



## LIS3DH

### MEMS digital output motion sensor ultra low-power high performance 3-axes “nano” accelerometer

#### Features

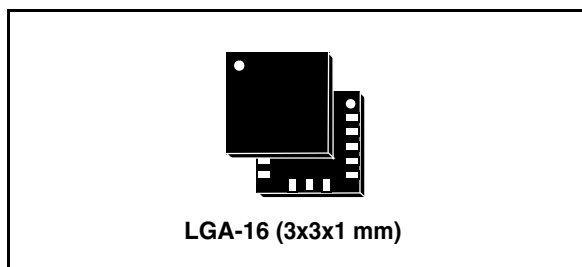
- Wide supply voltage, 1.71 V to 3.6 V
- Independent IOs supply (1.8 V) and supply voltage compatible
- Ultra low-power mode consumption down to 2  $\mu$ A
- $\pm 2g/\pm 4g/\pm 8g/\pm 16g$  dynamically selectable full-scale
- I<sup>2</sup>C/SPI digital output interface
- 16 bit data output
- 2 independent programmable interrupt generators for free-fall and motion detection
- 6D/4D orientation detection
- Free-fall detection
- Motion detection
- Embedded temperature sensor
- Embedded self-test
- Embedded 96 levels of 16 bit data output FIFO
- 10000 g high shock survivability
- ECOPACK<sup>®</sup> RoHS and “Green” compliant

#### Applications

- Motion activated functions
- Free-fall detection
- Click/double click recognition
- Intelligent power saving for handheld devices
- Pedometer
- Display orientation
- Gaming and virtual reality input devices
- Impact recognition and logging
- Vibration monitoring and compensation

#### Description

The LIS3DH is an ultra low-power high performance three axes linear accelerometer



belonging to the “nano” family, with digital I<sup>2</sup>C/SPI serial interface standard output. The device features ultra low-power operational modes that allow advanced power saving and smart embedded functions.

The LIS3DH has dynamically user selectable full scales of  $\pm 2g/\pm 4g/\pm 8g/\pm 16g$  and it is capable of measuring accelerations with output data rates from 1 Hz to 5 kHz. The self-test capability allows the user to check the functioning of the sensor in the final application. The device may be configured to generate interrupt signals by two independent inertial wake-up/free-fall events as well as by the position of the device itself. Thresholds and timing of interrupt generators are programmable by the end user on the fly. The LIS3DH has an integrated 32-level first in, first out (FIFO) buffer allowing the user to store data for host processor intervention reduction. The LIS3DH is available in small thin plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

**Table 1. Device summary**

| Order codes | Temp. range [°C] | Package | Packaging     |
|-------------|------------------|---------|---------------|
| LIS3DH      | -40 to +85       | LGA-16  | Tray          |
| LIS3DHTR    | -40 to +85       | LGA-16  | Tape and reel |

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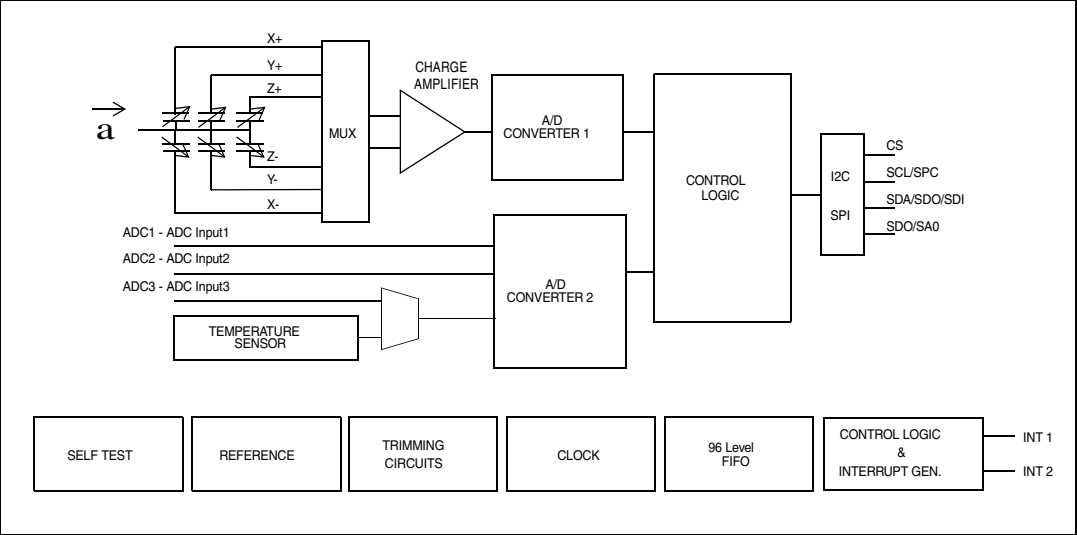
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# 1 Block diagram and pin description

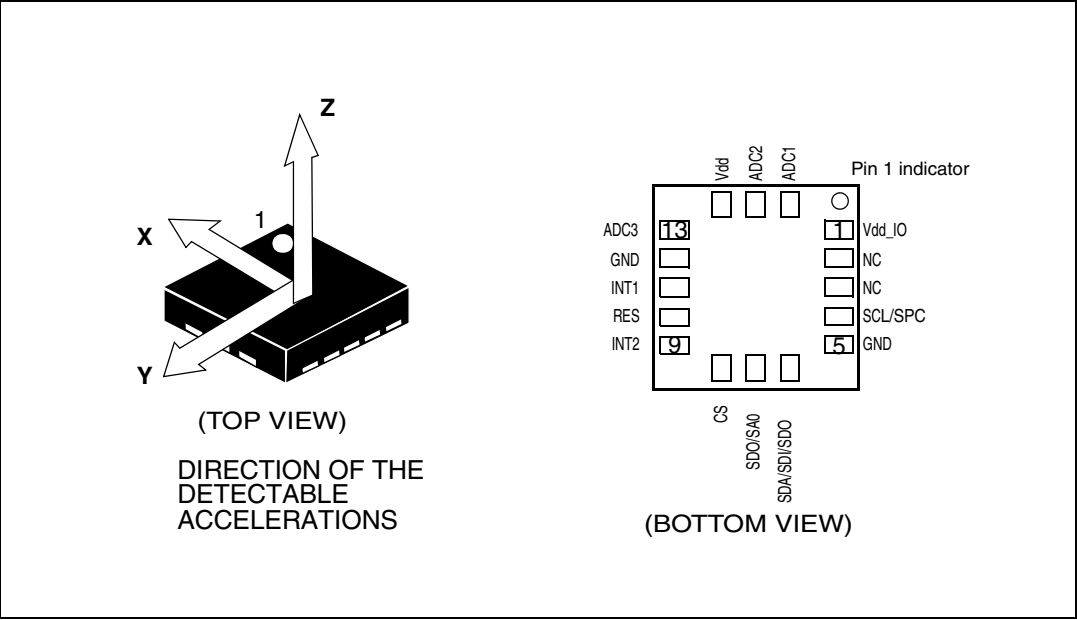
## 1.1 Block diagram

Figure 1. Block diagram



## 1.2 Pin description

Figure 2. Pin connection



**Table 2. Pin description**

| Pin# | Name              | Function                                                                                                       |
|------|-------------------|----------------------------------------------------------------------------------------------------------------|
| 1    | Vdd_IO            | Power supply for I/O pins                                                                                      |
| 2    | NC                | Not connected                                                                                                  |
| 3    | NC                | Not connected                                                                                                  |
| 4    | SCL<br>SPC        | I <sup>2</sup> C serial clock (SCL)<br>SPI serial port clock (SPC)                                             |
| 5    | GND               | 0V supply                                                                                                      |
| 6    | 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) |
| 7    | SDO<br>SA0        | SPI serial data output (SDO)<br>I <sup>2</sup> C less significant bit of the device address (SA0)              |
| 8    | CS                | SPI enable<br>I <sup>2</sup> C/SPI mode selection (1: I <sup>2</sup> C mode; 0: SPI enabled)                   |
| 9    | INT2              | Inertial interrupt 2                                                                                           |
| 10   | RES               | Connect to GND                                                                                                 |
| 11   | INT1              | Inertial interrupt 1                                                                                           |
| 12   | GND               | 0 V supply                                                                                                     |
| 13   | ADC3              | Analog to digital converter input 3                                                                            |
| 14   | Vdd               | Power supply                                                                                                   |
| 15   | ADC2              | Analog to digital converter input 2                                                                            |
| 16   | ADC1              | Analog to digital converter input 1                                                                            |

