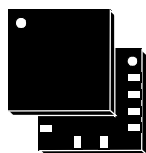


## Digital output magnetic sensor: ultra-low-power, high-performance 3-axis magnetometer

Datasheet - production data



LGA-12 (2.0x2.0x0.7 mm)

### Features

- 3 magnetic field channels
- **±50 gauss** magnetic dynamic range
- 16-bit data output
- SPI/I<sup>2</sup>C serial interfaces
- Analog supply voltage 1.71 V to 3.6 V
- Selectable power mode/resolution
- Single measurement mode
- Programmable interrupt generator
- Embedded self-test
- Embedded temperature sensor
- ECOPACK<sup>®</sup>, RoHS and “Green” compliant

### Applications

- Tilt-compensated compasses
- Map rotation
- Intelligent power saving for handheld devices
- Gaming and virtual reality input devices

### Description

The LIS2MDL is an ultra-low-power high-performance 3-axis digital magnetic sensor.

The LIS2MDL has a magnetic field dynamic range of ±50 gauss.

The LIS2MDL 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 device can be configured to generate an interrupt signal for magnetic field detection.

The LIS2MDL 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     |
|-------------|------------------|---------|---------------|
| LIS2MDL     | -40 to +85       | LGA-12  | Tray          |
| LIS2MDLTR   | -40 to +85       | LGA-12  | Tape and reel |

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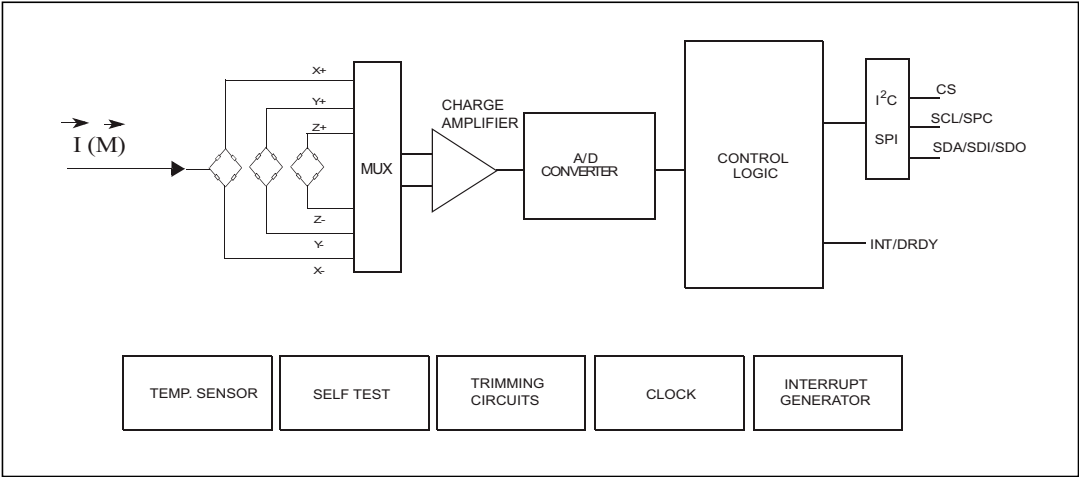
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# 1 Block diagram and pin description

## 1.1 Block diagram

Figure 1. Block diagram



## 1.2 Pin description

Figure 2. Pin connections

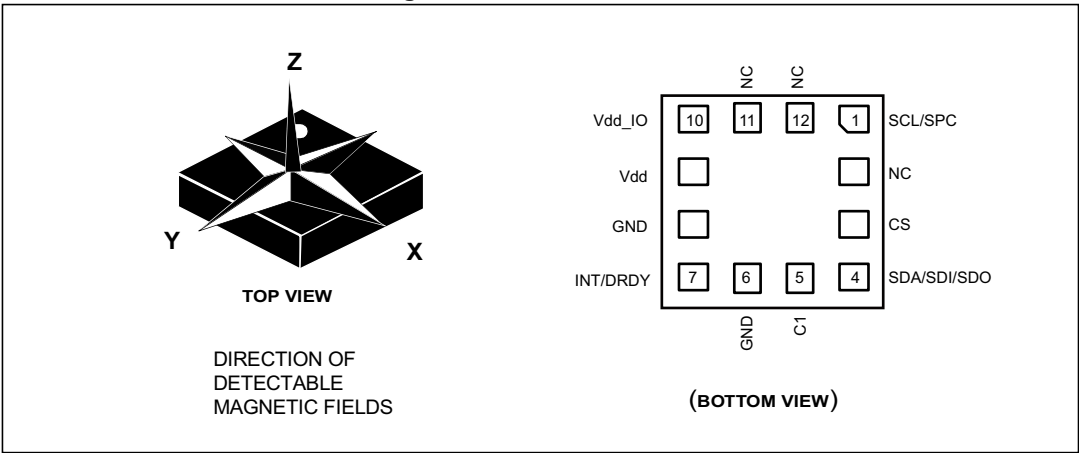


Table 2. Pin description

| Pin# | Name              | Function   |
|------|-------------------|--|
| 1    | SCL<br>SPC        | I <sup>2</sup> C serial clock (SCL)<br>SPI serial port clock (SPC)   |
| 2    | NC                | Internally not connected. Can be tied to Vdd, Vdd_IO or GND.   |
| 3    | CS                | SPI enable<br>I <sup>2</sup> C/SPI mode selection<br>1: SPI idle mode / I <sup>2</sup> C communication enabled;<br>0: SPI communication mode / I <sup>2</sup> C disabled |
| 4    | SDA<br>SDI<br>SDO | I <sup>2</sup> C serial data (SDA)<br>SPI serial data input (SDI)<br>3-wire interface serial data output (SDO)   |
| 5    | C1                | Capacitor connection (C1 = 220 nF)   |
| 6    | GND               | Connected to GND   |
| 7    | INT/DRDY          | Interrupt/data-ready signal  |
| 8    | GND               | 0 V  |
| 9    | Vdd               | Power supply   |
| 10   | Vdd_IO            | Power supply for I/O pins  |
| 11   | NC                | Internally not connected. Can be tied to Vdd, Vdd_IO or GND.   |
| 12   | NC                | Internally not connected. Can be tied to Vdd, Vdd_IO or GND.   |



## 2 Module specifications

### 2.1 Sensor characteristics

@ Vdd = 2.5 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            |
|--------|--|--|------|---------------------|------|-----------------|
| FS     | Magnetic dynamic range                                 |  |      | ±49.152             |      | gauss           |
| So     | Sensitivity <sup>(2)</sup>                             |  | -7%  | 1.5                 | +7%  | mgauss/<br>LSB  |
| TCSO   | Sensitivity change vs. temperature <sup>(3)</sup>      |  |      | ±0.03               |      | %/°C            |
| TyOff  | Magnetic sensor offset                                 | With offset cancellation <sup>(4)(5)</sup> | -60  |                     | +60  | mgauss          |
| TCOff  | Magnetic sensor offset change vs. temp. <sup>(4)</sup> | With offset cancellation                   | -0.3 |                     | +0.3 | mgauss/<br>°C   |
| RMS    | RMS noise <sup>(6)</sup>                               | High-resolution mode                       |      | 3                   |      | mgauss<br>(RMS) |
| ST     | Self-test <sup>(7)</sup>                               |  | 15   |                     | 500  | mgauss          |
| Top    | Operating temperature range                            |  | -40  |                     | +85  | °C              |

1. Typical specifications are not guaranteed.
2. Values after factory calibration test and trimming.
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. Based on characterization data on a limited number of samples, not measured during final test for production.
5. Excluding drift due to magnetic shock.
6. With low-pass filter or offset cancellation enabled.
7. "Self-test" is defined as:  $\text{OUTPUT}[\text{gauss}]_{(\text{Self-test enabled})} - \text{OUTPUT}[\text{gauss}]_{(\text{Self-test disabled})}$ .

a. The product is factory calibrated at 2.5 V. The operational power supply range is from 1.71 V to 3.6 V.

