah)

Step counter configuration register (r/w).

**Table 125. STEP\_COUNT\_DELTA\_A configuration register**

STEP_COUNT_D7	STEP_COUNT_D6	STEP_COUNT_D5	STEP_COUNT_D4	STEP_COUNT_D3	STEP_COUNT_D2	STEP_COUNT_D1	STEP_COUNT_D0
---------------	---------------	---------------	---------------	---------------	---------------	---------------	---------------

**Table 126. STEP\_COUNT\_DELTA\_A configuration register description**

STEP_COUNT_D[7:0]	Period of time to detect at least one step to generate step recognition. Default value: 0 1 LSB = 1.6384 s
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## 10.4 CTRL2\_A (3Fh)

Functional control register (r/w)

**Table 127. CTRL2\_A configuration register**

BOOT <sup>(1)</sup>	SOFT_RESET <sup>(1)</sup>	0 <sup>(2)</sup>	FUNC_CFG_EN	FDS_SLOPE <sup>(1)</sup>	IF_ADD_INC <sup>(1)</sup>	I2C_DISABLE <sup>(1)</sup>	SIM <sup>(1)</sup>
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1. Read-only bits
2. This bit must be set to '0' for the correct operation of the device.

**Table 128. CTRL2\_A configuration register description**

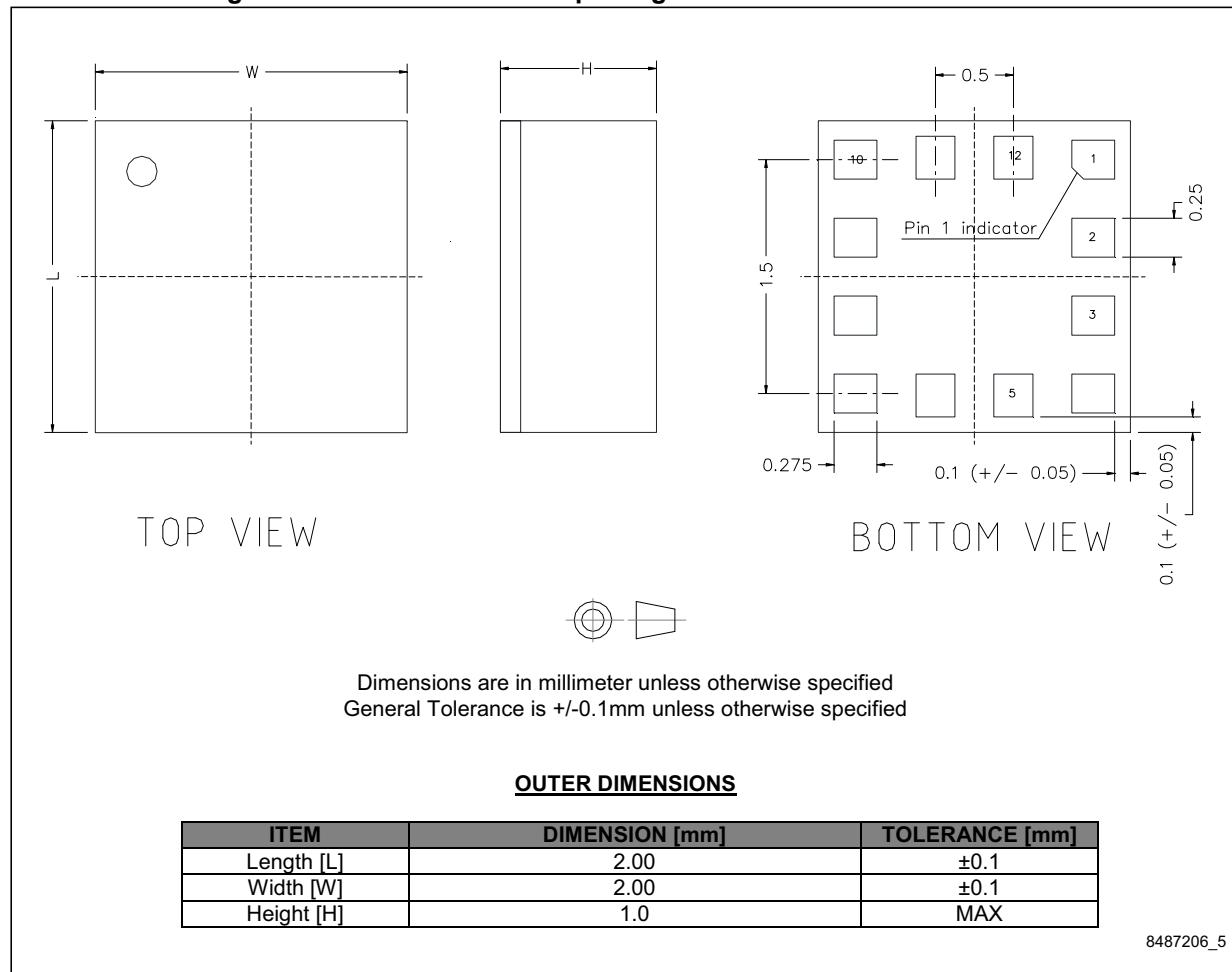
BOOT	Forces the reboot of the flash content in the trimming and configuration registers. READ ONLY.
SOFT_RESET	Soft reset acts as a reset for all control registers, then goes to 0. READ ONLY.
FUNC_CFG_EN	Default value: 1 (0: disable pedometer/sensor hub advanced functionalities; 1: enable pedometer/sensor hub advanced functionalities)
FDS_SLOPE	High-pass filter data selection on output register and FIFO. READ ONLY.
IF_ADD_INC	Register address automatically incremented during multiple byte access with a serial interface (I <sup>2</sup> C or SPI). READ ONLY.
I2C_DISABLE	Disable I <sup>2</sup> C communication protocol. READ ONLY.
SIM	SPI serial interface mode selection. READ ONLY.