## 2 Mechanical and electrical specifications

### 2.1 Mechanical characteristics

Vdd = 2.5 V, T = 25 °C unless otherwise noted <sup>(a)</sup>

**Table 3. Mechanical characteristics**

| Symbol | Parameter                                               | Test conditions                                                        | Min. | Typ. <sup>(1)</sup> | Max. | Unit        |
|--------|---------------------------------------------------------|------------------------------------------------------------------------|------|---------------------|------|-------------|
| FS     | Measurement range <sup>(2)</sup>                        | FS bit set to 00                                                       |      | ±2.0                |      |             |
|        |                                                         | FS bit set to 01                                                       |      | ±4.0                |      |             |
|        |                                                         | FS bit set to 10                                                       |      | ±8.0                |      |             |
|        |                                                         | FS bit set to 11                                                       |      | ±16.0               |      | g           |
| So     | Sensitivity                                             | FS bit set to 00                                                       |      | 1                   |      | mg/digit    |
|        |                                                         | FS bit set to 01                                                       |      | 2                   |      | mg/digit    |
|        |                                                         | FS bit set to 10                                                       |      | 4                   |      | mg/digit    |
|        |                                                         | FS bit set to 11                                                       |      | 12                  |      | mg/digit    |
| TCSO   | Sensitivity change vs temperature                       | FS bit set to 00                                                       |      | 0.01                |      | %/°C        |
| TyOff  | Typical zero-g level offset accuracy <sup>(3),(4)</sup> | FS bit set to 00                                                       |      | ±40                 |      | mg          |
| TCOff  | Zero-g level change vs temperature                      | Max delta from 25 °C                                                   |      | ±0.5                |      | mg/°C       |
| An     | Acceleration noise density                              | FS bit set to 00, Normal Mode ( <a href="#">Table 9</a> ), ODR = 100Hz |      | 220                 |      | ug/sqrt(Hz) |
| Vst    | Self-test output change <sup>(5),(6),(7)</sup>          | FS bit set to 00<br>X axis                                             |      | 276                 |      | LSb         |
|        |                                                         | FS bit set to 00<br>Y axis                                             |      | 276                 |      | LSb         |
|        |                                                         | FS bit set to 00<br>Z axis                                             |      | 984                 |      | LSb         |
| Top    | Operating temperature range                             |                                                                        | -40  |                     | +85  | °C          |

1. Typical specifications are not guaranteed.
2. Verified by wafer level test and measurement of initial offset and sensitivity.
3. Typical zero-g level offset value after MSL3 preconditioning.
4. Offset can be eliminated by enabling the built-in high pass filter.
5. The sign of "Self-test output change" is defined by CTRL\_REG4 STsign bit, for all axes.
6. Self-test output changes with the power supply. "Self-test output change" is defined as  $OUTPUT[LSb]_{(CTRL\_REG4\ ST\ bit=1)} - OUTPUT[LSb]_{(CTRL\_REG4\ ST\ bit=0)}$ . 1LSb=1mg, ±2 g Full-scale.
7. Output data reach 99% of final value after 1 ms when enabling self-test mode, due to device filtering.

a. The product is factory calibrated at 2.5 V. The operational power supply range is from 1.71V 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 condition | Min. | Typ. <sup>(1)</sup> | Max. | Unit                    |
|--------|-------------------------------------------------|----------------|------|---------------------|------|-------------------------|
| TSDr   | Temperature sensor output change vs temperature |                |      | 1                   |      | digit/°C <sup>(2)</sup> |
| TODR   | Temperature refresh rate                        |                |      | ODR                 |      | Hz                      |
| Top    | Operating temperature range                     |                | -40  |                     | +85  | °C                      |

1. Typical specifications are not guaranteed.

2. 8-bit resolution.

## 2.3 Electrical characteristics

Vdd = 2.5 V, T = 25 °C unless otherwise noted <sup>(c)</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 | I/O pins supply voltage <sup>(2)</sup> |                 | 1.71       |                     | Vdd+0.1    | V    |
| Idd    | Current consumption in normal mode     | 50 Hz ODR       |            | 11                  |            | µA   |
| Idd    | Current consumption in normal mode     | 1 Hz ODR        |            | 2                   |            | µA   |
| IddLP  | Current consumption in low-power mode  | 50 Hz ODR       |            | 6                   |            | µA   |
| IddPdn | Current consumption in power-down mode |                 |            | 0.5                 |            | 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              |                 | 0.9*Vdd_IO |                     |            | V    |
| VOL    | Low level output voltage               |                 |            |                     | 0.1*Vdd_IO | V    |
| BW     | System bandwidth <sup>(3)</sup>        |                 |            | ODR/2               |            | Hz   |
| Ton    | Turn-on time <sup>(4)</sup>            | ODR = 100 Hz    |            | 1                   |            | ms   |
| Top    | Operating temperature range            |                 | -40        |                     | +85        | °C   |

1. Typical specification are not guaranteed.

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

3. Referred to [Table 25](#) for the ODR value and configuration.

4. Time to obtain valid data after exiting power-down mode.

b. The product is factory calibrated at 2.5 V.

c. 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

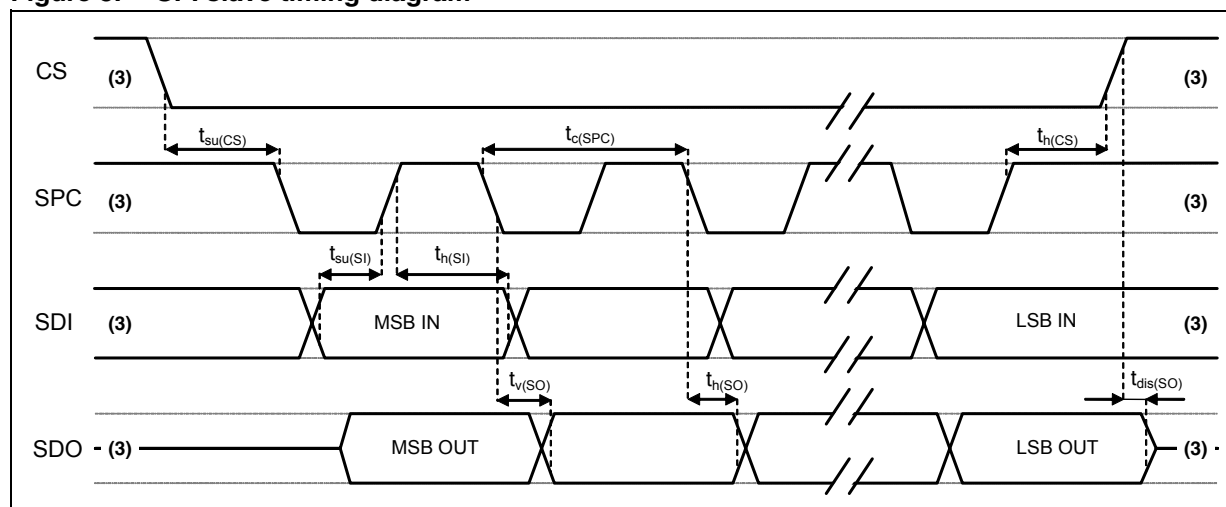
### 2.4.1 SPI - serial peripheral interface

Subject to general operating conditions for Vdd and Top.

**Table 6. SPI slave timing values**

| Symbol   | Parameter               | Value <sup>(1)</sup> |     | Unit |
|----------|-------------------------|----------------------|-----|------|
|          |                         | Min                  | Max |      |
| tc(SPC)  | SPI clock cycle         | 100                  |     | ns   |
| fc(SPC)  | SPI clock frequency     |                      | 10  | MHz  |
| tsu(CS)  | CS setup time           | 6                    |     | ns   |
| th(CS)   | CS hold time            | 8                    |     |      |
| tsu(SI)  | SDI input setup time    | 5                    |     |      |
| th(SI)   | SDI input hold time     | 15                   |     |      |
| tv(SO)   | SDO valid output time   |                      | 50  |      |
| th(SO)   | SDO output hold time    | 9                    |     |      |
| tdis(SO) | SDO output disable time |                      | 50  |      |

**Figure 3. SPI slave timing diagram**



- Note:
- 1 Values are guaranteed at 10 MHz clock frequency for SPI with both 4 and 3 wires, based on characterization results, not tested in production.
  - 2 Measurement points are done at  $0.2 \cdot V_{dd\_IO}$  and  $0.8 \cdot V_{dd\_IO}$ , for both Input and output port.
  - 3 When no communication is on-going, data on CS, SPC, SDI and SDO are driven by internal pull-up resistors.

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

Subject to general operating conditions for Vdd and top.

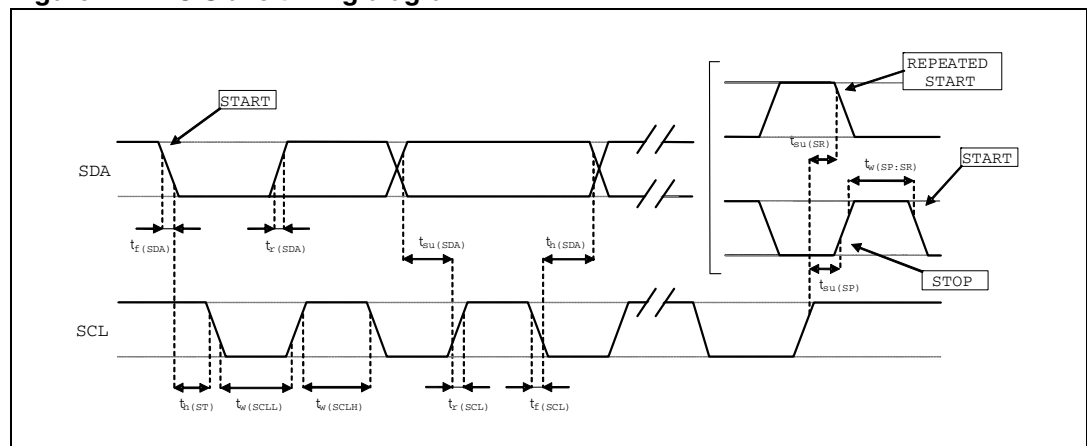
**Table 7. I<sup>2</sup>C slave timing values**

| 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 |         |
| $f_{(SCL)}$             | SCL clock frequency                            | 0                                             | 100  | 0                                         | 400 | kHz     |
| $t_{w(SCLL)}$           | SCL clock low time                             | 4.7                                           |      | 1.3                                       |     | $\mu$ s |
| $t_{w(SCLH)}$           | SCL clock high time                            | 4.0                                           |      | 0.6                                       |     |         |
| $t_{su(SDA)}$           | SDA setup time                                 | 250                                           |      | 100                                       |     | ns      |
| $t_{h(SDA)}$            | SDA data hold time                             | 0.01                                          | 3.45 | 0.01                                      | 0.9 | $\mu$ s |
| $t_{r(SDA)} t_{r(SCL)}$ | SDA and SCL rise time                          |                                               | 1000 | $20 + 0.1C_b^{(2)}$                       | 300 | ns      |
| $t_{f(SDA)} t_{f(SCL)}$ | SDA and SCL fall time                          |                                               | 300  | $20 + 0.1C_b^{(2)}$                       | 300 |         |
| $t_{h(ST)}$             | START condition hold time                      | 4                                             |      | 0.6                                       |     | $\mu$ s |
| $t_{su(SR)}$            | Repeated START condition setup time            | 4.7                                           |      | 0.6                                       |     |         |
| $t_{su(SP)}$            | STOP condition setup time                      | 4                                             |      | 0.6                                       |     |         |
| $t_{w(SP:SR)}$          | 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.