## 2.2 Temperature sensor characteristics

@ Vdd = 2.5 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. |                 |      | 8                   |      | digit/°C <sup>(2)</sup> |
| TODR   | Temperature refresh rate                   |                 |      | ODR <sup>(3)</sup>  |      | Hz                      |
| Top    | Operating temperature range                |                 | -40  |                     | +85  | °C                      |

1. Typical specifications are not guaranteed.

2. 12-bit resolution.

3. Refer to [Table 25](#).

## 2.3 Electrical characteristics

@ Vdd = 2.5 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         | 2.5                 | 3.6        | V    |
| Vdd_IO          | Module power supply for I/O <sup>(2)</sup>  |                 | 1.71         |                     | 3.6        | V    |
| Idd_HR          | Current consumption in high-resolution mode | ODR = 20 Hz     |              | 200                 |            | μA   |
| Idd_LP          | Current consumption in low-power mode       | ODR = 20 Hz     |              | 50                  |            | μA   |
| Idd_PD          | Current consumption in power-down           |                 |              | 1.5                 |            | μA   |
| VIH             | Digital high-level input voltage            |                 | 0.8*Vdd_IO   |                     |            | V    |
| VIL             | Digital low-level input voltage             |                 |              |                     | 0.2*Vdd_IO | V    |
| VOH             | High-level output voltage                   | IOH = 4 mA      | Vdd_IO - 0.2 |                     |            | V    |
| VOL             | Low-level output voltage                    | IOL = 4 mA      |              |                     | 0.2        | V    |
| T <sub>OP</sub> | 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.

b. The product is factory calibrated at 2.5 V. The operational power supply range is from 1.71 V to 3.6 V.

## 2.4 Communication interface characteristics

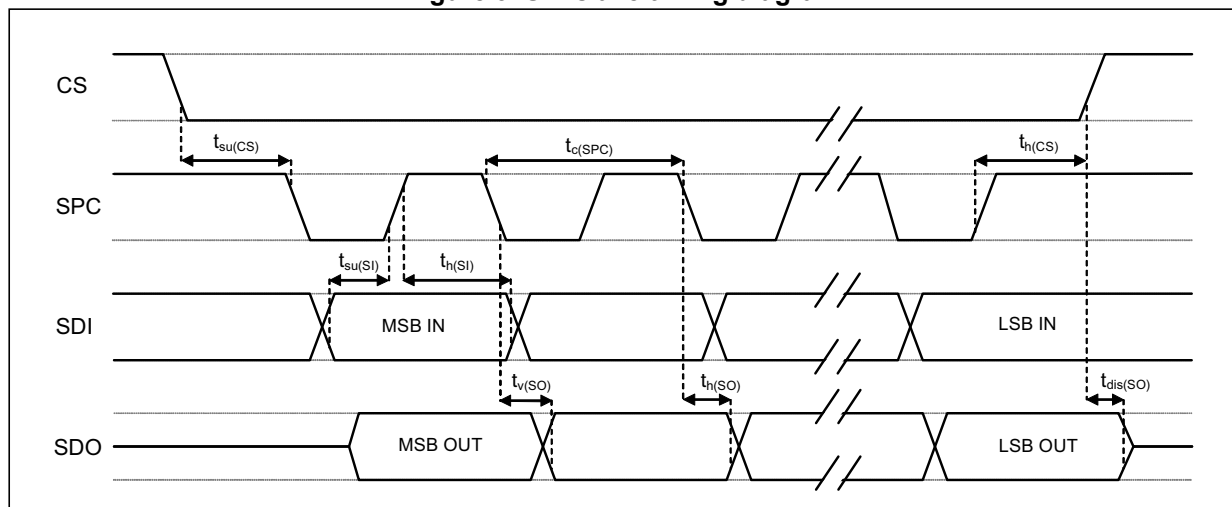
### 2.4.1 SPI - serial peripheral interface

Subject to general operating conditions for Vdd and Top.

**Table 6. SPI slave timing values**

| Symbol        | Parameter               | Value <sup>(1)</sup> |     | Unit |
|---------------|-------------------------|----------------------|-----|------|
|               |                         | Min                  | Max |      |
| $t_{c(SPC)}$  | SPI clock cycle         | 100                  |     | ns   |
| $f_{c(SPC)}$  | SPI clock frequency     |                      | 10  | MHz  |
| $t_{su(CS)}$  | CS setup time           | 5                    |     | ns   |
| $t_{h(CS)}$   | CS hold time            | 20                   |     |      |
| $t_{su(SI)}$  | SDI input setup time    | 5                    |     |      |
| $t_{h(SI)}$   | SDI input hold time     | 15                   |     |      |
| $t_{v(SO)}$   | SDO valid output time   |                      | 50  |      |
| $t_{h(SO)}$   | SDO output hold time    | 5                    |     |      |
| $t_{dis(SO)}$ | 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  $0.2 \cdot V_{dd\_IO}$  and  $0.8 \cdot V_{dd\_IO}$ , for both input and output ports.