## 11 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.

### 11.1 LGA-12 package information

Figure 21. LGA-12 2x2x1 mm package outline and mechanical data



## 11.2 LGA-12 packing information

Figure 22. Carrier tape information for LGA-12 package

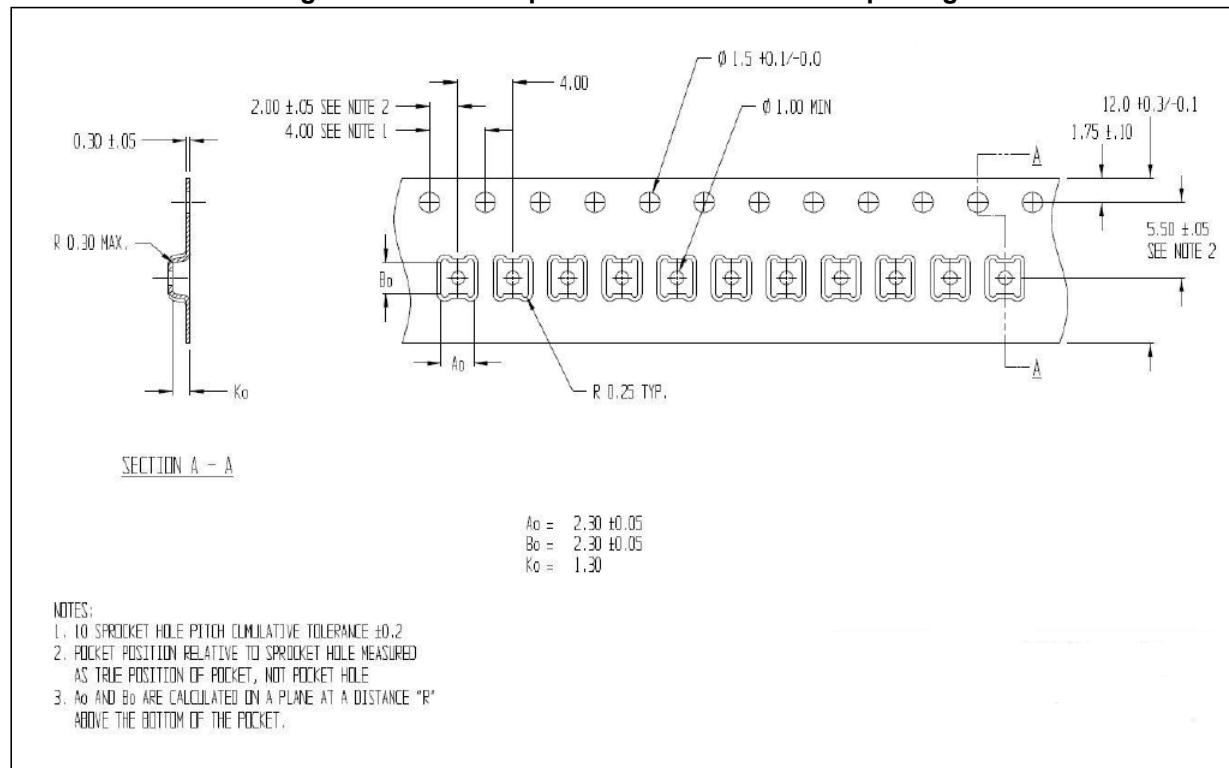
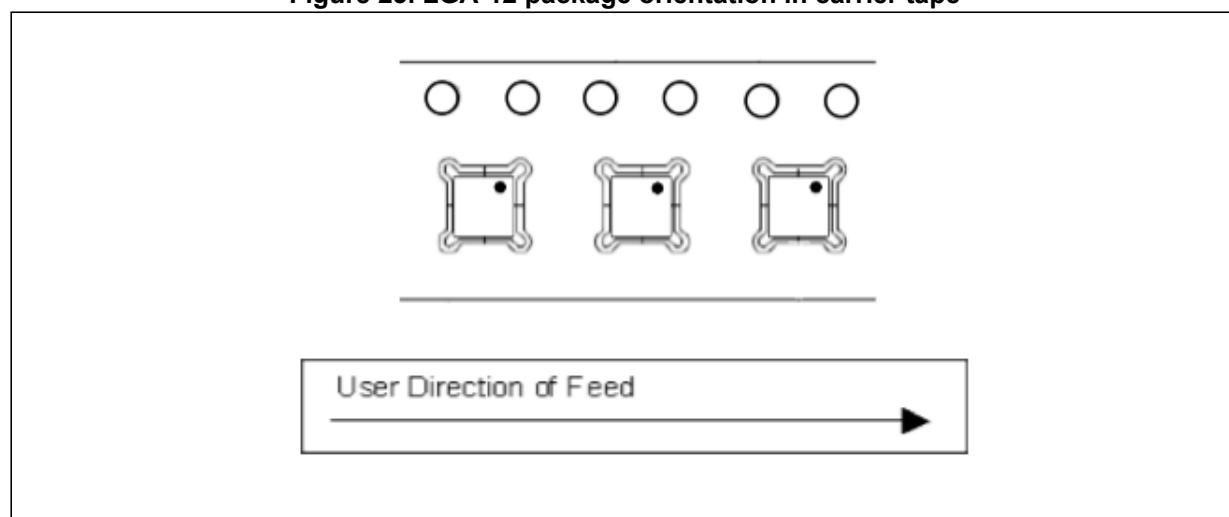
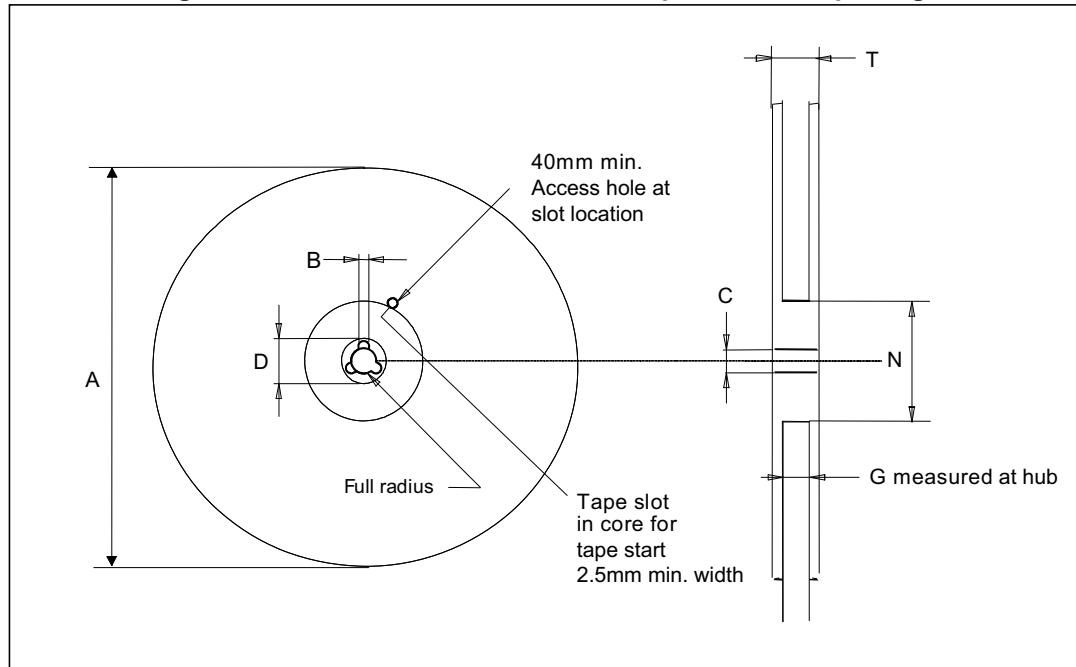