2.  $C_b$  = total capacitance of one bus line, in pF.

**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 port.

## 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 8. 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, SDO/SA0) | -0.3 to V <sub>dd_IO</sub> +0.3 | V    |
| A <sub>POW</sub>   | Acceleration (any axis, powered, V <sub>dd</sub> = 2.5 V)               | 3000 for 0.5 ms                 | g    |
|                    |                                                                         | 10000 for 0.1 ms                | g    |
| A <sub>UNP</sub>   | Acceleration (any axis, unpowered)                                      | 3000 for 0.5 ms                 | g    |
|                    |                                                                         | 10000 for 0.1 ms                | g    |
| T <sub>OP</sub>    | Operating temperature range                                             | -40 to +85                      | °C   |
| T <sub>STG</sub>   | Storage temperature range                                               | -40 to +125                     | °C   |
| ESD                | Electrostatic discharge protection                                      | 2 (HBM)                         | kV   |

*Note:* Supply voltage on any pin should never exceed 4.8 V



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



This is an ESD sensitive device, improper handling can cause permanent damages to the part.

## 3 Terminology and functionality

### 3.1 Terminology

#### 3.1.1 Sensitivity

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

#### 3.1.2 Zero-*g* level

Zero-*g* level offset (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 measure 0 *g* in X axis and 0 *g* in Y axis whereas the Z axis 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 2's complement number). A deviation from 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 over temperature, see "Zero-*g* level change vs. temperature". The Zero-*g* level tolerance (TyOff) describes the standard deviation of the range of Zero-*g* levels of a population of sensors.

### 3.2 Functionality

#### 3.2.1 Normal mode, low power mode

LIS3DH provides two different operating modes respectively reported as *normal mode* and *low power mode*. While normal mode guarantees high resolution, low power mode reduces further the current consumption.

The table below reported summarizes how to select the operating mode.

**Table 9. Operating mode selection**

| CTRL_REG1[3]<br>(LPen bit) | CTRL_REG4[3]<br>(HR bit) | Operating mode |
|----------------------------|--------------------------|----------------|
| 1                          | 0                        | Low power mode |
| 0                          | 1                        | Normal mode    |

### 3.2.2 Self-test

Self-test allows to check the sensor functionality without moving it. The self-test function is off when the self-test bit (ST) is programmed to '0'. When the self-test bit is programmed to '1' an actuation force is applied to the sensor, simulating a definite input acceleration. In this case the sensor outputs exhibit a change in their DC levels which are related to the selected full scale through the device sensitivity. When 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.

### 3.2.3 6D / 4D orientation detection

The LIS3DH include 6D / 4D orientation detection.

**6D / 4D orientation recognition:** In this configuration the interrupt is generated when the device is stable in a known direction. In 4D configuration Z axis position detection is disable.

## 3.3 Sensing element

A proprietary process is used to create a surface micro-machined accelerometer. The technology allows carrying out suspended silicon structures which are attached to the substrate in a few points called anchors and are free to move in the direction of the sensed acceleration. To be compatible with the traditional packaging techniques a cap is placed on top of the sensing element to avoid blocking the moving parts during the moulding phase of the plastic encapsulation.

When an acceleration is applied to the sensor the proof mass displaces from its nominal position, causing an imbalance in the capacitive half-bridge. This imbalance is measured using charge integration in response to a voltage pulse applied to the capacitor.

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

## 3.4 IC interface

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

The acceleration 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 LIS3DH features a Data-Ready signal (RDY) which indicates when a new set of measured acceleration data is available thus simplifying data synchronization in the digital system that uses the device.

The LIS3DH may also be configured to generate an inertial Wake-Up and Free-Fall interrupt signal accordingly to a programmed acceleration event along the enabled axes. Both Free-Fall and Wake-Up can be available simultaneously on two different pins.

### 3.5 **Factory calibration**

The IC interface is factory calibrated for sensitivity (So) and Zero-g level (TyOff).

The trimming values are stored inside the device in a non volatile memory. Any time the device is turned on, the trimming parameters are downloaded into the registers to be used during the active operation. This allows to use the device without further calibration.

### 3.6 **FIFO**

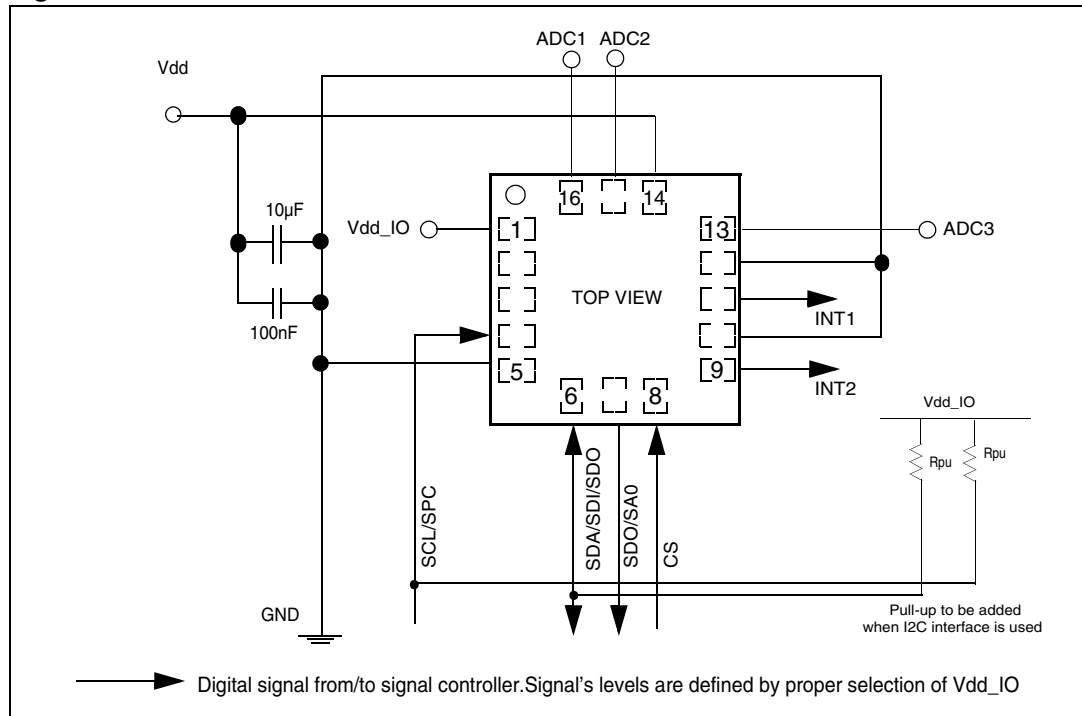
The LIS3DH contains a 10 bit, 32-level FIFO. Buffered output allows 4 operation modes: FIFO, stream, trigger and FIFO ByPass. Where FIFO bypass mode is activated FIFO is not operating and remains empty. In FIFO mode, data from acceleration detection on x, y, and z-axes measurements are stored in FIFO.

### 3.7 **Auxiliary ADC**

The LIS3DH contains an auxiliary 10 bit ADC with 3 separate dedicated inputs.

## 4 Application hints

**Figure 5. LIS3DH electrical connection**



The device core is supplied through Vdd line while the I/O pads are supplied through Vdd\_IO line. Power supply decoupling capacitors (100 nF ceramic, 10 µF aluminum) should be placed as near as possible to the pin 14 of the device (common design practice).

All the voltage and ground supplies must be present at the same time to have proper behavior of the IC (refer to [Figure 5](#)). It is possible to remove Vdd maintaining Vdd\_IO without blocking the communication bus, in this condition the measurement chain is powered off.

The functionality of the device and the measured acceleration data is 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.

The ADC1, ADC2 & ADC3 if not used can be left floating or keep connected to Vdd or GND.