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

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

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

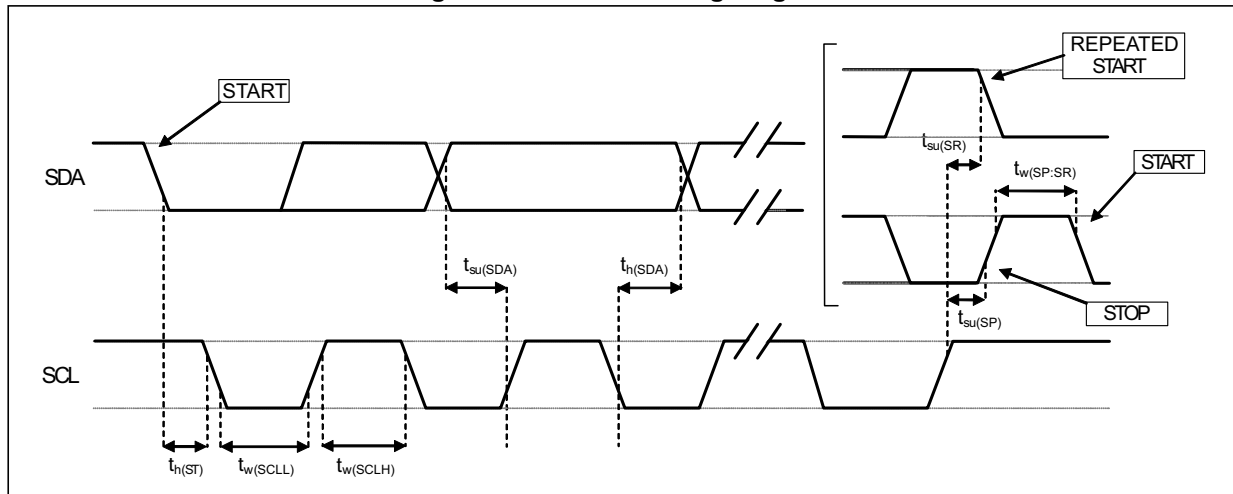
| Symbol                | Parameter                                      | I <sup>2</sup> C standard mode <sup>(1)</sup> |      | I <sup>2</sup> C fast mode <sup>(1)</sup> |     | Unit |
|-----------------------|--|---|------|---|-----|------|
|                       |  | Min   | Max  | Min                                       | 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                                       |     | μs   |
| 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                                       |     | ns   |
| t <sub>h(SDA)</sub>   | Data hold time                                 | 0   | 3.45 | 0   | 0.9 | μs   |
| 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                                       |      | μs   |
| 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   |      | ns   |
| t <sub>h(SDA)</sub>   | Data hold time                                 | 0  |     | 0  | 0.07 | μs   |
| 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  |
|--------------------|--|---------------------------------|-------|
| V <sub>dd</sub>    | Supply voltage   | -0.3 to 4.8                     | V     |
| V <sub>dd_IO</sub> | I/O pins supply voltage  | -0.3 to 4.8                     | V     |
| V <sub>in</sub>    | Input voltage on any control pin<br>(CS, SCL/SPC, SDA/SDI/SDO) | -0.3 to V <sub>dd_IO</sub> +0.3 | V     |
| 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 4.8 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**

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-gauss level**

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

### **3.3 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 Power modes

The LIS2MDL provides two different power modes: **high-resolution** and low-power modes.

The tables below summarize the 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[LPF]<br>or<br>CFG_REG_B[OFF_CANC] | (CFG_REG_A[LP = 0])<br>high-resolution mode |                | (CFG_REG_A[LP = 1])<br>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<br>(Hz) | Current consumption<br>( $\mu$ A)<br>(CFG_REG_A<br>[LP] = 0)<br>high-resolution<br>CFG_REG_B<br>[OFF_CANC] = 0 | Current consumption<br>( $\mu$ A)<br>(CFG_REG_A<br>[LP] = 1)<br>low-power<br>CFG_REG_B<br>[OFF_CANC] = 0 | Current consumption<br>( $\mu$ A)<br>(CFG_REG_A<br>[LP] = 0)<br>high-resolution<br>CFG_REG_B<br>[OFF_CANC] = 1 | Current consumption<br>( $\mu$ A)<br>(CFG_REG_A<br>[LP] = 1)<br>low-power<br>CFG_REG_B<br>[OFF_CANC] = 1 |
|-------------|--|--|--|--|
| 10          | 100  | 25   | 120  | 50   |
| 20          | 200  | 50   | 235  | 100  |
| 50          | 475  | 125  | 575  | 235  |
| 100         | 950  | 250  | 1130   | 460  |



The following table summarizes the turn-on time of the device in the two different power modes with the offset cancellation function enabled or disabled (see [Section 4.2: Magnetometer offset cancellation](#)).

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

| Operating mode      | Turn-on time            |                         |
|---------------------|-------------------------|-------------------------|
|                     | CFG_REG_A[OFF_CANC = 0] | CFG_REG_A[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 LIS2MDL 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 \(60h\)](#).

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 LIS2MDL 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[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:

$$(\text{Current\_consumption\_10Hz} - \text{Current\_consumption\_in\_power\_down}) / (10 \text{ Hz} / \text{ODR}) + \text{Current\_consumption\_in\_power\_down}$$

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

## 4.2 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 LIS2MDL 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 \(61h\)](#).

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 \(61h\)](#).

## 4.3 Magnetometer interrupt

In the LIS2MDL the magnetometer interrupt signal generation is based on the comparison between data and a programmable threshold.

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

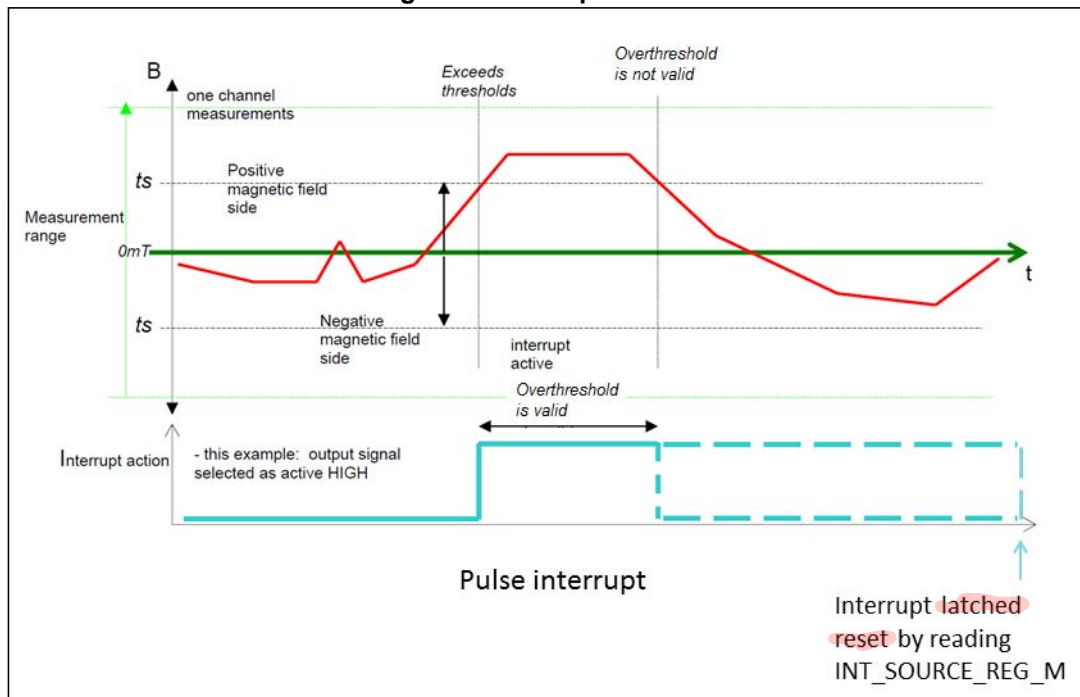
In the LIS2MDL the user can select the axis/axes in which the interrupt function can be enabled. In order to do this, the `XIEN`, `YIEN`, and `ZIEN` bits in [INT\\_CTRL\\_REG \(63h\)](#) need be set properly.

The threshold value can be programmed by setting the [INT\\_THS\\_L\\_REG \(65h\)](#) and [INT\\_THS\\_H\\_REG \(66h\)](#) 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 \(64h\)](#) 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 \(61h\)](#).

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 \(63h\)](#) 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 \(63h\)](#) to '1'.

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

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 \(62h\)](#) must be set to '1'.

## 4.4 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 LIS2MDL 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.

