LIS3DSH

MEMS digital output motion sensor ultra low-power high performance three-axis “nano” accelerometer

Preliminary data

Features

- Wide supply voltage, 1.71 V to 3.6 V
- Independent IOs supply (1.8 V) and supply voltage compatible
- Ultra low-power consumption
- ±2*g*/±4*g*/±6*g*/±8*g*/±16*g* dynamically selectable full-scale
- I^2C/SPI digital output interface
- 16-bit data output
- Programmable embedded state machines
- Embedded temperature sensor
- Embedded self-test
- Embedded FIFO
- 10000 *g* high shock survivability
- ECOPACK® RoHS and “Green” compliant

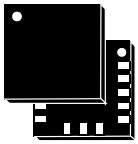
Applications

- Motion controlled user interface
- Gaming and virtual reality
- Pedometer
- Intelligent power saving for handheld devices
- Display orientation
- Click/double click recognition
- Impact recognition and logging
- Vibration monitoring and compensation

Description

The LIS3DSH is an ultra low-power high performance three-axis linear accelerometer belonging to the “nano” family with embedded state machine that can be programmed to implement autonomous applications.

The LIS3DSH has dynamically selectable full scales of ±2*g*/±4*g*/±6*g*/±8*g*/±16*g* and it is capable of measuring accelerations with output data rates from 3.125 Hz to 1.6 kHz.



LGA-16 (3x3x1 mm)

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

The device can be configured to generate interrupt signals activated by user defined motion patterns.

The LIS3DSH has an integrated first in, first out (FIFO) buffer allowing the user to store data for host processor intervention reduction.

The LIS3DSH is available in a small thin plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

Table 1. Device summary

Order codes	Temperature range [° C]	Package	Packaging
LIS3DSH	-40 to +85	LGA-16	Tray
LIS3DSHTR	-40 to +85	LGA-16	Tape and reel

1 Contents

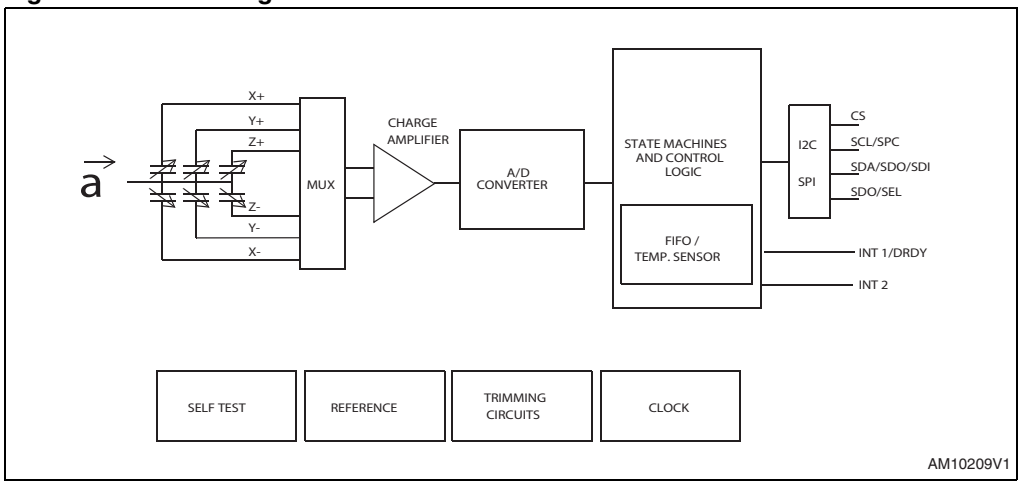
List of tables

List of figures

2 Block diagram and pin description

2.1 Block diagram

Figure 1. Block diagram



2.2 Pin description

Figure 2. Pin connection

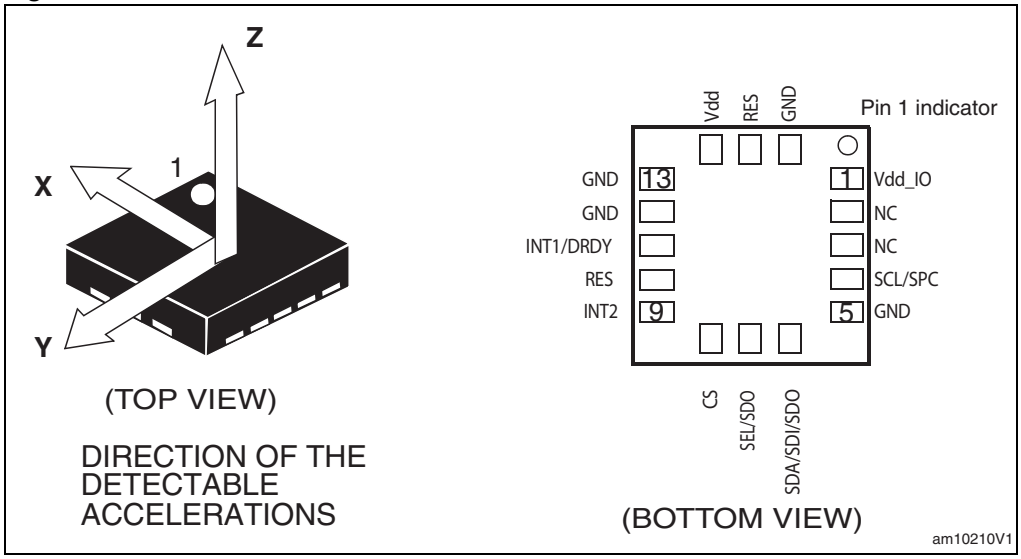


Table 2. Pin description

Pin#	Name	Function
1	Vdd_IO	Power supply for I/O pins
2	NC	Not connected
3	NC	Not connected
4	SCL SPC	I^2C serial clock (SCL) SPI serial port clock (SPC)
5	GND	0 V supply
6	SDA SDI SDO	I^2C serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)
7	SEL SDO	I^2C address selection SPI serial data output (SDO)
8	CS	SPI enable I^2C/SPI mode selection (1: SPI idle mode / I^2C communication enabled; 0: SPI communication mode / I^2C disabled)
9	INT 2	Interrupt 2
10	Reserved	Connect to GND
11	INT 1/DRDY	Interrupt 1/ DRDY
12	GND	0 V supply
13	GND	0 V supply
14	Vdd	Power supply
15	Reserved	Connect to Vdd
16	GND	0 V supply

3 Mechanical and electrical specifications

3.1 Mechanical characteristics

@ Vdd = 2.5 V, T = 25 °C unless otherwise noted[a].

Table 3. Mechanical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.[1]	Max.	Unit
FS	Measurement range[2]	FS bit set to 000		±2.0		*g*
		FS bit set to 001		±4.0		*g*
		FS bit set to 010		±6.0		*g*
		FS bit set to 011		±8.0		*g*
		FS bit set to 100		±16.0		*g*
So	Sensitivity	FS bit set to 000		0.06		mg/digit
		FS bit set to 001		0.12		mg/digit
		FS bit set to 010		0.18		mg/digit
		FS bit set to 011		0.24		mg/digit
		FS bit set to 100		0.73		mg/digit
TCSo	Sensitivity change vs. temperature	FS bit set to 00		0.01		%/°C
TyOff	Typical zero-*g* level offset accuracy[3]	FS bit set to 00		±40		m*g*
TCOff	Zero-*g* level change vs. temperature	Max. delta from 25 °C		±0.5		m*g*/°C
An	Acceleration noise density	FS bit set to 00, normal mode, ODR = 100 Hz		150		u*g*/ sqrt(Hz)
ST	Self test positive difference[4]	± 2g range, X,Y-axis ST2,ST1 = [01] see *Figure 24*		140		m*g*
		± 2g range, Z-axis ST2,ST1 = [01] see *Figure 24*		590		
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. Self-test output change" is defined as: $OUTPUT[mg]_{(CNTL5\ ST2,\ ST1\ bits=01)}$ - $OUTPUT[mg]_{(CNTL5\ ST2,\ ST1\ bits=00)}$

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

3.2 Electrical characteristics

@ Vdd = 2.5 V, T = 25 °C unless otherwise noted[b].