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

### 4.1 Soldering information

The LGA package is compliant with the ECOPACK<sup>®</sup>, RoHS and “Green” standard. 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 Digital main blocks

### 5.1 FIFO

LIS3DH embeds a 32-slot of 10bit data FIFO for each of the three output channels, X, Y and Z. This allows a consistent power saving for the system, since the host processor does not need to continuously poll data from the sensor, but it can wakeup only when needed and burst the significant data out from the FIFO. This buffer can work accordingly to four different modes: Bypass mode, FIFO mode, Stream mode and Stream-to-FIFO mode. Each mode is selected by the FIFO\_MODE bits into the FIFO\_CTRL\_REG (2E). Programmable Watermark level, FIFO\_empty or FIFO\_Full events can be enabled to generate dedicated interrupts on INT1/2 pin (configuration through FIFO\_CFG\_REG).

#### 5.1.1 Bypass mode

In Bypass mode, the FIFO is not operational and for this reason it remains empty. As described in the next figure, for each channel only the first address is used. The remaining FIFO slots are empty.

#### 5.1.2 FIFO mode

In FIFO mode, data from X, Y and Z channels are stored into the FIFO. A watermark interrupt can be enabled (FIFO\_WTMK\_EN bit into FIFO\_CTRL\_REG in order to be raised when the FIFO is filled to the level specified into the FIFO\_WTMK\_LEVEL bits of FIFO\_CTRL\_REG. The FIFO continues filling until it is full (32 slots of 10data for X, Y and Z). When full, the FIFO stops collecting data from the input channels.

#### 5.1.3 Stream mode

In the stream mode, data from X, Y and Z measurement are stored into the FIFO. A watermark interrupt can be enabled and set as in the FIFO mode. The FIFO continues filling until it's full (32 slots of 10data for X, Y and Z). When full, the FIFO discards the older data as the new arrive.

#### 5.1.4 Stream-to-FIFO mode

In Stream-to\_FIFO mode, data from X, Y and Z measurement are stored into the FIFO. A watermark interrupt can be enabled (FIFO\_WTMK\_EN bit into FIFO\_CTRL\_REG) in order to be raised when the FIFO is filled to the level specified into the FIFO\_WTMK\_LEVEL bits of FIFO\_CTRL\_REG. The FIFO continues filling until it's full (32 slots of 10 data for X, Y and Z). When full, the FIFO discards the older data as the new arrive. Once trigger event occurs, the FIFO starts operating in FIFO mode.

#### 5.1.5 Retrieve data from FIFO

FIFO data is read through OUT\_X (Addr reg 28h,29h), OUT\_Y (Addr reg 2Ah,2Bh) and OUT\_Z (Addr reg 2Ch,2Dh). When the FIFO is in stream, Trigger or FIFO mode, a read operation to the OUT\_X, OUT\_Y or OUT\_Z registers provides the data stored into the FIFO. Each time data is read from the FIFO, the oldest X, Y and Z data are placed into the OUT\_X, OUT\_Y and OUT\_Z registers and both single read and read\_burst operations can be used.

## 6 Digital interfaces

The registers embedded inside the LIS3DH may be accessed through both the I<sup>2</sup>C and SPI serial interfaces. The latter may be SW configured to operate either in 3-wire or 4-wire interface mode.

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

**Table 10. Serial interface pin description**

| Pin name          | Pin description                                                                                                |
|-------------------|----------------------------------------------------------------------------------------------------------------|
| CS                | SPI enable<br>I <sup>2</sup> C/SPI mode selection (1: I <sup>2</sup> C mode; 0: SPI enabled)                   |
| 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) |
| SA0<br>SDO        | I <sup>2</sup> C less significant bit of the device address (SA0)<br>SPI serial data output (SDO)              |

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

The LIS3DH I<sup>2</sup>C is a bus slave. The I<sup>2</sup>C is employed to write data into registers whose content can also be read back.

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

**Table 11. Serial interface pin description**

| 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 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.

The Slave Address (SAD) associated to the LIS3DH is 001100xb. **SDO/SA0** pad can be used to modify less significant bit of the device address. If SA0 pad is connected to voltage supply, LSb is '1' (address 0011001b) else if SA0 pad is connected to ground, LSb value is '0' (address 0011000b). This solution permits to connect and address two different accelerometers to the same I<sup>2</sup>C lines.

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

The I<sup>2</sup>C embedded inside the LIS3DH 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, a 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/write.

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 transmit to the slave with direction unchanged. [Table 12](#) explains how the SAD+Read/Write bit pattern is composed, listing all the possible configurations.

**Table 12. SAD+Read/Write patterns**

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

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

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

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

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

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

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

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

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

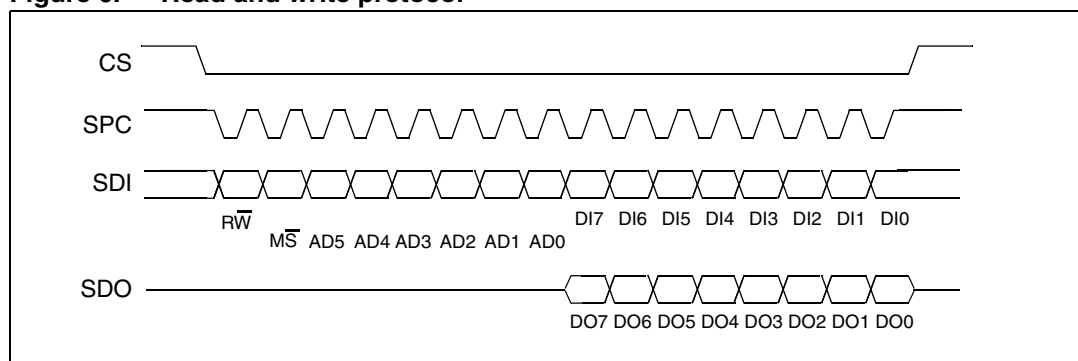
Data are transmitted in byte format (DATA). Each data transfer contains 8 bits. The number of bytes transferred per transfer is unlimited. Data is transferred with the Most Significant bit (MSb) first. If a receiver can't receive another complete byte of data until it has performed some other function, 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 order to read multiple bytes, it is necessary to assert the most significant bit of the sub-address field. In other words, SUB(7) must be equal to 1 while SUB(6-0) represents the address of first register to be read.

In the presented communication format MAK is Master acknowledge and NMAK is No Master Acknowledge.

## 6.2 SPI bus interface

The LIS3DH SPI is a bus slave. The SPI allows to write and read the registers of the device. The Serial Interface interacts with the outside world with 4 wires: **CS**, **SPC**, **SDI** and **SDO**.

**Figure 6. 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 multiple of 8 in case of multiple bytes read/write. Bit duration is the time between two falling edges of **SPC**. The first bit (bit 0) starts at the first falling edge of **SPC** after the falling edge of **CS** while the last bit (bit 15, bit 23, ...) starts at the last falling edge of **SPC** just before the rising edge of **CS**.

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

**bit 1:**  $\overline{MS}$  bit. When 0, the address remains unchanged in multiple read/write commands. When 1, the address is auto incremented in multiple read/write commands.

**bit 2-7:** address  $AD(5:0)$ . 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).

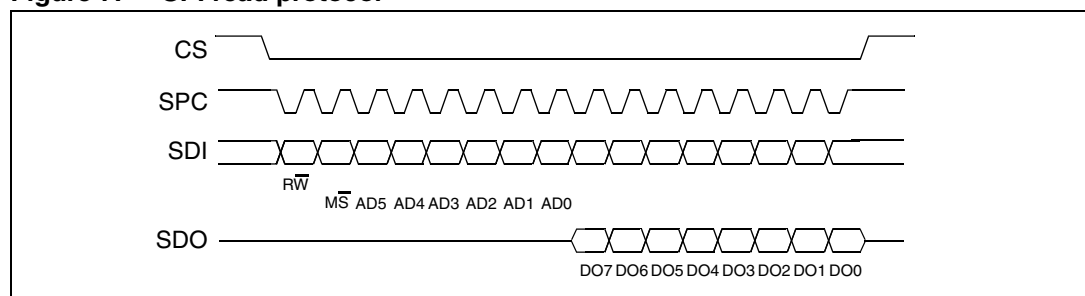
**bit 8-15:** data  $DO(7:0)$  (read mode). This is the data that is read from the device (MSb first).

In multiple read/write commands further blocks of 8 clock periods is added. When  $\overline{MS}$  bit is '0' the address used to read/write data remains the same for every block. When  $\overline{MS}$  bit is '1' the address used to read/write data is increased at every block.

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

### 6.2.1 SPI read

Figure 7. SPI read protocol



The SPI Read command is performed with 16 clock pulses. Multiple byte read command is performed adding blocks of 8 clock pulses at the previous one.

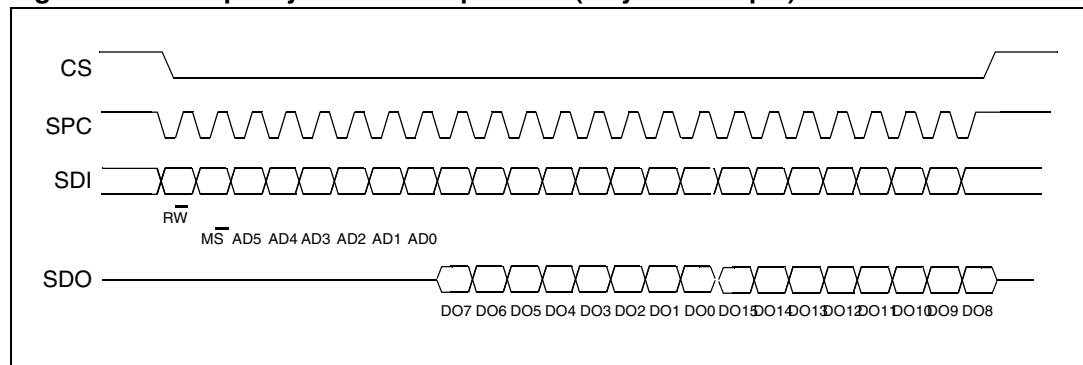
**bit 0:** READ bit. The value is 1.