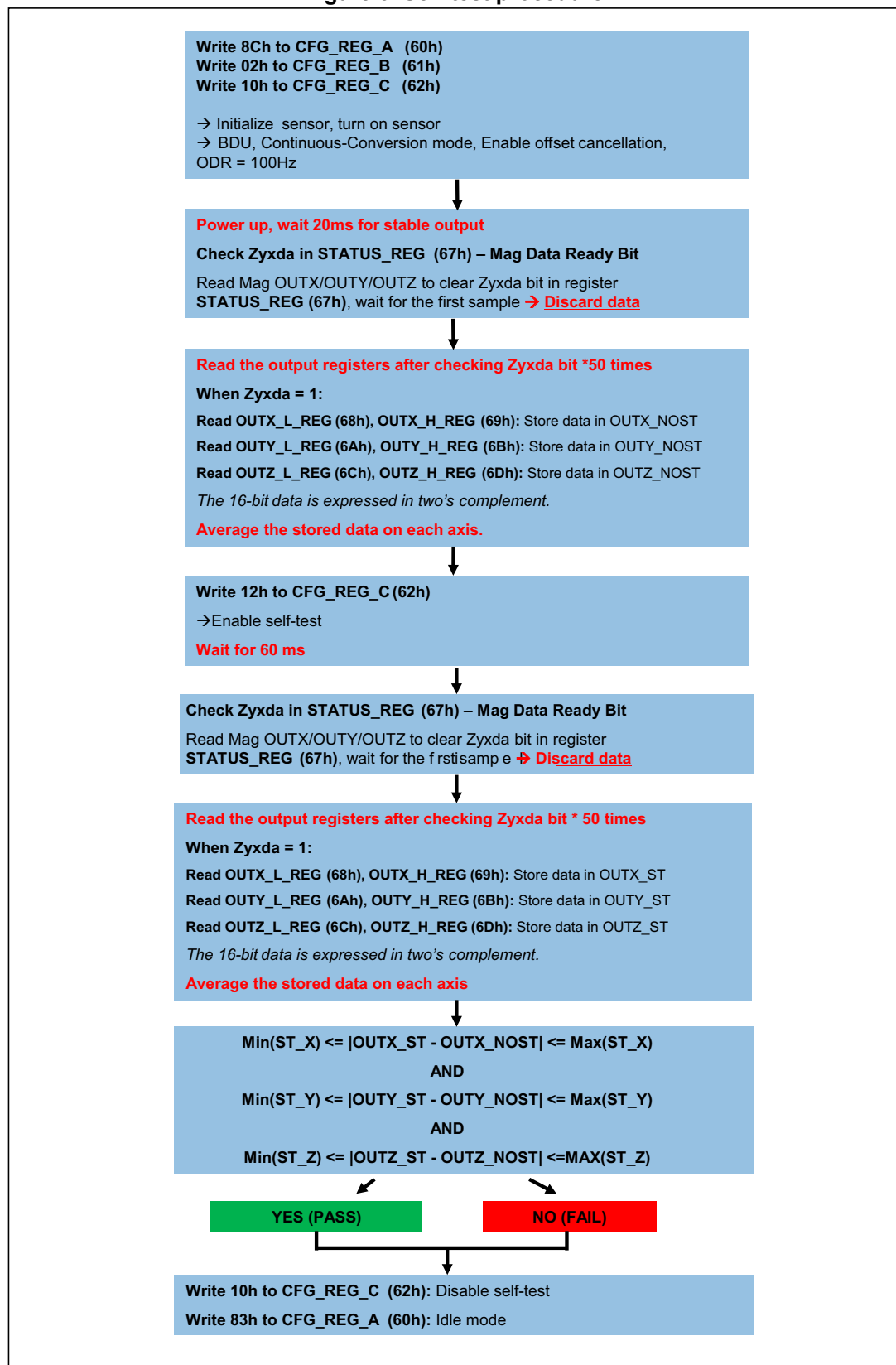
Hard-iron data have the same format and weight of the magnetic output data. The hard-iron values stored in dedicated registers are automatically subtracted from the output data.

### 4.4.1 Self-test

When the 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. Self-test procedure



## 4.5 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 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 LIS2MDL features a data-ready signal which indicates when new sets of measured magnetic data are available, thus simplifying data synchronization in the digital system that uses the device.

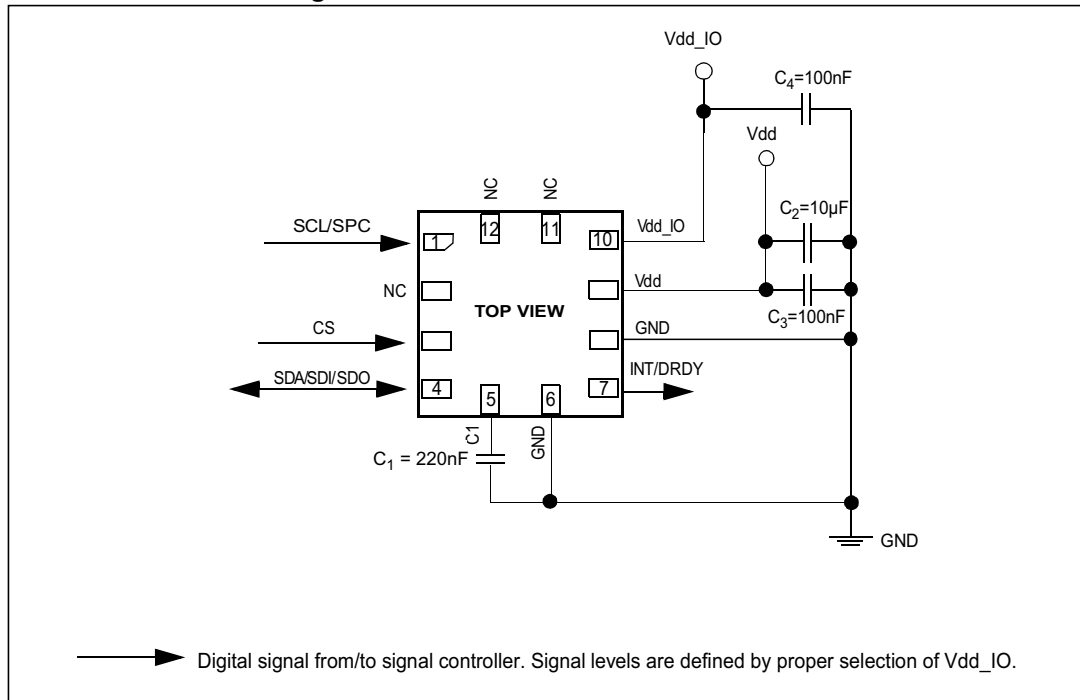
## 4.6 Factory calibration

The IC interface is factory calibrated for sensitivity (So) and Zero-*gauss* level (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 7. LIS2MDL 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 µF 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 avoids 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 interrupt pin (INT) can be completely programmed by the user through the I<sup>2</sup>C/SPI interface.