Table 4. Electrical characteristics (1)

Symbol	Parameter	Test conditions	Min.	Typ.(2)	Max.	Unit
Vdd	Supply voltage		1.71	2.5	3.6	V
Vdd_IO	I/O pins supply voltage(3)		1.71		Vdd+0.1	V
IddA	Current consumption in Active mode	1.6 kHz ODR		225		µA
		3.125 Hz ODR		11		µA
IddPdn	Current consumption in power-down/standby mode			2		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
Top	Operating temperature range		-40		+85	°C

1. The product is factory calibrated at 2.5 V. The operational power supply range is from 1.71 V to 3.6 V.
2. Typical specifications are not guaranteed.
3. It is possible to remove Vdd maintaining Vdd_IO without blocking the communication buses, 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.

3.3 Communication interface characteristics

3.3.1 SPI - serial peripheral interface

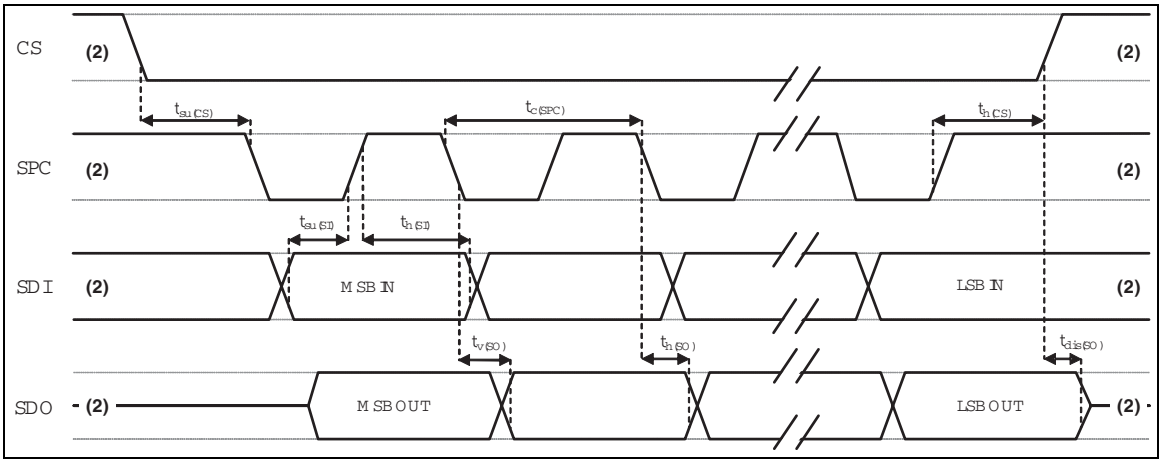
Subject to general operating conditions for Vdd and Top.

Table 5. SPI slave timing values

Symbol	Parameter	Value (1)		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	

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.

Figure 3. SPI slave timing diagram (c)



2. When no communication is on-going, data on SDO is driven by internal pull-up resistor.

c. Measurement points are done at 0.2·Vdd_IO and 0.8·Vdd_IO, for both input and output ports.

3.3.2 I²C - inter IC control interface

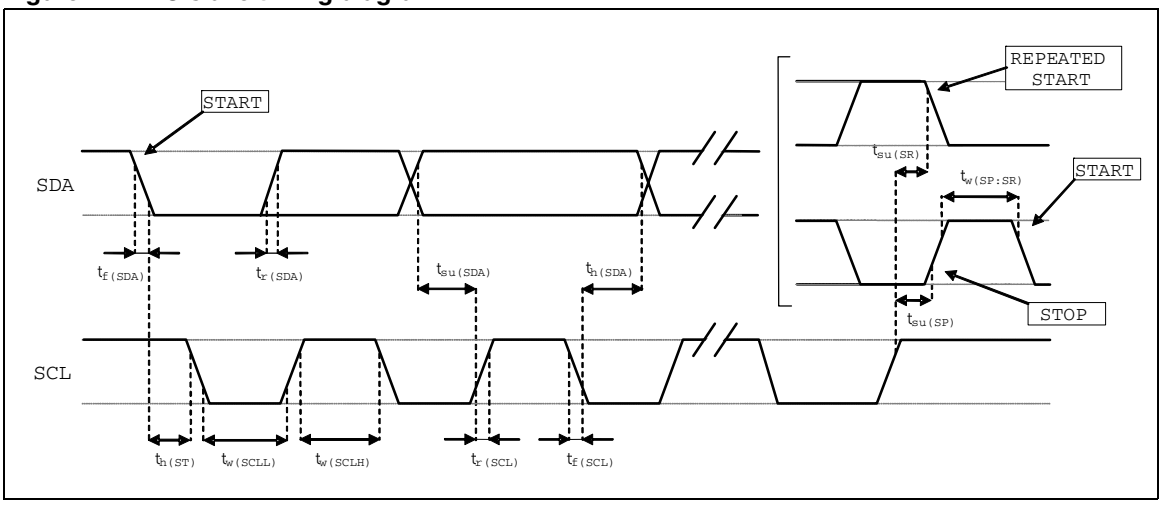
Subject to general operating conditions for Vdd and Top.

Table 6. I²C slave timing values

Symbol	Parameter	I²C standard mode (1)		I²C fast mode (1)		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		µs
$t_{w(SCLH)}$	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	µs
$t_{r(SDA)}$ $t_{r(SCL)}$	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		µs
$t_{su(SR)}$	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 I²C protocol requirement, not tested in production.
2. Cb = total capacitance of one bus line, in pF.

Figure 4. I²C slave timing diagram (d)



d. Measurement points are done at 0.2·Vdd_IO and 0.8·Vdd_IO, for both ports.

3.4 Absolute maximum ratings

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

Table 7. Absolute maximum ratings

Symbol	Ratings	Maximum value	Unit
Vdd	Supply voltage	-0.3 to 4.8	V
Vdd_IO	I/O pins supply voltage	-0.3 to 4.8	V
Vin	Input voltage on any control pin (CS, SCL/SPC, SDA/SDI/SDO, SDO/SEL)	-0.3 to Vdd_IO +0.3	V
A_{POW}	Acceleration (any axis, powered, Vdd = 2.5 V)	3000 for 0.5 ms	g
		10000 for 0.1 ms	g
A_{UNP}	Acceleration (any axis, unpowered)	3000 for 0.5 ms	g
		10000 for 0.1 ms	g
T_{OP}	Operating temperature range	-40 to +85	°C
T_{STG}	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 damage to the part.

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

3.5 Terminology

3.5.1 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, ±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.