**bit 1:**  $\overline{MS}$  bit. When 0 do not increment address, when 1 increment address in multiple reading.

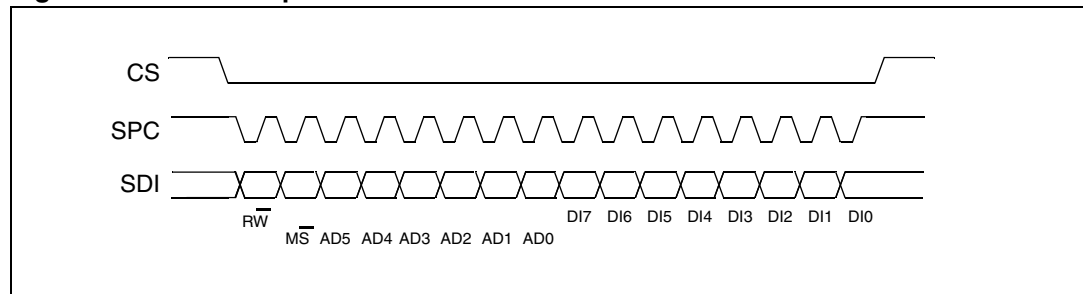
**bit 2-7:** address  $AD(5:0)$ . This is the address field of the indexed register.

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

**bit 16-...** : data  $DO(...-8)$ . Further data in multiple byte reading.

**Figure 8. Multiple bytes SPI read protocol (2 bytes example)**

### 6.2.2 SPI write

**Figure 9. SPI write protocol**

The SPI Write command is performed with 16 clock pulses. Multiple byte write command is performed adding blocks of 8 clock pulses at the previous one.

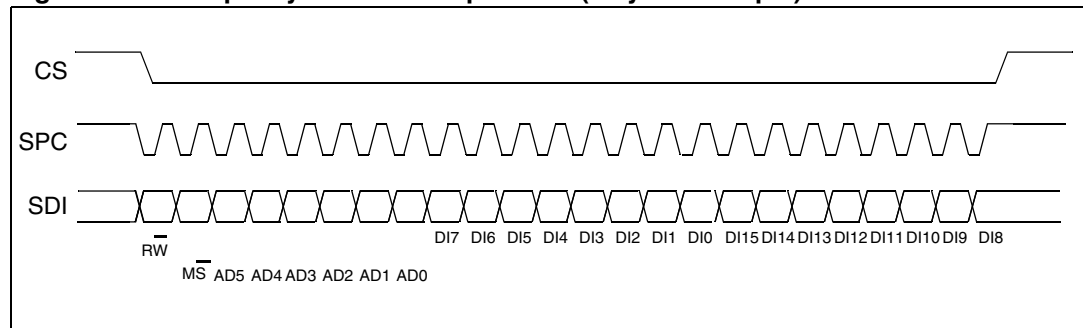
**bit 0:** WRITE bit. The value is 0.

**bit 1:**  $\overline{MS}$  bit. When 0 do not increment address, when 1 increment address in multiple writing.

**bit 2 -7:** address AD(5:0). 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).

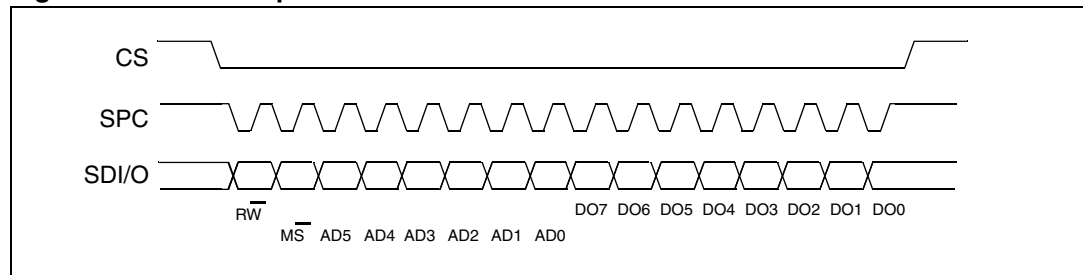
**bit 16-...** : data DI(...-8). Further data in multiple byte writing.

**Figure 10. Multiple bytes SPI write protocol (2 bytes example)**

### 6.2.3 SPI read in 3-wires mode

3-wires mode is entered by setting to '1' bit SIM (SPI serial interface mode selection) in CTRL\_REG4.

**Figure 11. SPI read protocol in 3-wires mode**



The SPI read command is performed with 16 clock pulses:

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

**bit 1:**  $\overline{MS}$  bit. When 0 do not increment address, when 1 increment address in multiple reading.

**bit 2-7:** address AD(5:0). 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).

Multiple read command is also available in 3-wires mode.

## 7 Register mapping

The table given below provides a listing of the 8 bit registers embedded in the device and the related addresses:

**Table 17. Register address map**

| Name                     | Type | Register address |          | Default  | Comment        |
|--------------------------|------|------------------|----------|----------|----------------|
|                          |      | Hex              | Binary   |          |                |
| Reserved (do not modify) |      | 00 - 06          |          |          | Reserved       |
| STATUS_REG_AUX           | r    | 07               | 000 0111 |          |                |
| OUT_ADC1_L               | r    | 08               | 000 1000 | output   |                |
| OUT_ADC1_H               | r    | 09               | 000 1001 | output   |                |
| OUT_ADC2_L               | r    | 0A               | 000 1010 | output   |                |
| OUT_ADC2_H               | r    | 0B               | 000 1011 | output   |                |
| OUT_ADC3_L               | r    | 0C               | 000 1100 | output   |                |
| OUT_ADC3_H               | r    | 0D               | 000 1101 | output   |                |
| INT_COUNTER_REG          | r    | 0E               | 000 1110 |          |                |
| WHO_AM_I                 | r    | 0F               | 000 1111 | 00110011 | Dummy register |
| Reserved (do not modify) |      | 10 - 1E          |          |          | Reserved       |
| TEMP_CFG_REG             | rw   | 1F               | 001 1111 |          |                |
| CTRL_REG1                | rw   | 20               | 010 0000 | 00000111 |                |
| CTRL_REG2                | rw   | 21               | 010 0001 | 00000000 |                |
| CTRL_REG3                | rw   | 22               | 010 0010 | 00000000 |                |
| CTRL_REG4                | rw   | 23               | 010 0011 | 00000000 |                |
| CTRL_REG5                | rw   | 24               | 010 0100 | 00000000 |                |
| CTRL_REG6                | rw   | 25               | 010 0101 | 00000000 |                |
| REFERENCE                | rw   | 26               | 010 0110 | 00000000 |                |
| STATUS_REG2              | r    | 27               | 010 0111 | 00000000 |                |
| OUT_X_L                  | r    | 28               | 010 1000 | output   |                |
| OUT_X_H                  | r    | 29               | 010 1001 | output   |                |
| OUT_Y_L                  | r    | 2A               | 010 1010 | output   |                |
| OUT_Y_H                  | r    | 2B               | 010 1011 | output   |                |
| OUT_Z_L                  | r    | 2C               | 010 1100 | output   |                |
| OUT_Z_H                  | r    | 2D               | 010 1101 | output   |                |
| FIFO_CTRL_REG            | rw   | 2E               | 010 1110 | 00000000 |                |
| FIFO_SRC_REG             | r    | 2F               | 010 1111 |          |                |
| INT1_CFG                 | rw   | 30               | 011 0000 | 00000000 |                |

Table 17. Register address map

| Name          | Type | Register address |          | Default  | Comment |
|---------------|------|------------------|----------|----------|---------|
|               |      | Hex              | Binary   |          |         |
| INT1_SOURCE   | r    | 31               | 011 0001 | 00000000 |         |
| INT1_THS      | rw   | 32               | 011 0010 | 00000000 |         |
| INT1_DURATION | rw   | 33               | 011 0011 | 00000000 |         |
| Reserved      | rw   | 34-37            |          | 00000000 |         |
| CLICK_CFG     | rw   | 38               | 011 1000 | 00000000 |         |
| CLICK_SRC     | r    | 39               | 011 1001 | 00000000 |         |
| CLICK_THS     | rw   | 3A               | 011 1010 | 00000000 |         |
| TIME_LIMIT    | rw   | 3B               | 011 1011 | 00000000 |         |
| TIME_LATENCY  | rw   | 3C               | 011 1100 | 00000000 |         |
| TIME_WINDOW   | rw   | 3D               | 011 1101 | 00000000 |         |

Registers marked as *Reserved* must not be changed. The writing to those registers may cause permanent damages 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 Registers description

### 8.1 STATUS\_AUX (07h)

**Table 18. STATUS\_REG\_AUX register**

|       |     |     |     |       |     |     |     |
|-------|-----|-----|-----|-------|-----|-----|-----|
| 321OR | 3OR | 2OR | 1OR | 321DA | 3DA | 2DA | 1DA |
|-------|-----|-----|-----|-------|-----|-----|-----|

**Table 19. STATUS\_REG\_AUX description**

|       |                                                                                                                                                  |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 321OR | 1, 2 and 3 axis data overrun. Default value: 0<br>(0: no overrun has occurred; 1: a new set of data has overwritten the previous ones)           |
| 3OR   | 3 axis data overrun. Default value: 0<br>(0: no overrun has occurred;<br>1: a new data for the 3-axis has overwritten the previous one)          |
| 2OR   | 2 axis data overrun. Default value: 0<br>(0: no overrun has occurred;<br>1: a new data for the 4-axis has overwritten the previous one)          |
| 1OR   | 1 axis data overrun. Default value: 0<br>(0: no overrun has occurred;<br>1: a new data for the 1-axis has overwritten the previous one)          |
| 321DA | 1, 2 and 3 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)           |
| 3DA   | 3 axis new data available. Default value: 0<br>(0: a new data for the 3-axis is not yet available;<br>1: a new data for the 3-axis is available) |
| 2DA   | 2 axis new data available. Default value: 0<br>(0: a new data for the 2-axis is not yet available;<br>1: a new data for the 2-axis is available) |
| 1DA   | 1 axis new data available. Default value: 0<br>(0: a new data for the 1-axis is not yet available;<br>1: a new data for the 1-axis is available) |

### 8.2 OUT\_1\_L (08h), OUT\_1\_H (09h)

1-axis acceleration data. The value is expressed in two's complement.