Table 14. Internal pin status

| Pin# | Name              | Function   | Pin status                                       |
|------|-------------------|--|--|
| 1    | SCL<br>SPC        | I <sup>2</sup> C serial clock (SCL)<br>SPI serial port clock (SPC)   | Default: input without pull-up                   |
| 2    | NC                |  | Internally not connected                         |
| 3    | CS                | SPI enable<br>I <sup>2</sup> C/SPI mode selection<br>1: SPI idle mode / I <sup>2</sup> C communication enabled;<br>0: SPI communication mode / I <sup>2</sup> C disabled | Default: input without pull-up                   |
| 4    | SDA<br>SDI<br>SDO | I <sup>2</sup> C serial data (SDA)<br>SPI serial data input (SDI)<br>3-wire interface serial data output (SDO)   | Default: (SDA) input without pull-up             |
| 5    | C1                | Capacitor connection (C1 = 220 nF)   | External capacitor, voltage forced by the device |
| 6    | GND               | 0 V  |  |
| 7    | INT/DRDY          | 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   | NC                |  | Internally not connected                         |
| 12   | NC                |  | Internally not connected                         |

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



## 5.1 Soldering information

The LGA package is compliant with the ECOPACK<sup>®</sup>, 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.

## 5.3

## Startup sequence

The following general-purpose sequence can be used to configure the device:

1. Write CFG\_REG\_A = 00h // Mag = 10 Hz (high-resolution and continuous mode)
2. Write CFG\_REG\_C = 01h // Mag data-ready interrupt enable

3. 校准

## 6 Digital interfaces

The registers embedded inside the LIS2MDL 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 onto the same pads. To select/exploit the I<sup>2</sup>C interface, the CS line must be tied high (i.e. connected to Vdd\_IO).

**Table 15. Serial interface pin description**

| Pin name          | Pin description  |
|-------------------|--|
| CS                | SPI enable<br>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<br>SPC        | I <sup>2</sup> C serial clock (SCL)<br>SPI serial port clock (SPC)   |
| SDA<br>SDI<br>SDO | I <sup>2</sup> C serial data (SDA)<br>SPI serial data input (SDI)<br>3-wire interface serial data output (SDO)   |

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

The LIS2MDL 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 16. 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 LIS2MDL 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 MSB enables address auto increment. If the MSB of the SUB field is '1', the SUB (register address) is automatically increased to allow multiple data read/writes.

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 21](#) explains how the SAD+read/write bit pattern is composed, listing all the possible configurations.

**Table 17. Transfer when master is writing one byte to slave**

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

**Table 18. Transfer when master is writing multiple bytes to slave**

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

**Table 19. 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 20. Transfer when master is receiving (reading) multiple bytes of data from slave**

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

Data are transmitted in byte format (DATA). Each data transfer contains 8 bits. The number of bytes transferred per transfer is unlimited. Data is transferred with the Most Significant bit

(MSb) first. If a 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 slave address is 0011110b.

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 sub-address byte. If the bit is '0' (Write) the master will transmit to the slave with direction unchanged. [Table 21](#) explains how the SAD+Read/Write bit patterns are composed, listing all the possible configurations.

**Table 21. SAD + Read/Write patterns**

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

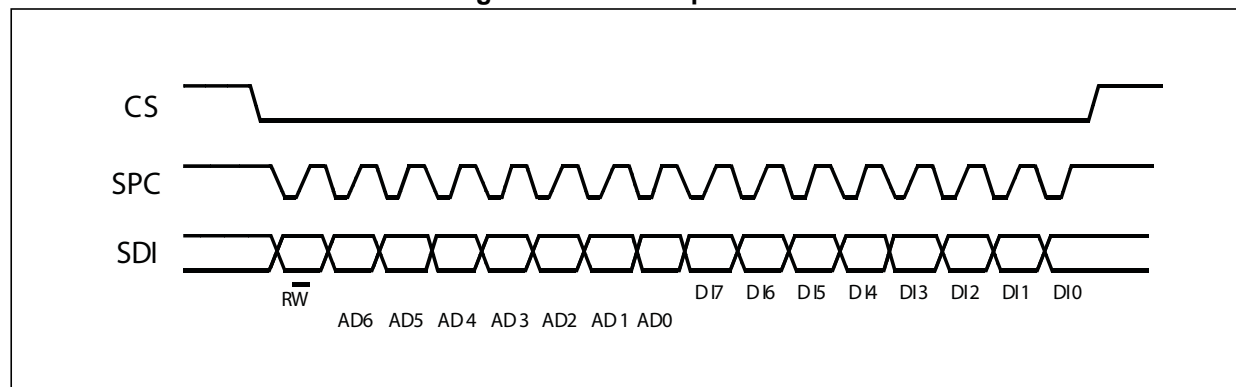
## 6.2 SPI bus interface

The LIS2MDL SPI is a bus slave. The SPI allows writing and reading the registers of the device.

The serial interface interacts with the application using 3 wires: **CS**, **SPC**, **SDI/O**.

### 6.2.1 SPI write

Figure 8. 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.

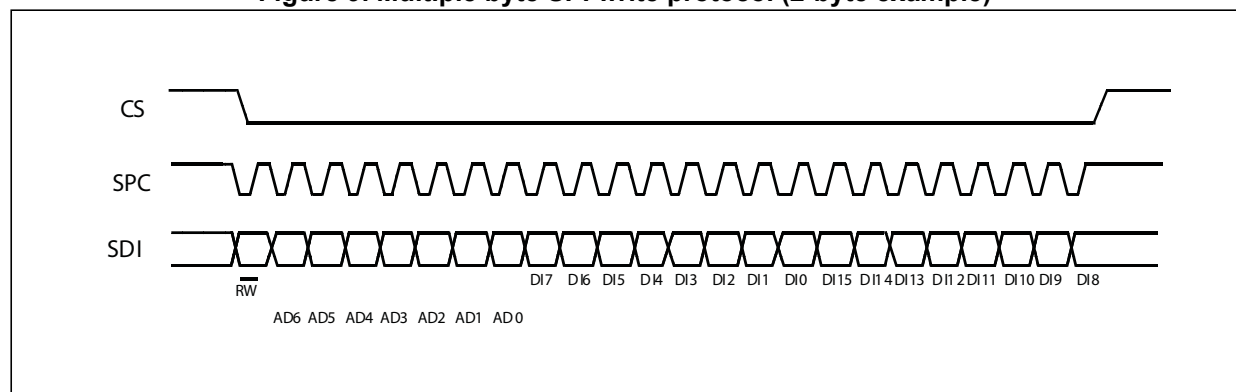
**bit 0:** WRITE bit. The value is 0.

**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).

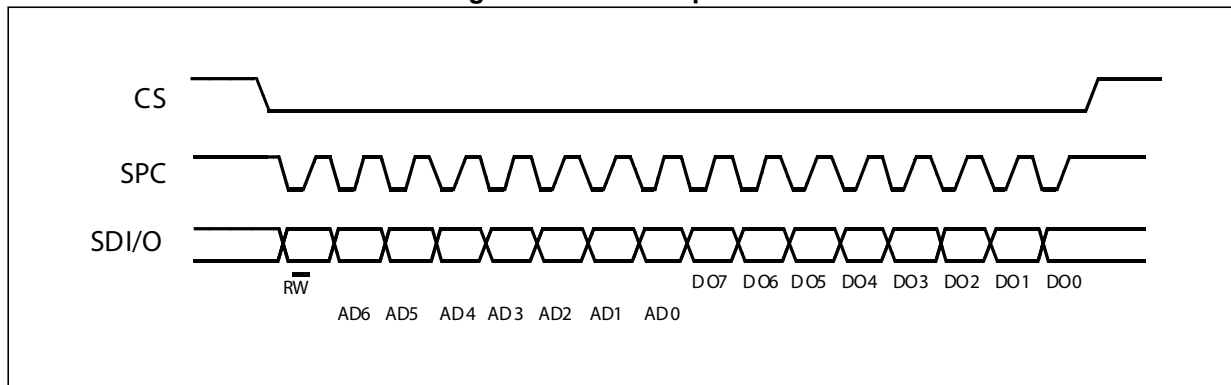
**bit 16-...** : data DI(...-8). Further data in multiple byte writes.