3.5.2 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 measures 0 *g* in X axis and 0 *g* in Y axis, whereas the Z axis measures 1 *g*. The output is ideally in the middle of the dynamic range of the sensor (content of OUT registers 00h, data expressed as 2's complement number). A deviation from the ideal value in this case is called Zero-*g* offset. Offset is to some extent a result of stress to MEMS sensor and therefore the offset can slightly change after mounting the sensor onto a printed circuit board or exposing it to extensive mechanical stress. Offset changes little 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.

3.6 Functionality

3.6.1 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 in *Table 3*, then the sensor is working properly and the parameters of the interface chip are within the defined specifications.

3.7 Sensing element

A proprietary process is used to create a surface micro-machined accelerometer. The technology allows to carry 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 a few pF and when an acceleration is applied, the maximum variation of the capacitive load is in the fF range.

3.8 IC interface

The complete measurement chain is made up of 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 through an analog-to-digital converter.

The acceleration data may be accessed through an I^2C/SPI interface, therefore making the device particularly suitable for direct interfacing with a microcontroller.

The LIS3DSH features a Data-Ready signal (RDY) which indicates when a new set of measured acceleration data is available, therefore simplifying data synchronization in the digital system that uses the device.

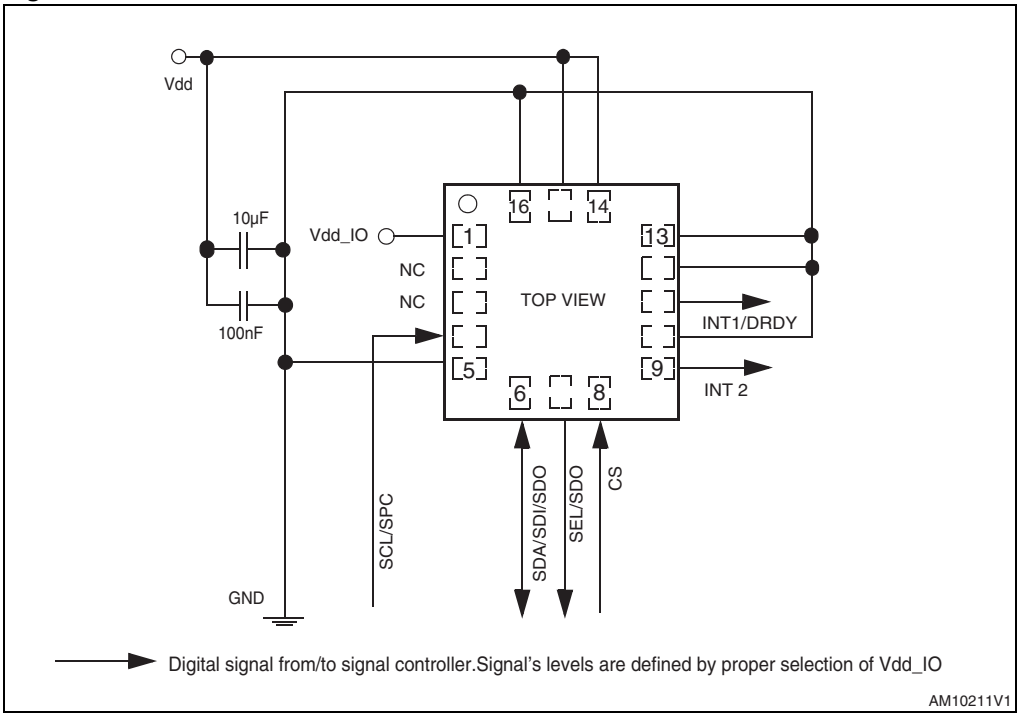
3.9 Factory calibration

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.

4 Application hints

Figure 5. LIS3DSH electrical connection



The device core is supplied through the Vdd line while the I/O pins are supplied through the Vdd_IO line. Power supply decoupling capacitors (100 nF ceramic, 10 µF) should be placed as near as possible to 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^2C or SPI interfaces. When using the I^2C, CS must be tied high.

4.1 Soldering information

The LGA package is compliant with the ECOPACK®, 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.

5 Digital main blocks

5.1 State machine

The LIS3DSH embeds two state machines able to run a user defined program.

The program is made up of a set of instructions that define the transition to successive states. Conditional branches are possible.

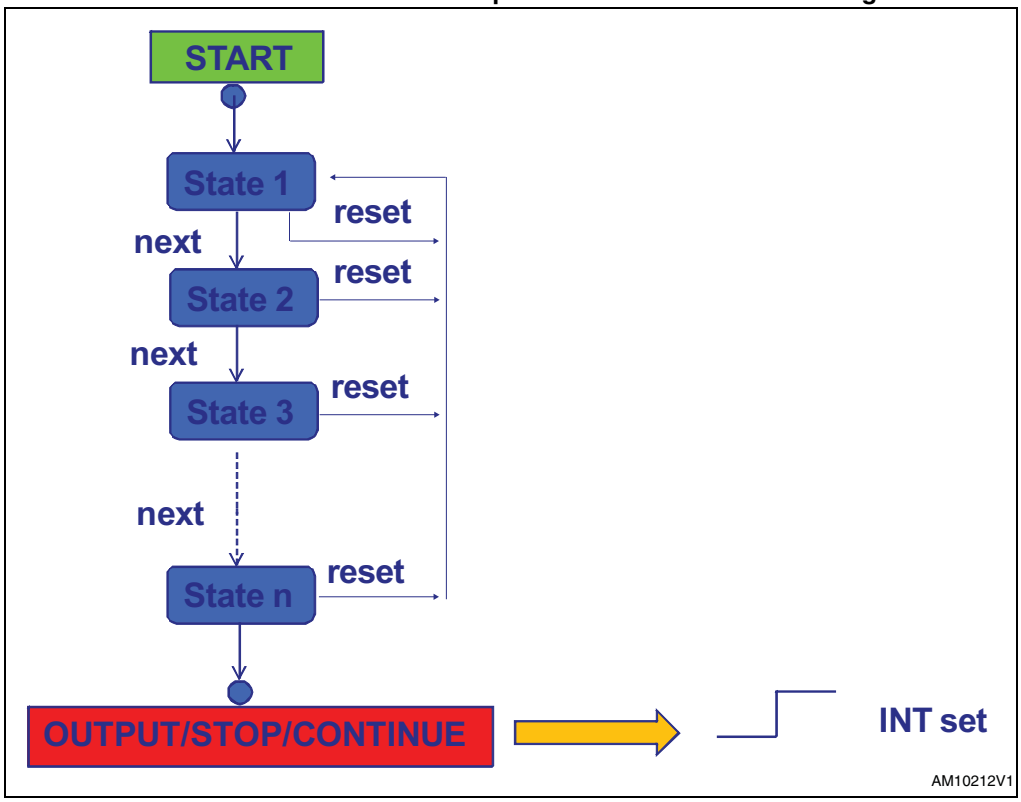
From each state (n) it is possible to have transition to the next state (n+1) or to reset state. Transition to reset point happens when “RESET condition” is true; Transition to the next step happens when “NEXT condition” is true.

Interrupt is triggered when output/stop/continue state is reached.

Each state machine allows to implement gesture recognition in a flexible way, free-fall, wake-up, 4D/6D orientation, pulse counter and step recognition, click/double click, shake/double shake, face-up/face-down, turn/double turn:

- Code and parameters are loaded by the host into dedicated memory areas for the state program
- State program with timing based on ODR or decimated time
- Possibility of conditional branches

Table 8. LIS3DSH state machines: sequence of state to execute an algorithm



5.2 FIFO

LIS3DSH embeds an acceleration 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 wake up only when needed and burst the significant data out from the FIFO. This buffer can work according to four different modes: Bypass mode, FIFO mode, Stream mode and Stream-to-FIFO mode. Each mode is selected by the FIFO_MODE bits. Programmable Watermark level, FIFO_empty or FIFO_Full events can be enabled to generate dedicated interrupts on the INT1/2 pin.