### 8.3 OUT\_2\_L (0Ah), OUT\_2\_H (0Bh)

2-axis acceleration data. The value is expressed in two's complement.

### 8.4 OUT\_3\_L (0Ch), OUT\_3\_H (0Dh)

3-axis acceleration data. The value is expressed in two's complement.

## 8.5 INT\_COUNTER (0Eh)

**Table 20. INT\_COUNTER register**

|     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|
| IC7 | IC6 | IC5 | IC4 | IC3 | IC2 | IC1 | IC0 |
|-----|-----|-----|-----|-----|-----|-----|-----|

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

**Table 21. WHO\_AM\_I register**

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

Device identification register.

## 8.7 TEMP\_CFG\_REG (1Fh)

**Table 22. TEMP\_CFG\_REG register**

|        |         |   |   |   |   |   |   |
|--------|---------|---|---|---|---|---|---|
| ADC_PD | TEMP_EN | 0 | 0 | 0 | 0 | 0 | 0 |
|--------|---------|---|---|---|---|---|---|

**Table 23. TEMP\_CFG\_REG description**

|         |                                                                                  |
|---------|----------------------------------------------------------------------------------|
| ADC_PD  | ADC enable. Default value: 0<br>(0: ADC disabled; 1: ADC enabled)                |
| TEMP_EN | Temperature sensor (T) enable. Default value: 0<br>(0: T disabled; 1: T enabled) |

## 8.8 CTRL\_REG1 (20h)

**Table 24. CTRL\_REG1 register**

|      |      |      |      |      |     |     |     |
|------|------|------|------|------|-----|-----|-----|
| ODR3 | ODR2 | ODR1 | ODR0 | LPen | Zen | Yen | Xen |
|------|------|------|------|------|-----|-----|-----|

**Table 25. CTRL\_REG1 description**

|        |                                                                                                                               |
|--------|-------------------------------------------------------------------------------------------------------------------------------|
| ODR3-0 | Data rate selection. Default value: 00<br>(0000:50 Hz; Others: Refer to <a href="#">Table 25</a> , "Data rate configuration") |
| LPen   | Low power mode enable. Default value: 0<br>(0: normal mode, 1: low power mode)                                                |
| Zen    | Z axis enable. Default value: 1<br>(0: Z axis disabled; 1: Z axis enabled)                                                    |
| Yen    | Y axis enable. Default value: 1<br>(0: Y axis disabled; 1: Y axis enabled)                                                    |
| Xen    | X axis enable. Default value: 1<br>(0: X axis disabled; 1: X axis enabled)                                                    |

**ODR<3:0>** is used to set power mode and ODR selection. In the following table are reported all frequency resulting in combination of ODR<3:0>

**Table 26. Data rate configuration**

| ODR3 | ODR2 | ODR1 | ODR0 | Power mode selection                       |
|------|------|------|------|--------------------------------------------|
| 0    | 0    | 0    | 0    | Power down mode                            |
| 0    | 0    | 0    | 1    | Normal / low power mode (1 Hz)             |
| 0    | 0    | 1    | 0    | Normal / low power mode (10 Hz)            |
| 0    | 0    | 1    | 1    | Normal / low power mode (25 Hz)            |
| 0    | 1    | 0    | 0    | Normal / low power mode (50 Hz)            |
| 0    | 1    | 0    | 1    | Normal / low power mode (100 Hz)           |
| 0    | 1    | 1    | 0    | Normal / low power mode (200 Hz)           |
| 0    | 1    | 1    | 1    | Normal / low power mode (400 Hz)           |
| 1    | 0    | 0    | 0    | Low power mode (1.6 KHz)                   |
| 1    | 0    | 0    | 1    | Normal (1.25 kHz) / low power mode (5 KHz) |

## 8.9 CTRL\_REG2 (21h)

**Table 27. CTRL\_REG2 register**

| HPM1 | HPM0 | HPCF2 | HPCF1 | FDS | HPCLICK | HPIS2 | HPIS1 |
|------|------|-------|-------|-----|---------|-------|-------|
|------|------|-------|-------|-----|---------|-------|-------|

**Table 28. CTRL\_REG2 description**

|               |                                                                                                                                           |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| HPM1 -HPM0    | High pass filter mode selection. Default value: 00<br>Refer to Table 29, "High pass filter mode configuration"                            |
| HPCF2 - HPCF1 | High pass filter cut off frequency selection                                                                                              |
| FDS           | Filtered data selection. Default value: 0<br>(0: internal filter bypassed; 1: data from internal filter sent to output register and FIFO) |
| HPCLICK       | High pass filter enabled for CLICK function.<br>(0: filter bypassed; 1: filter enabled)                                                   |
| HPIS2         | High pass filter enabled for AOI function on interrupt 2,<br>(0: filter bypassed; 1: filter enabled)                                      |
| HPIS1         | High pass filter enabled for AOI function on interrupt 1,<br>(0: filter bypassed; 1: filter enabled)                                      |

**Table 29. High pass filter mode configuration**

| HPM1 | HPM0 | High pass filter mode                       |
|------|------|---------------------------------------------|
| 0    | 0    | Normal mode (reset reading HP_RESET_FILTER) |
| 0    | 1    | Reference signal for filtering              |
| 1    | 0    | Normal mode                                 |
| 1    | 1    | Autoreset on interrupt event                |

## 8.10 CTRL\_REG3 (22h)

**Table 30. CTRL\_REG3 register**

|          |         |         |          |          |        |            |    |
|----------|---------|---------|----------|----------|--------|------------|----|
| I1_CLICK | I1_AOI1 | I1_AOI2 | I1_DRDY1 | I1_DRDY2 | I1_WTM | I1_OVERRUN | -- |
|----------|---------|---------|----------|----------|--------|------------|----|

**Table 31. CTRL\_REG3 description**

|            |                                                                               |
|------------|-------------------------------------------------------------------------------|
| I1_CLICK   | CLICK interrupt on INT1. Default value 0.<br>(0: Disable; 1: Enable)          |
| I1_AOI1    | AOI1 interrupt on INT1. Default value 0.<br>(0: Disable; 1: Enable)           |
| I1_AOI2    | AOI2 interrupt on INT1. Default value 0.<br>(0: Disable; 1: Enable)           |
| I1_DRDY1   | DRDY1 interrupt on INT1. Default value 0.<br>(0: Disable; 1: Enable)          |
| I1_DRDY2   | DRDY2 interrupt on INT1. Default value 0.<br>(0: Disable; 1: Enable)          |
| I1_WTM     | FIFO Watermark interrupt on INT1. Default value 0.<br>(0: Disable; 1: Enable) |
| I1_OVERRUN | FIFO Overrun interrupt on INT1. Default value 0.<br>(0: Disable; 1: Enable)   |

## 8.11 CTRL\_REG4 (23h)

**Table 32. CTRL\_REG4 register**

|     |     |     |     |    |     |     |     |
|-----|-----|-----|-----|----|-----|-----|-----|
| BDU | BLE | FS1 | FS0 | HR | ST1 | ST0 | SIM |
|-----|-----|-----|-----|----|-----|-----|-----|

**Table 33. CTRL\_REG4 description**

|         |                                                                                                                          |
|---------|--------------------------------------------------------------------------------------------------------------------------|
| BDU     | Block data update. Default value: 0<br>(0: continuous update; 1: output registers not updated until MSB and LSB reading) |
| BLE     | Big/little endian data selection. Default value 0.<br>(0: Data LSB @ lower address; 1: Data MSB @ lower address)         |
| FS1-FS0 | Full scale selection. default value: 00<br>(00: +/- 2G; 01: +/- 4G; 10: +/- 8G; 11: +/- 16G)                             |

**Table 33. CTRL\_REG4 description (continued)**

|         |                                                                                                          |
|---------|----------------------------------------------------------------------------------------------------------|
| HR      | High resolution output mode: Default value: 0<br>(0: High resolution disable; 1: High resolution Enable) |
| ST1-ST0 | Self test enable. Default value: 00<br>(00: Self test disabled; Other: See <a href="#">Table 34</a> )    |
| SIM     | SPI serial interface mode selection. Default value: 0<br>(0: 4-wire interface; 1: 3-wire interface).     |