Figure 9. Multiple byte SPI write protocol (2-byte example)



### 6.2.2 SPI read

Figure 10. SPI read protocol



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

**bit 0:** WRITE 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 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.

**Table 22. Register address map**

| Name           | Type <sup>(1)</sup> | Register address |          | Default  | Comment                           |
|----------------|---------------------|------------------|----------|----------|-----------------------------------|
|                |                     | Hex              | Binary   |          |                                   |
| Reserved       |                     | 00 - 44          |          |          | Reserved                          |
| OFFSET_X_REG_L | R/W                 | 45               | 01000101 | 00000000 | Hard-iron registers               |
| OFFSET_X_REG_H | R/W                 | 46               | 01000110 | 00000000 |                                   |
| OFFSET_Y_REG_L | R/W                 | 47               | 01000111 | 00000000 |                                   |
| OFFSET_Y_REG_H | R/W                 | 48               | 01001000 | 00000000 |                                   |
| OFFSET_Z_REG_L | R/W                 | 49               | 01001001 | 00000000 |                                   |
| OFFSET_Z_REG_H | R/W                 | 4A               | 01001010 | 00000000 |                                   |
| RESERVED       |                     | 4B-4C            |          |          |                                   |
| WHO_AM_I       | R                   | 4F               | 01001111 | 01000000 |                                   |
| RESERVED       |                     | 50-5F            |          |          |                                   |
| CFG_REG_A      | R/W                 | 60               | 01100000 | 00000011 | Configuration registers           |
| CFG_REG_B      | R/W                 | 61               | 01100001 | 00000000 |                                   |
| CFG_REG_C      | R/W                 | 62               | 01100010 | 00000000 |                                   |
| INT_CTRL_REG   | R/W                 | 63               | 01100011 | 11100000 | Interrupt configuration registers |
| INT_SOURCE_REG | R                   | 64               | 01100100 |          |                                   |
| INT_THS_L_REG  | R/W                 | 65               | 01100101 | 00000000 |                                   |
| INT_THS_H_REG  | R/W                 | 66               | 01100110 | 00000000 |                                   |
| STATUS_REG     | R                   | 67               | 01100111 |          |                                   |
| OUTX_L_REG     | R                   | 68               | 01101000 | output   | Output registers                  |
| OUTX_H_REG     | R                   | 69               | 01101001 | output   |                                   |
| OUTY_L_REG     | R                   | 6A               | 01101010 | output   |                                   |
| OUTY_H_REG     | R                   | 6B               | 01101010 | output   |                                   |
| OUTZ_L_REG     | R                   | 6C               | 01101100 | output   |                                   |
| OUTZ_H_REG     | R                   | 6D               | 01101101 | output   |                                   |
| TEMP_OUT_L_REG | R                   | 6E               | 01101110 | output   | Temperature sensor registers      |
| TEMP_OUT_H_REG | R                   | 6F               | 01101111 | output   |                                   |

1. R = read-only register, R/W = 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 OFFSET\_X\_REG\_L (45h) and OFFSET\_X\_REG\_H (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.

### 8.2 OFFSET\_Y\_REG\_L (47h) and OFFSET\_Y\_REG\_H (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.

### 8.3 OFFSET\_Z\_REG\_L (49h) and OFFSET\_Z\_REG\_H (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.

### 8.4 WHO\_AM\_I (4Fh)

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

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|

## 8.5 CFG\_REG\_A (60h)

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

**Table 23. CFG\_REG\_A register**

| COMP_TEMP_EN | REBOOT | SOFT_RST | LP | ODR1 | ODR0 | MD1 | MD0 |
|--------------|--------|----------|----|------|------|-----|-----|
|--------------|--------|----------|----|------|------|-----|-----|

**Table 24. CFG\_REG\_A 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<br>0: high-resolution mode 1: low-power mode enabled   |
| ODR[1:0]                    | Output data rate configuration (see <a href="#">Table 25: 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 26: System mode</a> )                            |

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

**Table 25. Output data rate configuration**

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

**Table 26. System mode**

| MD1 | MD0 | Mode  |
|-----|-----|---|
| 0   | 0   | <b>Continuous mode.</b> 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 (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.  |

## 8.6 CFG\_REG\_B (61h)

**Table 27. CFG\_REG\_B\_M register**

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

**Table 28. 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.<br>0: offset cancellation in single measurement mode disabled;<br>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.<br>0: set pulse is released every 63 ODR;<br>1: set pulse is released only at power-on after PD condition.   |
| OFF_CANC          | Enables offset cancellation.<br>0: offset cancellation disabled; 1: offset cancellation enabled  |
| LPF               | Low-pass filter enable (see <a href="#">Table 29</a> )<br>0: digital filter disabled; 1: digital filter enabled  |

**Table 29. Digital low-pass filter**

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

## 8.7 CFG\_REG\_C (62h)

**Table 30. CFG\_REG\_C 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 31. CFG\_REG\_C register description**

|             |  |
|-------------|--|
| INT_MAG_PIN | If '1', the INTERRUPT signal (INT bit inside <a href="#">INT_SOURCE_REG (64h)</a> ) is driven on the INT/DRDY 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 INT/DRDY pin is configured as a digital output.  |

## 8.8 INT\_CTRL\_REG (63h)

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

**Table 32. INT\_CTRL\_REG 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 33. INT\_CTRL\_REG register description**

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

## 8.9 INT\_SOURCE\_REG (64h)

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

**Table 34. INT\_SOURCE\_REG 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 |
|----------|----------|----------|----------|----------|----------|------|-----|

**Table 35. INT\_SOURCE\_REG 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 (64h)</a> . |
| INT      | This bit signals when the interrupt event occurs.  |

## 8.10 INT\_THS\_L\_REG (65h)

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

**Table 36. INT\_THS\_L\_REG register**

|     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|
| TH7 | TH6 | TH5 | TH4 | TH3 | TH2 | TH1 | TH0 |
|-----|-----|-----|-----|-----|-----|-----|-----|

**Table 37. INT\_THS\_L\_REG register description**

|         |                                    |
|---------|------------------------------------|
| TH[7:0] | Threshold value for the interrupt. |
|---------|------------------------------------|

## 8.11 INT\_THS\_H\_REG (66h)

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

**Table 38. INT\_THS\_H\_REG register**

|      |      |      |      |      |      |     |     |
|------|------|------|------|------|------|-----|-----|
| TH15 | TH14 | TH13 | TH12 | TH11 | TH10 | TH9 | TH8 |
|------|------|------|------|------|------|-----|-----|

**Table 39. INT\_THS\_H\_REG register description**

|          |                                    |
|----------|------------------------------------|
| TH[15:8] | Threshold value for the interrupt. |
|----------|------------------------------------|

These registers set the threshold value for the output to generate the interrupt (INT bit in [INT\\_SOURCE\\_REG \(64h\)](#)). 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.