5.2.1 Bypass mode

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

5.2.2 FIFO mode

In FIFO mode, data from X, Y, and Z channels are stored in the FIFO. A Watermark interrupt can be enabled in order to be raised when the FIFO is filled to the level specified by the internal register. The FIFO continues filling until it is full. When full, the FIFO stops collecting data from the input channels.

5.2.3 Stream mode

In Stream mode, data from the X, Y, and Z measurement are stored in the FIFO. A Watermark interrupt can be enabled and set as in the FIFO mode. The FIFO continues filling until it's full. When full, the FIFO discards the older data as the new arrive.

5.2.4 Stream-to-FIFO mode

In Stream-to_FIFO mode, data from the X, Y, and Z measurement are stored in the FIFO. A Watermark interrupt can be enabled in order to be raised when the FIFO is filled to the level specified by the internal register. The FIFO continues filling until it's full. When full, the FIFO discards the older data as the new arrive. Once trigger event occurs, the FIFO starts operating in FIFO mode.

5.2.5 Retrieve data from FIFO

FIFO data is read through the OUT_X, OUT_Y and OUT_Z registers. 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 in the FIFO. Each time data is read from the FIFO, the oldest X, Y, and Z data are placed in 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 LIS3DSH may be accessed through both the I^2C 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 pins. To select/exploit the I^2C interface, the CS line must be tied high (i.e. connected to Vdd_IO).

Table 9. Serial interface pin description

Pin name	Pin description
CS	SPI enable I2C/SPI mode selection (1: SPI idle mode / I2C communication enabled; 0: SPI communication mode / I2C disabled)
SCL SPC	I^2C serial clock (SCL) SPI serial port clock (SPC)
SDA SDI SDO	I^2C serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)
SEL SDO	I^2C address selection SPI serial data output (SDO)

6.1 I^2C serial interface

The LIS3DSH I^2C is a bus slave. The I^2C is employed to write data into registers whose content can also be read back.

The relevant I^2C terminology is given in the table below.

Table 10. 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^2C bus: the serial clock line (SCL) and the serial data line (SDA). The latter is a bi-directional line used for sending and receiving the data to/from the interface. Both lines must be connected to Vdd_IO through an external pull-up resistor. When the bus is free, both lines are high.

The I^2C interface is compliant with fast mode (400 kHz) I^2C standards as well as with normal mode.

6.1.1 I²C 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 LIS3DSH is 00111xxb whereas the xx bits are modified by the SEL/SDO pin in order to modify the device address. If the SEL pin is connected to the voltage supply, the address is 0011101b, otherwise the address is 0011110b if the SEL pin is connected to ground. This solution permits to connect and address two different accelerometers to the same I²C 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 I²C embedded inside the LIS3DSH behaves as 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 represents the actual register address while the ADD_INC bit (CTRL_REG6) defines the address increment.

The slave address is completed with a read/write bit. If the bit is '1' (Read), a repeated start (SR) condition must be issued after the two sub-address bytes; if the bit is '0' (Write), the master transmits to the slave with direction unchanged. *Table 11* explains how the SAD+Read/Write bit pattern is composed, listing all the possible configurations.

Table 11. SAD+Read/Write patterns

Command	SAD[6:2]	SAD[1] = $\overline{SEL}$	SAD[0] = SEL	R/W	SAD+R/W
Read	00111	1	0	1	00111101
Write	00111	1	0	0	00111100
Read	00111	0	1	1	00111011
Write	00111	0	1	0	00111010

Table 12. Transfer when master is writing one byte to slave

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

Table 13. Transfer when master is writing multiple bytes to slave:

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

Table 14. 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 15. 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.

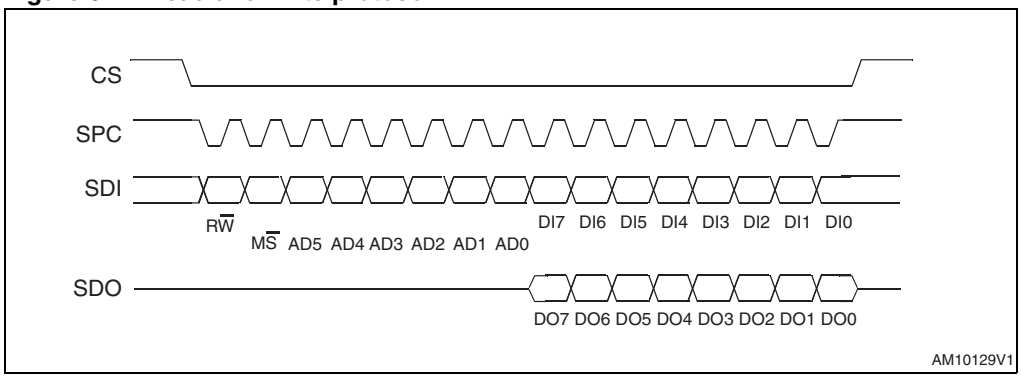
In the presented communication format, MAK is Master acknowledge and NMAK is No Master Acknowledge.

6.2 SPI bus interface

The LIS3DSH 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 multiples 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: R$\overline{W}$ 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 the latter case, the chip drives **SDO** at the start of bit 8.

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

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

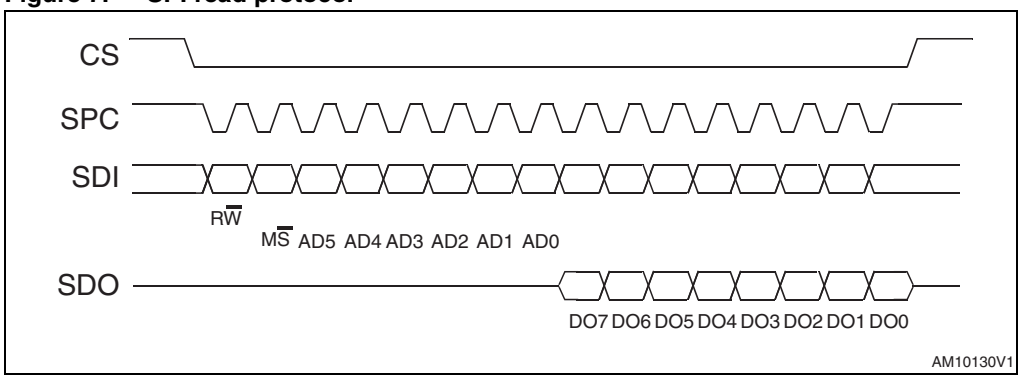
bit 8-15: data DO(7:0) (read mode). This is the data that is read from the device (MSb first).

In multiple read/write commands further blocks of 8 clock periods are added. When the ADD_INC(CTRL_REG6) bit is ‘0’, the address used to read/write data remains the same for every block. When the ADD_INC bit is ‘1’, the address used to read/write data is increased at every block.

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

6.2.1 SPI read

Figure 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.