**Table 34. Self test mode configuration**

| ST1 | ST0 | Self test mode |
|-----|-----|----------------|
| 0   | 0   | Normal mode    |
| 0   | 1   | Self test 0    |
| 1   | 0   | Self test 1    |
| 1   | 1   | --             |

## 8.12 CTRL\_REG5 (24h)

**Table 35. CTRL\_REG5 register**

|      |         |    |    |          |          |   |   |
|------|---------|----|----|----------|----------|---|---|
| BOOT | FIFO_EN | -- | -- | LIR_INT1 | D4D_INT1 | 0 | 0 |
|------|---------|----|----|----------|----------|---|---|

**Table 36. CTRL\_REG5 description**

|          |                                                                                                                                                                                                |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BOOT     | Reboot memory content. Default value: 0<br>(0: normal mode; 1: reboot memory content)                                                                                                          |
| FIFO_EN  | FIFO enable. Default value: 0<br>(0: FIFO disable; 1: FIFO Enable)                                                                                                                             |
| LIR_INT1 | Latch interrupt request on INT1_SRC register, with INT1_SRC register cleared by reading INT1_SRC itself. Default value: 0.<br>(0: interrupt request not latched; 1: interrupt request latched) |
| D4D_INT1 | 4D enable: 4D detection is enabled on INT1 when 6D bit on INT1_CFG is set to 1.                                                                                                                |

## 8.13 CTRL\_REG6 (25h)

**Table 37. CTRL\_REG6 register**

|            |         |   |         |   |    |           |   |
|------------|---------|---|---------|---|----|-----------|---|
| I2_CLICKen | I2_INT1 | 0 | BOOT_I1 | 0 | -- | H_LACTIVE | - |
|------------|---------|---|---------|---|----|-----------|---|

## 8.14 REFERENCE/DATACAPTURE (26h)

**Table 38. REFERENCE register**

|      |      |      |      |      |      |      |      |
|------|------|------|------|------|------|------|------|
| Ref7 | Ref6 | Ref5 | Ref4 | Ref3 | Ref2 | Ref1 | Ref0 |
|------|------|------|------|------|------|------|------|

**Table 39. REFERENCE register description**

|            |                                                            |
|------------|------------------------------------------------------------|
| Ref 7-Ref0 | Reference value for Interrupt generation. Default value: 0 |
|------------|------------------------------------------------------------|

## 8.15 STATUS\_REG (27h)

**Table 40. STATUS register**

|       |     |     |     |       |     |     |     |
|-------|-----|-----|-----|-------|-----|-----|-----|
| ZYXOR | ZOR | YOR | XOR | ZYXDA | ZDA | YDA | XDA |
|-------|-----|-----|-----|-------|-----|-----|-----|

**Table 41. STATUS 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 ones)           |
| ZOR   | Z axis data overrun. Default value: 0<br>(0: no overrun has occurred; 1: a new data for the Z-axis has overwritten the previous one)             |
| YOR   | Y axis data overrun. Default value: 0<br>(0: no overrun has occurred;<br>1: a new data for the Y-axis has overwritten the previous one)          |
| XOR   | X axis data overrun. Default value: 0<br>(0: no overrun has occurred;<br>1: a new data for the X-axis has overwritten the previous one)          |
| 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;<br>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;<br>1: a new data for the Y-axis is available) |

## 8.16 OUT\_X\_L (28h), OUT\_X\_H (29h)

X-axis acceleration data. The value is expressed in two's complement.

## 8.17 OUT\_Y\_L (2Ah), OUT\_Y\_H (2Bh)

Y-axis acceleration data. The value is expressed in two's complement.

## 8.18 OUT\_Z\_L (2Ch), OUT\_Z\_H (2Dh)

Z-axis acceleration data. The value is expressed in two's complement.

## 8.19 FIFO\_CTRL\_REG (2Eh)

**Table 42. REFERENCE register**

|     |     |    |      |      |      |      |      |
|-----|-----|----|------|------|------|------|------|
| FM1 | FM0 | TR | FTH4 | FTH3 | FTH2 | FTH1 | FTH0 |
|-----|-----|----|------|------|------|------|------|

**Table 43. REFERENCE register description**

|         |                                                                                                                                               |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| FM1-FM0 | FIFO mode selection. Default value: 00 (see <a href="#">Table 44</a> )                                                                        |
| TR      | Trigger selection. Default value: 0<br>0: Trigger event linked to trigger signal on INT1<br>1: Trigger event linked to trigger signal on INT2 |
| FTH4:0  | Default value: 0                                                                                                                              |

**Table 44. FIFO mode configuration**

| FM1 | FM0 | Self test mode |
|-----|-----|----------------|
| 0   | 0   | Bypass mode    |
| 0   | 1   | FIFO mode      |
| 1   | 0   | Stream mode    |
| 1   | 1   | Trigger mode   |

## 8.20 FIFO\_SRC\_REG (2Fh)

**Table 45. FIFO\_SRC register**

|     |           |       |      |      |      |      |      |
|-----|-----------|-------|------|------|------|------|------|
| WTM | OVFN_FIFO | EMPTY | FSS4 | FSS3 | FSS2 | FSS1 | FSS0 |
|-----|-----------|-------|------|------|------|------|------|

## 8.21 INT1\_CFG (30h)

**Table 46. INT1\_CFG register**

|     |    |               |                 |               |                 |               |                 |
|-----|----|---------------|-----------------|---------------|-----------------|---------------|-----------------|
| AOI | 6D | ZHIE/<br>ZUPE | ZLIE/<br>ZDOWNE | YHIE/<br>YUPE | YLIE/<br>YDOWNE | XHIE/<br>XUPE | XLIE/<br>XDOWNE |
|-----|----|---------------|-----------------|---------------|-----------------|---------------|-----------------|

**Table 47. INT1\_CFG description**

|               |                                                                                                                                                       |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| AOI           | And/Or combination of Interrupt events. Default value: 0. Refer to <a href="#">Table 48, "Interrupt mode"</a>                                         |
| 6D            | 6 direction detection function enabled. Default value: 0. Refer to <a href="#">Table 48, "Interrupt mode"</a>                                         |
| ZHIE/<br>ZUPE | Enable interrupt generation on Z high event or on Direction recognition. Default value: 0 (0: disable interrupt request; 1: enable interrupt request) |

**Table 47. INT1\_CFG description**

|                 |                                                                                                                                                        |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| ZLIE/<br>ZDOWNE | Enable interrupt generation on Z low event or on Direction recognition. Default value: 0 (0: disable interrupt request; 1: enable interrupt request)   |
| YHIE/<br>YUPE   | Enable interrupt generation on Y high event or on Direction recognition. Default value: 0 (0: disable interrupt request; 1: enable interrupt request.) |
| YLIE/<br>YDOWNE | Enable interrupt generation on Y low event or on Direction recognition. Default value: 0 (0: disable interrupt request; 1: enable interrupt request.)  |
| XHIE/<br>XUPE   | Enable interrupt generation on X high event or on Direction recognition. Default value: 0 (0: disable interrupt request; 1: enable interrupt request.) |
| XLIE/XDOWNE     | Enable interrupt generation on X low event or on Direction recognition. Default value: 0 (0: disable interrupt request; 1: enable interrupt request.)  |

Content of this register is loaded at boot.

Write operation at this address is possible only after system boot.

**Table 48. Interrupt mode**

| AOI | 6D | Interrupt mode                      |
|-----|----|-------------------------------------|
| 0   | 0  | OR combination of interrupt events  |
| 0   | 1  | 6 direction movement recognition    |
| 1   | 0  | AND combination of interrupt events |
| 1   | 1  | 6 direction position recognition    |

Difference between AOI-6D = '01' and AOI-6D = '11'.

AOI-6D = '01' is movement recognition. An interrupt is generate when orientation move from unknown zone to known zone. The interrupt signal stay for a duration ODR.

AOI-6D = '11' is direction recognition. An interrupt is generate when orientation is inside a known zone. The interrupt signal stay until orientation is inside the zone.

## 8.22 INT1\_SRC (31h)

**Table 49. INT1\_SRC register**

|   |    |    |    |    |    |    |    |
|---|----|----|----|----|----|----|----|
| 0 | IA | ZH | ZL | YH | YL | XH | XL |
|---|----|----|----|----|----|----|----|

**Table 50. INT1\_SRC description**

|    |                                                                                                                           |
|----|---------------------------------------------------------------------------------------------------------------------------|
| IA | Interrupt active. Default value: 0<br>(0: no interrupt has been generated; 1: one or more interrupts have been generated) |
| ZH | Z high. Default value: 0<br>(0: no interrupt, 1: Z High event has occurred)                                               |
| ZL | Z low. Default value: 0<br>(0: no interrupt; 1: Z Low event has occurred)                                                 |
| YH | Y high. Default value: 0<br>(0: no interrupt, 1: Y High event has occurred)                                               |

**Table 50. INT1\_SRC description**

|    |                                                                             |
|----|-----------------------------------------------------------------------------|
| YL | Y low. Default value: 0<br>(0: no interrupt, 1: Y Low event has occurred)   |
| XH | X high. Default value: 0<br>(0: no interrupt, 1: X High event has occurred) |
| XL | X low. Default value: 0<br>(0: no interrupt, 1: X Low event has occurred)   |

Interrupt 1 source register. Read only register.