## 8.12 STATUS\_REG (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 40. STATUS\_REG register**

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

**Table 41. STATUS\_REG register description**

|       |   |
|-------|---|
| Zyxor | X-, Y- and Z-axis data overrun. Default value: 0<br>(0: no overrun has occurred; 1: a new set of data has overwritten the previous set).      |
| zor   | Z-axis data overrun. Default value: 0<br>(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<br>(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<br>(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<br>(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<br>(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<br>(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<br>(0: a new data for the X-axis is not yet available; 1: a new data for the X-axis is available) |

## 8.13 OUTX\_L\_REG, OUTX\_H\_REG (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 42. OUTX\_L\_REG register**

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|

**Table 43. OUTX\_H\_REG 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.

## 8.14 OUTY\_L\_REG, OUTY\_H\_REG (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 44. OUTY\_L\_REG register**

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|

**Table 45. OUTY\_H\_REG 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.

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

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

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

**Table 46. OUTZ\_L\_REG register**

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|

**Table 47. OUTZ\_H\_REG 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.

## 8.16 TEMP\_OUT\_L\_REG (6Eh), TEMP\_OUT\_H\_REG (6Fh)

Temperature sensor data.

These registers contain temperature values from the internal temperature sensor. The output value is expressed as a signed 16-bit byte in 2's complement. The four most significant bits contain a copy of the sign bit.

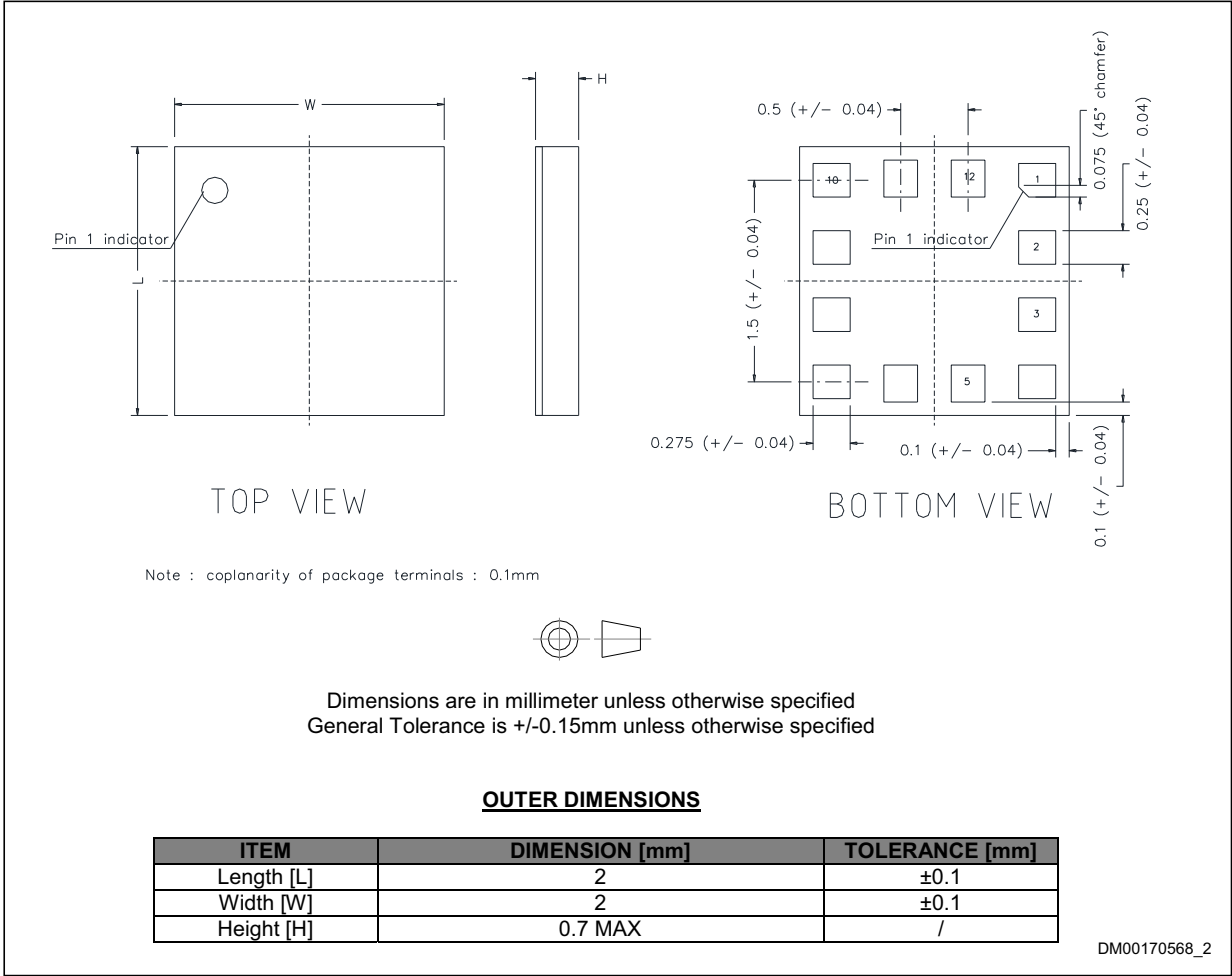
The nominal sensitivity is 8 LSB/°C.