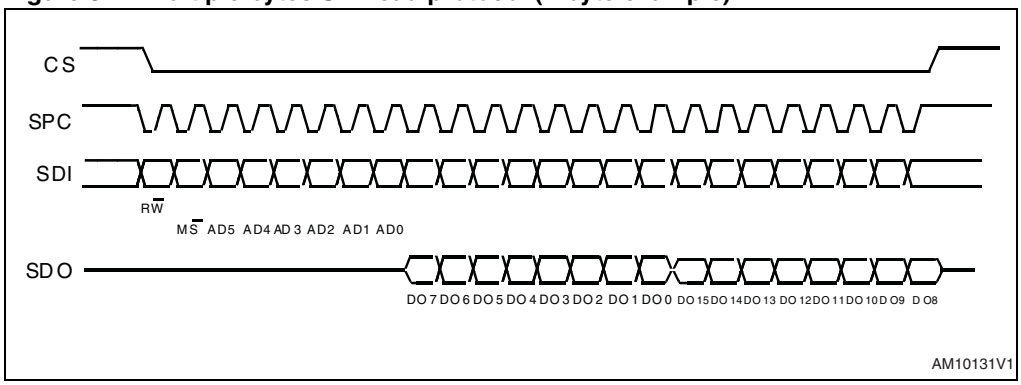
bit 0: READ bit. The value is 1.

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

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

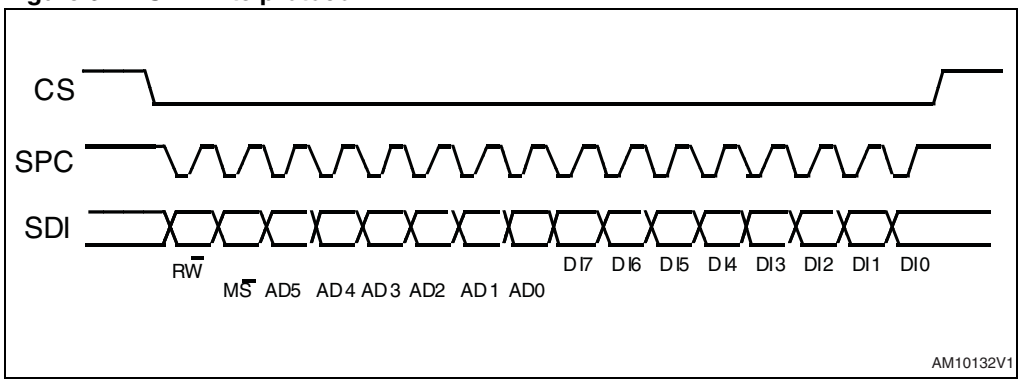
bit 16-... : data DO(...-8). Further data in multiple byte reading.

Figure 8. Multiple bytes SPI read protocol (2-byte 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.

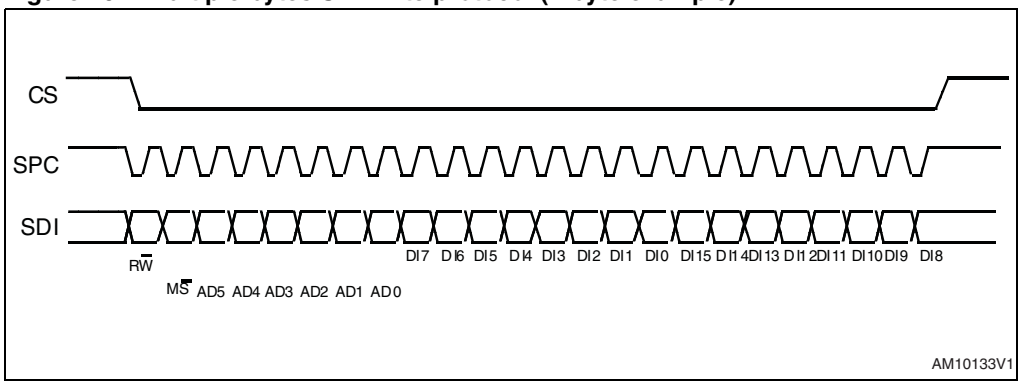
bit 0: WRITE bit. The value is 0.

bit 1 -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 writing.

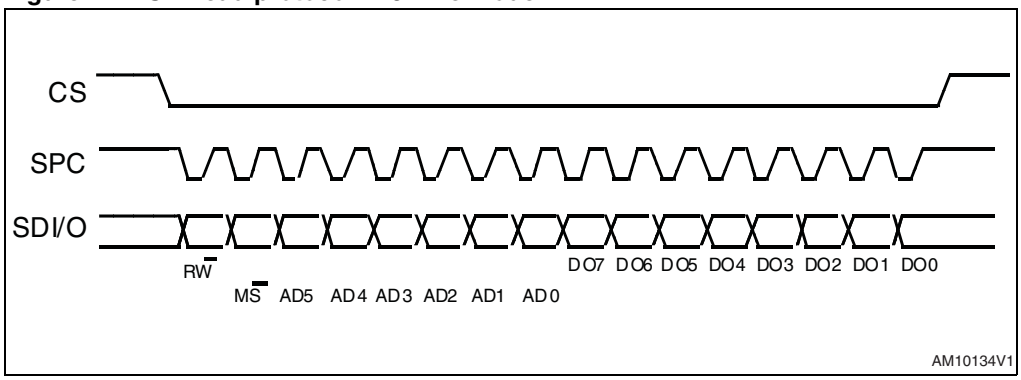
Figure 10. Multiple bytes SPI write protocol (2-byte example)



6.2.3 SPI read in 3-wire mode

3-wire mode is entered by setting to ‘1’ bit SIM (SPI serial interface mode selection) by internal register.

Figure 11. SPI read protocol in 3-wire mode



The SPI read command is performed with 16 clock pulses:

bit 0: READ bit. The value is 1.

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

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

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

7 Register mapping

Table 16 provides a list of the 8/16-bit registers embedded in the device and the related address:

Table 16. Register address map

Name	Type	Register address		Default	Comment
		Hex	Binary		
INFO1	r	0D	00001101	0010 0001	Information register 1
INFO2	r	0E	00001110	0000 0000	Information register 2
WHO_AM_I	r	OF	00001111	0011 1111	Who I am ID
CTRL_REG3	r/w	23	00100011	-	Control registers
CTRL_REG4	r/w	20	00100000	-	
CTRL_REG5	r/w	24	00100100	-	
CTRL_REG6	r/w	25	00100101	-	
STATUS	r	27	00100111	-	Status data register
OUT_T	r	0C	00001100	-	Temperature output
OFF_X	r/w	10	00010000	0000 0000	X-axis offset correction
OFF_Y	r/w	11	00010001	0000 0000	Y-axis offset correction
OFF_Z	r/w	12	00010010	0000 0000	Z-axis offset correction
CS_X	r/w	13	00010011	0000 0000	Constant shift X
CS_Y	r/w	14	00010100	0000 0000	Constant shift Y
CS_Z	r/w	15	00010101	0000 0000	Constant shift Z
LC_L	r/w	16	00010110	0000 0001	Long counter registers
LC_H	r/w	17	00010111	0000 0000	
STAT	r	18	00011000	-	Interrupt synchronization
VFC_1	r/w	1B	00011011	-	Vector filter coefficient 1
VFC_2	r/w	1C	00011100	-	Vector filter coefficient 2
VFC_3	r/w	1D	00011101	-	Vector filter coefficient 3
VFC_4	r/w	1E	00011110	-	Vector filter coefficient 4
THRS3	r/w	1F	00011111	-	Threshold value 3
OUT_X_L	r	28	00101000	0000 0000	Output registers
OUT_X_H	r	29	00101001		
OUT_Y_L	r	2A	00101010		
OUT_Y_H	r	2B	00101011		
OUT_Z_L	r	2C	00101100		
OUT_Z_H	r	2D	00101101		