Figure 23. LGA-12 package orientation in carrier tape



**Figure 24. Reel information for carrier tape of LGA-12 package****Table 129. Reel dimensions for carrier tape of LGA-12 package**

Reel dimensions (mm)	
A (max)	330
B (min)	1.5
C	13 ±0.25
D (min)	20.2
N (min)	60
G	12.4 +2/-0
T (max)	18.4

## 12 Revision history

**Table 130. Document revision history**

Date	Revision	Changes
31-Aug-2016	5	<p>Document status promoted to production data</p> <p>Updated <a href="#">Table 3: Sensor characteristics</a></p> <p>Updated <a href="#">Table 5: Electrical characteristics</a></p> <p>Updated <math>A_{POW}</math> and <math>A_{UNP}</math> in <a href="#">Table 9: Absolute maximum ratings</a></p> <p>Updated <a href="#">Table 11: Current consumption of operating modes</a></p> <p>Updated <a href="#">Table 16: Current consumption of operating modes</a></p> <p>Updated <a href="#">Section 4.1.1: Magnetometer power modes</a></p> <p>Updated <a href="#">Figure 5 and Figure 6</a></p> <p>Added <a href="#">Table 19: Pin status</a></p> <p>Updated default value of CTRL2_A (21h) in <a href="#">Table 28: Register map</a></p> <p>Updated <a href="#">CFG_REG_A_M (60h)</a> and <a href="#">INT_THS_H_REG_M (66h)</a></p> <p>Updated default values of PEDO_DEB_REG_A (2Bh) and CTRL2_A (3Fh) in <a href="#">Table 120: Register map - advanced configuration functions</a></p> <p>Updated <a href="#">PEDO_DEB_REG_A (2Bh)</a></p> <p>Updated <a href="#">STEP_COUNTER_MINTHS_A (3Ah)</a></p> <p>Added <a href="#">Section 11.2: LGA-12 packing information</a></p>
26-Sep-2016	6	<p>Updated <a href="#">Section 4.1.2: Magnetometer offset cancellation</a> and added OFF_CANC_ONE_SHOT bit to <a href="#">CFG_REG_B_M (61h)</a></p> <p>Updated <a href="#">Figure 21: LGA-12 2x2x1 mm package outline and mechanical data</a></p>
28-Nov-2018	7	Updated <a href="#">Table 5: Electrical characteristics</a>

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