Reading at this address clears INT1\_SRC IA bit (and the interrupt signal on INT 1 pin) and allows the refreshment of data in the INT1\_SRC register if the latched option was chosen.

## 8.23 INT1\_THS (32h)

**Table 51. INT1\_THS register**

|   |      |      |      |      |      |      |      |
|---|------|------|------|------|------|------|------|
| 0 | THS6 | THS5 | THS4 | THS3 | THS2 | THS1 | THS0 |
|---|------|------|------|------|------|------|------|

**Table 52. INT1\_THS description**

|             |                                                |
|-------------|------------------------------------------------|
| THS6 - THS0 | Interrupt 1 threshold. Default value: 000 0000 |
|-------------|------------------------------------------------|

## 8.24 INT1\_DURATION (33h)

**Table 53. INT1\_DURATION register**

|   |    |    |    |    |    |    |    |
|---|----|----|----|----|----|----|----|
| 0 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|----|----|----|----|----|----|----|

**Table 54. INT1\_DURATION description**

|         |                                         |
|---------|-----------------------------------------|
| D6 - D0 | Duration value. Default value: 000 0000 |
|---------|-----------------------------------------|

**D6 - D0** bits set the minimum duration of the Interrupt 1 event to be recognized. Duration steps and maximum values depend on the ODR chosen.

## 8.25 CLICK\_CFG (38h)

**Table 55. CLICK\_CFG register**

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| -- | -- | ZD | ZS | YD | YS | XD | XS |
|----|----|----|----|----|----|----|----|

**Table 56. CLICK\_CFG description**

|    |                                                                                                                                                                                      |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ZD | Enable interrupt double CLICK-CLICK on Z axis. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request on measured accel. value higher than preset threshold) |
| ZS | Enable interrupt single CLICK-CLICK on Z axis. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request on measured accel. value higher than preset threshold) |
| YD | Enable interrupt double CLICK-CLICK on Y axis. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request on measured accel. value higher than preset threshold) |
| YS | Enable interrupt single CLICK-CLICK on Y axis. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request on measured accel. value higher than preset threshold) |
| XD | Enable interrupt double CLICK-CLICK on X axis. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request on measured accel. value higher than preset threshold) |
| XS | Enable interrupt single CLICK-CLICK on X axis. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request on measured accel. value higher than preset threshold) |

## 8.26 CLICK\_SRC (39h)

**Table 57. CLICK\_SRC register**

|  |    |        |        |      |   |   |   |
|--|----|--------|--------|------|---|---|---|
|  | IA | DCLICK | SCLICK | Sign | Z | Y | X |
|--|----|--------|--------|------|---|---|---|

**Table 58. CLICK\_SRC description**

|        |                                                                                                                              |
|--------|------------------------------------------------------------------------------------------------------------------------------|
| -      | -                                                                                                                            |
| IA     | Interrupt active. Default value: 0<br>(0: no interrupt has been generated; 1: one or more interrupts have been generated)    |
| DCLICK | Double CLICK-CLICK enable. Default value: 0 (0:double CLICK-CLICK detection disable, 1: double CLICK-CLICK detection enable) |
| SCLICK | Single CLICK-CLICK enable. Default value: 0 (0:Single CLICK-CLICK detection disable, 1: single CLICK-CLICK detection enable) |
| Sign   | CLICK-CLICK Sign. 0: positive detection, 1: negative detection                                                               |
| Z      | Z CLICK-CLICK detection. Default value: 0<br>(0: no interrupt, 1: Z High event has occurred)                                 |
| Y      | Y CLICK-CLICK detection. Default value: 0<br>(0: no interrupt, 1: Y High event has occurred)                                 |
| X      | X CLICK-CLICK detection. Default value: 0<br>(0: no interrupt, 1: X High event has occurred)                                 |

## 8.27 CLICK\_THS (3Ah)

**Table 59. CLICK\_THS register**

|   |      |      |      |      |      |      |      |
|---|------|------|------|------|------|------|------|
| - | Ths6 | Ths5 | Ths4 | Ths3 | Ths2 | Ths1 | Ths0 |
|---|------|------|------|------|------|------|------|

**Table 60. CLICK\_SRC description**

|           |                                                |
|-----------|------------------------------------------------|
| Ths6-Ths0 | CLICK-CLICK threshold. Default value: 000 0000 |
|-----------|------------------------------------------------|

## 8.28 TIME\_LIMIT (3Bh)

**Table 61. TIME\_LIMIT register**

|   |      |      |      |      |      |      |      |
|---|------|------|------|------|------|------|------|
| - | TLI6 | TLI5 | TLI4 | TLI3 | TLI2 | TLI1 | TLI0 |
|---|------|------|------|------|------|------|------|

**Table 62. TIME\_LIMIT description**

|           |                                                 |
|-----------|-------------------------------------------------|
| TLI7-TLI0 | CLICK-CLICK Time Limit. Default value: 000 0000 |
|-----------|-------------------------------------------------|

## 8.29 TIME\_LATENCY (3Ch)

**Table 63. TIME\_LATENCY register**

|      |      |      |      |      |      |      |      |
|------|------|------|------|------|------|------|------|
| TLA7 | TLA6 | TLA5 | TLA4 | TLA3 | TLA2 | TLA1 | TLA0 |
|------|------|------|------|------|------|------|------|

**Table 64. TIME\_LATENCY description**

|           |                                                   |
|-----------|---------------------------------------------------|
| TLA7-TLA0 | CLICK-CLICK time latency. Default value: 000 0000 |
|-----------|---------------------------------------------------|

## 8.30 TIME\_WINDOW(3Dh)

**Table 65. TIME\_WINDOW register**

|     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|
| TW7 | TW6 | TW5 | TW4 | TW3 | TW2 | TW1 | TW0 |
|-----|-----|-----|-----|-----|-----|-----|-----|

**Table 66. TIME\_WINDOW description**

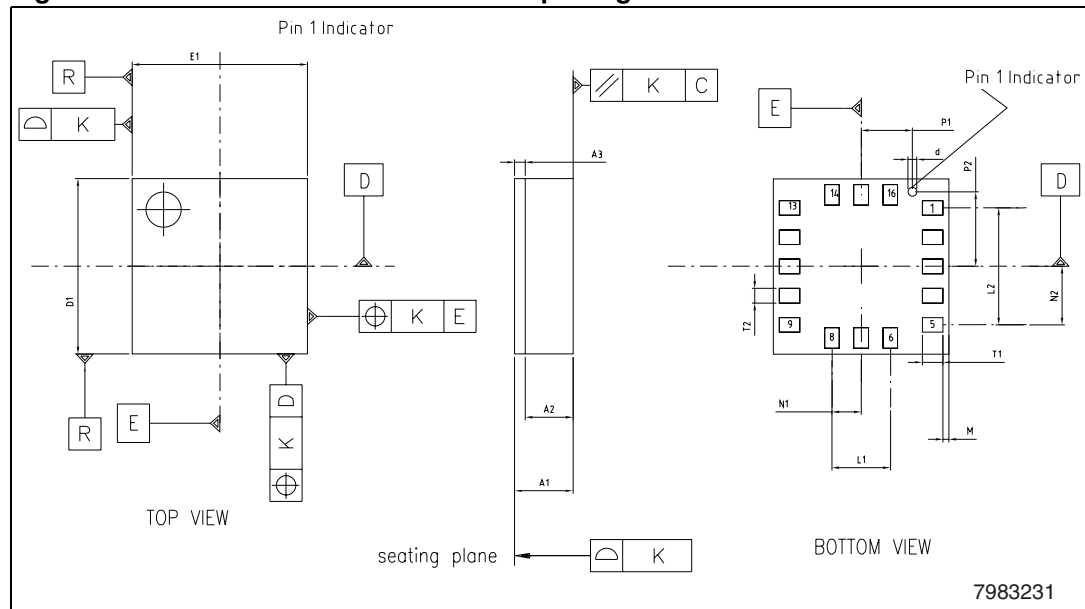
|         |                         |
|---------|-------------------------|
| TW7-TW0 | CLICK-CLICK time window |
|---------|-------------------------|

## 9 Package information

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

**Table 67. LGA-16: Mechanical data**

| Dim | mm   |       |      |
|-----|------|-------|------|
|     | Min. | Typ.  | Max. |
| A1  |      |       | 1    |
| A2  |      | 0.785 |      |
| A3  |      | 0.2   |      |
| D1  | 2.85 | 3     | 3.15 |
| E1  | 2.85 | 3     | 3.15 |
| L1  |      | 1     | 1.06 |
| L2  |      | 2     | 2.06 |
| N1  |      | 0.5   |      |
| N2  |      | 1     |      |
| M   | 0.04 | 0.1   | 0.16 |
| P1  |      | 0.875 |      |
| P2  |      | 1.275 |      |
| T1  | 0.29 | 0.35  | 0.41 |
| T2  | 0.19 | 0.25  | 0.31 |
| d   |      | 0.15  |      |
| k   |      | 0.05  |      |

**Figure 12. LGA-16: Mechanical data and package dimensions**

## 10 Revision history

**Table 68. Document revision history**

| Date        | Revision | Changes         |
|-------------|----------|-----------------|
| 21-May-2010 | 1        | Initial release |

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#### Как с нами связаться

**Телефон:** 8 (812) 309 58 32 (многоканальный)

**Факс:** 8 (812) 320-02-42

**Электронная почта:** [org@eplast1.ru](mailto:org@eplast1.ru)

**Адрес:** 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.