Table 16. Register address map (continued)

Name	Type	Register address		Default	Comment
		Hex	Binary		
FIFO_CTRL	r/w	2E	00101110	0000 0000	FIFO registers
FIFO_SRC	r	2F	00101111	-	
CTRL_REG1	r/w	21	00100001	0000 0000	SM1 control register
ST1_X	w	40-4F	01000000 01001111	-	SM1 code register (X =1-16)
TIM4_1	w	50	01010000	-	SM1 general timer
TIM3_1	w	51	01010001	-	
TIM2_1	w	52-53	01010010 01010011	-	
TIM1_1	w	54-55	01010100 01010101	-	
THRS2_1	w	56	01010110	-	SM1 threshold value 1
THRS1_1	w	57	01010111	-	SM1 threshold value 2
MASK1_B	w	59	01011001	-	SM1 axis and sign mask
MASK1_A	w	5A	01011010	-	SM1 axis and sign mask
SETT1	w	5B	01011011	-	SM1 detection settings
PR1	r	5C	01011100	-	Program-reset pointer
TC1	r	5D-5E	01011101 01011110	-	Timer counter
OUTS1	r	5F	01011111	-	Main set flag
PEAK1	r	19	00011001	-	Peak value
CTRL_REG2	r/w	22	00100010	-	SM2 control register
ST2_X	w	60-6F	01100000 01101111	-	SM2 code register (X =1-16)
TIM4_2	w	70	01110000	-	SM2 general timer
TIM3_2	w	71	01110001	-	
TIM2_2	w	72-73	01110010 01110011	-	
TIM1_2	w	74-75	01110100 01110101	-	
THRS2_2	w	76	01110110	-	SM2 threshold value 1
THRS1_2	w	77	01110111	-	SM2 threshold value 2
MASK2_B	w	79	01111001	-	SM2 axis and sign mask
MASK2_A	w	7A	01111010		SM2 axis and sign mask
SETT2	w	7B	01111011	-	SM2 detection settings

Table 16. Register address map (continued)

Name	Type	Register address		Default	Comment
		Hex	Binary		
PR2	r	7C	01111100	-	Program-reset pointer
TC2	r	7D-7E	01111101 01111110	-	Timer counter
OUTS2	r	7F	01111111		Main set flag
PEAK2	r	1A	00011010	-	Peak value
DES2	w	78	01111000	-	Decimation factor

8 Register description

8.1 INFO1 (0Dh)

Read only information register.

Table 17. INFO1 register default value

0	0	1	0	0	0	0	1

8.2 INFO2 (0Eh)

Read only information register.

Table 18. INFO2 register default value

0	0	0	0	0	0	0	0

8.3 WHO_AM_I (0Fh)

Who_AM_I register.

Table 19. WHO_AM_I register default value

0	0	1	1	1	1	1	1

8.4 CTRL_REG3 (23h)

Control register 3.

Table 20. Control register 3

DR_EN	IEA	IEL	INT2_EN	INT1_EN	VFILT	-	STRT

Table 21. CTRL_REG3 register description

DR_EN	DRDY signal enable to INT1. Default value:0 0 = data ready signal not connected, 1 = data ready signal connected to INT1
IEA	Interrupt signal polarity. Default value:0 0 = interrupt signals active LOW, 1 = interrupt signals active HIGH
IEL	Interrupt signal latching. Default value:0 0 = interrupt signals latched, 1 = interrupt signal pulsed
INT2_EN	Interrupt 2 enable/disable. Default value:0 0 = INT2 signal disabled, 1 = INT2 signal enabled
INT1_EN	Interrupt 2 enable/disable. Default Value:0 0 = INT1/DRDY signal disabled, 1 = INT1/DRDY signal enabled

Table 21. CTRL_REG3 register description (continued)

VFILT	Vector filter enable/disable. Default value:0 0 = vector filter disabled, 1 = vector filter enabled
STRT	Soft reset bit 0 = no soft reset, 1 = soft reset (POR function)

8.5 CTRL_REG4 (20h)

Control register 4.

Table 22. Control register 4

ODR3	ODR2	ODR1	ODR0	BDU	ZEN	YEN	XEN

Table 23. CTRL_REG4 register description

ODR 3:0	Output data rate and power mode selection. Default value:0000 (see *Table 24*)
BDU	Block data update. Default value:0 0:continuos update,1:output registers not updated until MSB and LSB reading)
Zen	Z axis enable. Default value:1 (0:Z axis disabled; 1:Z axis enabled)
Yen	Y axis enable. Default value:1 (0:Y axis disabled; 1:Y axis enabled)
Xen	X axis enable. Default value:1 0=X axis disabled; 1=X axis enabled

ODR<3:0> is used to set Power Mode and ODR selection. In *Table 24* (output data rate selection *Table 22*) all frequencies available are reported.

Table 24. CTRL4 ODR configuration

ODR3	ODR2	ODR1	ODR0	ODR selection
0	0	0	0	Power down
0	0	0	1	3.125 Hz
0	0	1	0	6.25 Hz
0	0	1	1	12.5 Hz
0	1	0	0	25 Hz
0	1	0	1	50 Hz
0	1	1	0	100 Hz
0	1	1	1	400 Hz
1	0	0	0	800 Hz
1	0	0	1	1600 Hz

The **BDU** bit is used to inhibit the output registers update until both upper and lower register parts are read. In default mode (BDU='0') the output register values are updated continuously. If for any reason it is not sure whether to read faster than the output data rate it is recommended to set the BDU bit to '1'. In this way the content of output registers is not updated until both MSb and LSb are read avoiding the reading of values related to a different sample time.

8.6 CTRL_REG5 (24h)

Control register 5.

Table 25. Control register 5

BW2	BW1	FSCALE2	FSCALE1	FSCALE0	ST2	ST1	SIM

Table 26. Control register 5 description

BW2:BW1	Anti-aliasing filter bandwidth. Default value: 00 00=800 Hz; 01=400 Hz; 10:=200 Hz; 11:=50 Hz)
FSCALE2:0	Full-scale selection. Default value: 00 000=+/- 2G; 001=+/- 4G; 010=+/- 6G; 011=+/- 8G; 100=+/- 16G
ST2:1	Self-test enable. Default value: 00 00=self-test disabled;
SIM	SPI serial interface mode selection. Default value: 0 0=4-wire interface; 1:=3-wire interface

Table 27. Self-test mode selection

ST2	ST1	Self test mode
0	0	Normal mode
0	1	Positive sign self-test
1	0	Negative sign self-test
1	1	Not allowed

8.7 CTRL_REG6 (25h)

Control register 6.

Table 28. Control register 6

BOOOT	FIFO_EN	WTM_EN	ADD_ INC	P1_ EMPTY	P1_WTM	P1_OVER RUN	P2_ BOOT

Table 29. Control register 6 description

BOOT	Force reboot, cleared as soon as the reboot is finished. Active high.
FIFO_EN	FIFO enable. Default value 0. 0=disable; 1=enable
WTM_EN	Enable FIFO Watermark level use. Default value 0. 0=disable; 1=enable
ADD_INC	Register address automatically incremented during a multiple byte access with a serial interface (I^2C or SPI). 0=disable; 1=enable
P1_EMPTY	Enable FIFO Empty indication on int1. Default value 0. 0=disable; 1=enable
P1_WTM	FIFO Watermark interrupt on int1. Default value 0. 0:=disable; 1=enable
P1_OVERRUN	FIFO overrun interrupt on int1. Default value 0. 0=disable; 1=enable
P2_BOOT	BOOT interrupt on int2. Default value 0. 0=disable; 1=enable

8.8 STATUS (27h)

Status register.