# 9 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.

## 9.1 LGA-12 package information

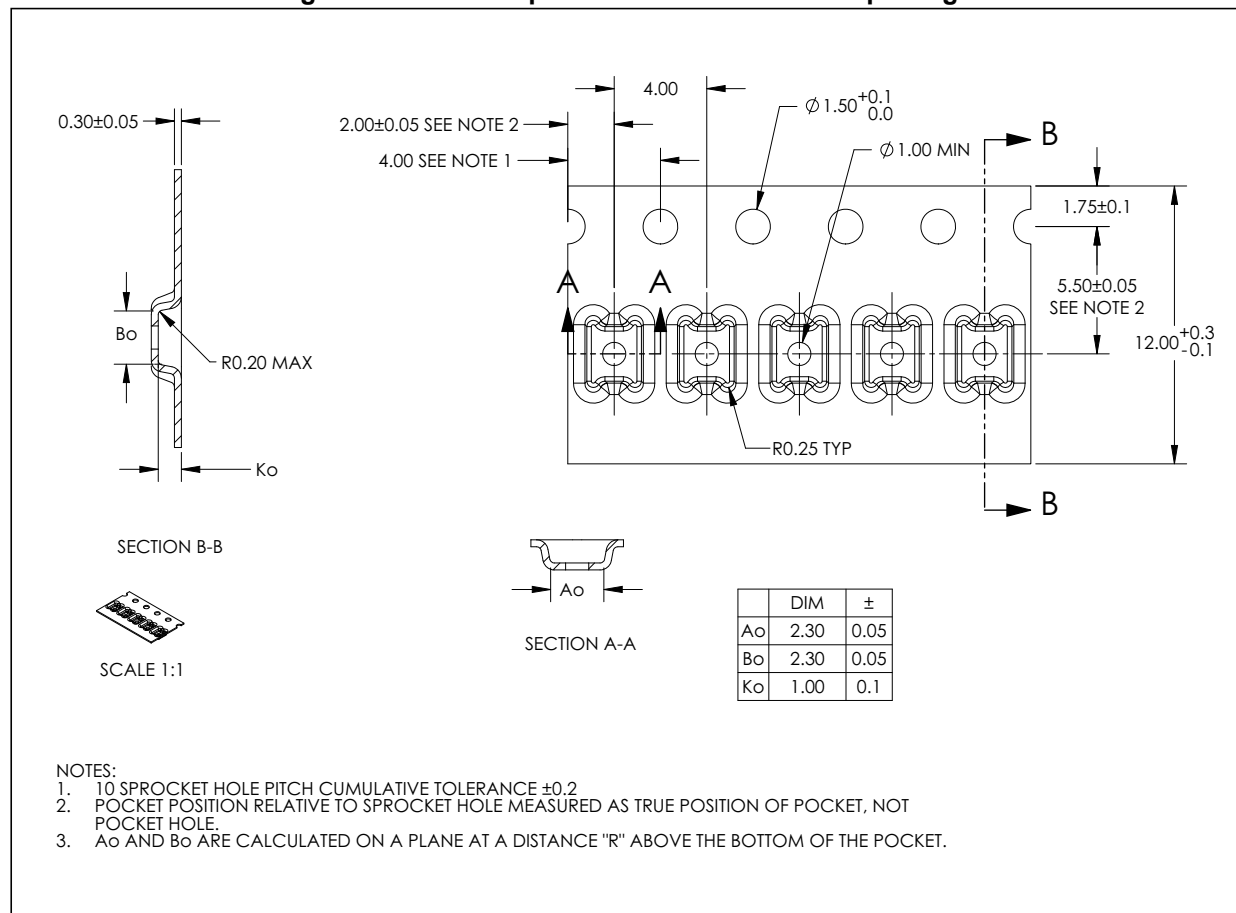
Figure 11. LGA-12 2.0 x 2.0 x 0.7 mm package outline and mechanical data





## 9.2 LGA-12 packing information

### Figure 12. Carrier tape information for LGA-12 package



**Figure 13. LGA-12 package orientation in carrier tape**

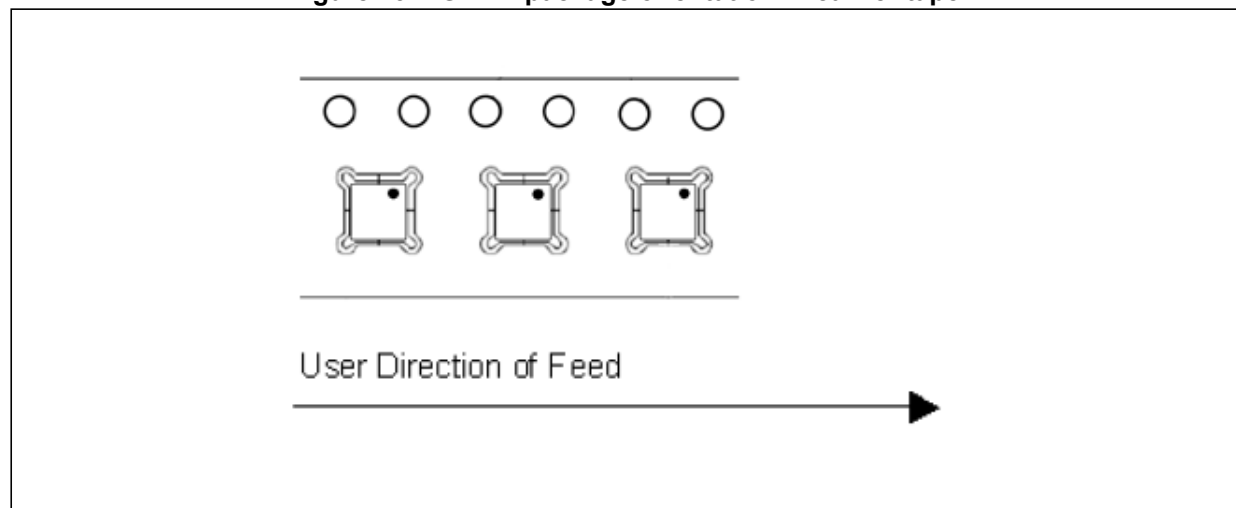


Figure 14. Reel information for carrier tape of LGA-12 package

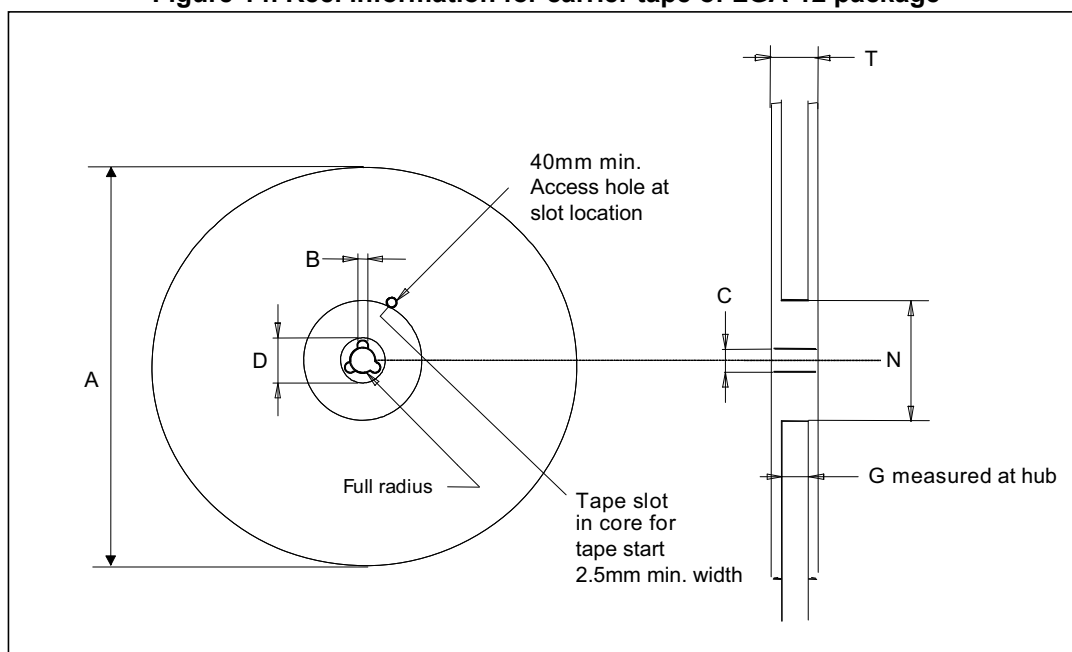


Table 48. Reel dimensions for carrier tape of LGA-12 package

| 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       |

## 10 Revision history

**Table 49. Document revision history**

| <b>Date</b> | <b>Revision</b> | <b>Changes</b>  |
|-------------|-----------------|---|
| 11-May-2017 | 1               | Initial release   |
| 18-Jul-2017 | 2               | Document status promoted to "Datasheet - production data" |

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