Table 30. Status register

ZYXOR	ZOR	YOR	XOR	ZYXDA	ZDA	YDA	XDA

Table 31. Status register description

ZYXOR	X, Y, and Z axis data overrun. Default value: 0 0=no overrun has occurred; 1=a new set of data has overwritten the previous ones
ZOR	Z axis data overrun. Default value: 0 0=no overrun has occurred; 1=a new set of data for the Z-axis has overwritten the previous one
YOR	Y axis data overrun. Default value: 0 0=no overrun has occurred; 1=a new data for the Y-axis has overwritten the previous one
XOR	X axis data overrun. Default value: 0 0=no overrun has occurred; 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 0=a new set of data is not yet available; 1=a new set of data is available
ZDA	Z axis new data available. Default value: 0 0=a new data for the Z-axis is not yet available; 1=a new data for the Z-axis is available

Table 31. Status register description (continued)

YDA	Y axis new data available. Default value: 0 0=a new data for the Y-axis is not yet available; 1=a new data for the Y-axis is available
XDA	X axis new data available. Default value: 0 0=a new data for the X-axis is not yet available; 1=a new data for the X-axis is available

8.9 OUT_T (0Ch)

Temperature output register. Temperature data (1LSB/deg - 8-bit resolution). The value is expressed as two's complement.

Table 32. OUT_T register

Temp7	Temp6	Temp5	Temp4	Temp3	Temp2	Temp1	Temp0

Table 33. OUT_T register description

Temp7-Temp0	Temperature data.

8.10 OFF_X (10h)

Offset correction X-axis register,signed value.

Table 34. Offset X default value

0	0	0	0	0	0	0	0

8.11 OFF_Y (11h)

Offset correction Y-axis register, signed value.

Table 35. Offset Y default value

0	0	0	0	0	0	0	0

8.12 OFF_Z (12h)

Offset correction Z-axis register, signed value.

Table 36. Offset Z default value

0	0	0	0	0	0	0	0

8.13 CS_X (13h)

Constant shift signed value X-axis register - state machine only.

Table 37. Constant shift X-axis default value

0	0	0	0	0	0	0	0

8.14 CS_Y (14h)

Constant shift signed value Y-axis register - state machine only.

Table 38. Constant shift Y-axis default value

0	0	0	0	0	0	0	0

8.15 CS_Z (15h)

Constant shift signed value Y-axis register - state machine only.

Table 39. Constant shift Y-axis default value

0	0	0	0	0	0	0	0

8.16 LC (16h - 17h)

16-bit long-counter register for interrupt state machine programs timing.

Table 40. LC_L default value

0	0	0	0	0	0	0	1

Table 41. LC_H default value

0	0	0	0	0	0	0	0

01h=counting stopped, 00h=counter full:interrupt available and counter is set to default.
Values higher than 00h:counting

8.17 STAT (18h)

Interrupt status - interrupt synchronization register.

Table 42. STAT register

LONG	SYNCW	SYNC1	SYNC2	INT_SM1	INT_SM2	DOR	DRDY

Table 43. STAT register description

LONG	0=no interrupt, 1=long counter (LC) interrupt flag common for both SM
SYNCW	Synchronization for external Host Controller interrupt based on output data 0=no action waiting from host; 1=action from host based on output data
SYNC1	0=SM1 running normally, 1=SM1 stopped and await restart request from SM2
SYNC2	0=SM2 running normally, 1=SM2 stopped and await restart request from SM1
INT_SM1	SM1 - Interrupt Selection - 1=SM1 interrupt enable; 0: SM1 interrupt disable
NT_SM2	SM2 - Interrupt Selection - 1=SM2 interrupt enable; 0: SM2 interrupt disable
DOR	Data overrun indicates not read data from output register when next data samples measure start; 0=no overrun, 1=data overrun data overrun bit is reset when next sample is ready
DRDY	data ready from output register 0=data not ready, 1=data ready

8.18 VFC_1 (1Bh)

Vector coefficient register 1 for DIff filter.

Table 44. Vector filter coefficient register 1 default value

0	0	0	0	0	0	0	0

8.19 VFC_2 (1Ch)

Vector coefficient register 2 for DIff filter.

Table 45. Vector filter coefficient register 2 default value

0	0	0	0	0	0	0	0

8.20 VFC_3 (1Dh)

Vector coefficient register 3 for FSM2 filter.

Table 46. Vector filter coefficient register 3 default value

0	0	0	0	0	0	0	0

8.21 VFC_4 (1Eh)

Vector coefficient register 4 for DIff filter.

Table 47. Vector filter coefficient register 4 default value

0	0	0	0	0	0	0	0

8.22 THRS3 (1Fh)

Threshold value e register.

Table 48. Threshold value register 3 default value

0	0	0	0	0	0	0	0

8.23 OUT_X (28h - 29h)

X-axis output register.

Table 49. OUT_X_L register default value

0	0	0	0	0	0	0	0

Table 50. OUT_X_H register default value

0	0	0	0	0	0	0	0

8.24 OUT_Y (2Ah - 2Bh)

Y-axis output register.

Table 51. OUT_Y_L register default value

0	0	0	0	0	0	0	0

Table 52. OUT_Y_H register default value

0	0	0	0	0	0	0	0

8.25 OUT_Z (2Ch - 2Dh)

Z-axis output register.

Table 53. OUT_Z_L register default value

0	0	0	0	0	0	0	0

Table 54. OUT_Z_H register default value

0	0	0	0	0	0	0	0

8.26 FIFO_CTRL (2Eh)

FIFO control register.

Table 55. FIFO control register

FMODE2	FMODE1	FMODE0	WTMP4	WTMP3	WTMP2	WTMP1	WTMP4

FMODE2:FMODE0 = FIFO Mode Selection.

WTMP4:WTMP0 = FIFO Watermark pointer; FIFO deep if the Watermark is enabled.

Table 56. FIFO mode selection

FMODE2	FMODE1	FMODE0	Mode
0	0	0	Bypass Mode. FIFO turned off
0	0	1	FIFO Mode. Stop collecting data when FIFO is full.
0	1	0	Stream Mode. If the FIFO is full the new sample overwrites the older one
0	1	1	Stream mode until trigger is de-asserted, then FIFO mode
1	0	0	Bypass mode until trigger is de-asserted, then Stream mode
1	0	1	Not Used
1	1	0	Not Used.
1	1	1	Bypass mode until trigger is de-asserted, then FIFO mode

The FIFO trigger is the INT2 source.

8.27 FIFO_SRC (2Fh)

FIFO SRC control register.

Table 57. FIFO_SRC register

WTM	OVRN_ FIFO	EMPTY	FSS4	FSS3	FSS2	FSS1	FSS0

Table 58. FIFO_SRC register description

WTM	Watermark status. 0=FIFO filling is lower than WTM level; 1=FIFO filling is equal or higher than WTM level
OVRN_FIFO	Overrun bit status. 0=FIFO is not completely filled; 1=FIFO is completely filled
EMPTY	FIFO empty bit. 0=FIFO not empty; 1=FIFO empty)
FSS4-FSS0	FIFO stored data level

8.28 CTRL_REG1 (21h)

SM1 control register.

Table 59. SM1 control register

HYST2_1	HYST1_1	HYST0_1	-	SM1_PIN	-	-	SM1_EN

Table 60. SM1 control register structure

HYST2_1 HYST1_1 HYST0_1	Hysteresis unsigned value to be added or subtracted from threshold value in SM1 Default value=000
SM1_PIN	0=SM1 interrupt routed to INT1, 1=SM1 interrupt routed to INT2 pin Default value=0
SM1_EN	0=SM1 disabled, 1=SM1 enabled Default value=0

8.29 STx_1 (40h-4Fh)

State machine 1 code register STx_1 (x = 1-16).

State machine 1 system register is made up of 16, 8- bit registers to implement 16-step op-code.

8.30 TIM4_1 (50h)

8-bit general timer (unsigned value) for SM1 operation timing.

Table 61. Timer4 default value

0	0	0	0	0	0	0	0

8.31 TIM3_1 (51h)

8-bit general timer (unsigned value) for SM1 operation timing.

Table 62. Timer3 default value

0	0	0	0	0	0	0	0

8.32 TIM2_1 (52h - 53h)

16-bit general timer (unsigned value) for SM1 operation timing.

Table 63. TIM2_1_L default value

0	0	0	0	0	0	0	0

Table 64. TIM2_1_H default value

0	0	0	0	0	0	0	0

8.33 TIM1_1 (54h - 55h)

16-bit general timer (unsigned value) for SM1 operation timing.

Table 65. TIM1_1_L default value

0	0	0	0	0	0	0	0

Table 66. TIM1_1_H default value

0	0	0	0	0	0	0	0

8.34 THRS2_1 (56h)

Threshold value for SM1 operation.

Table 67. THRS2_1 default value

0	0	0	0	0	0	0	0

8.35 THRS1_1 (57h)

Threshold value for SM1 operation.

Table 68. THRS1_1 default value

0	0	0	0	0	0	0	0

8.36 MASK1_B (59h)

Axis and sign mask (swap) for SM1 motion detection operation.

Table 69. MASK1_B axis and sign mask register

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V

Table 70. MASK1_B register structure

P_X	0=X + disabled, 1=X + enabled
N_X	0=X - disabled, 1=X – enabled
P_Y	0=Y+ disabled, 1=Y + enabled
N_Y	0=Y- disabled, 1=Y – enabled
P_Z	0=Z + disabled, 1=Z + enabled
N_Z	0=Z - disabled, 1=Z – enabled
P_V	0=V + disabled, 1=V + enabled
N_V	0=V - disabled, 1=V – enabled

8.37 MASK1_A (5Ah)

Axis and sign mask (default) for SM1 motion detection operation.

Table 71. MASK1_A axis and sign mask register

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V

Table 72. MASK1_A register structure

P_X	0=X + disabled, 1=X + enabled
N_X	0=X - disabled, 1=X – enabled
P_Y	0=Y + disabled, 1=Y + enabled
N_Y	0=Y - disabled, 1=Y – enabled
P_Z	0=Z + disabled, 1=Z + enabled
N_Z	0=Z - disabled, 1= Z – enabled
P_V	0=V + disabled, 1=V + enabled
N_V	0=V - disabled, 1=V – enabled

8.38 SETT1 (5Bh)

Setting of threshold, peak detection and flags for SM1 motion detection operation.

Table 73. SETT1 register structure

P_DET	THR3_SA	ABS	-	-	THR3_MA	R_TAM	SITR

Table 74. SETT1 register description

P_DET	SM1 peak detection. Default value:0 0=peak detection disabled, 1=peak detection enabled
THR3_SA	Default value:0 0=no action, 1=threshold 3 limit value for axis and sign mask reset (MASKB_1)
ABS	Default value:0 0=unsigned thresholds, 1=signed thresholds
THR3_MA	Default value:0 0=no action, 1=threshold 3 limit value for axis and sign mask reset (MASKA_1)
R_TAM	Next condition validation flag. Default value:0 0=no valid next condition found, 1=valid next condition found and reset
SITR	Default value:0 0=no actions, 1=program flow can be modified by STOP and CONT commands

8.39 PR1 (5Ch)

Program and reset pointer for SM1 motion detection operation.

Table 75. PR1 register

PP3	PP2	PP1	PP0	RP3	RP2	RP1	RP0

Table 76. PR1 register description

PP3-PP0	SM1 program pointer address
RP3-RP0	SM1 reset pointer address

8.40 TC1 (5Dh-5E)

16-bit general timer (unsigned output value) for SM1 operation timing.

Table 77. TC1_L default value

0	0	0	0	0	0	0	0

Table 78. TC1_H default value

0	0	0	0	0	0	0	0

8.41 OUTS1 (5Fh)

Output flags on axis for interrupt SM1 management.

Table 79. OUTS1 register

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V

Read action of this register, depending on the flag affects SM1 interrupt functions.

Table 80. OUTS1 register description

P_X	0=X + no show, 1=X+ show
N_X	0=X - no show, 1=X – show
P_Y	0=Y + no show, 1=Y + show
N_Y	0=Y - no show, 1=Y – show
P_Z	0=Z + no show, 1=Z + show
N_Z	0=Z - no show, 1=Z – show
P_V	0=V + no show, 1=V + show
N_V	0=V - no show, 1=V – show

8.42 PEAK1 (19h)

Peak detection value register for SM1 operation.

Table 81. PEAK1 default value

0	0	0	0	0	0	0	0

Peak detected value for next condition SM1.

8.43 CTRL_REG2 (22h)

State program 2 interrupt MNG - SM2 control register.

Table 82. SM2 control register

HYST2_2	HYST1_2	HYST0_2	-	SM2_PIN	-	-	SM2_EN

Table 83. SM2 control register description

HYST2_2 HYST1_2 HYST0_2	Hysteresis unsigned value to be added or subtracted from threshold value in SM2. Default value=000
SM2_PIN	0=SM2 interrupt routed to INT1, 1=SM2 interrupt routed to INT1 pin. Default value=0
SM2_EN	0=SM2 disabled, 1=SM2 enabled. Default value=0

8.44 STx_1 (60h-6Fh)

State Machine 2 code register STx_1 (x = 1-16).

State machine 2 system register is made up of 16 8-bit registers, to implement 16-step op-code.

8.45 TIM4_2 (70h)

8-bit general timer (unsigned value) for SM2 operation timing.

Table 84. Timer4 default value

0	0	0	0	0	0	0	0

8.46 TIM3_2 (71h)

8-bit general timer (unsigned value) for SM2 operation timing.

Table 85. Timer3 default value

0	0	0	0	0	0	0	0

8.47 TIM2_2 (72h - 73h)

16-bit general timer (unsigned value) for SM2 operation timing.

Table 86. TIM2_2_L default value

0	0	0	0	0	0	0	0

Table 87. TIM2_2_H default value

0	0	0	0	0	0	0	0

8.48 TIM1_2 (74h - 75h)

16-bit general timer (unsigned value) for SM2 operation timing.

Table 88. TIM1_2_L default value

0	0	0	0	0	0	0	0

Table 89. TIM1_2_H default value

0	0	0	0	0	0	0	0

8.49 THRS2_2 (76h)

Threshold signed value for SM2 operation.

Table 90. THRS2_2 default value

0	0	0	0	0	0	0	0

8.50 THRS1_2 (77h)

Threshold signed value for SM2 operation.

Table 91. THRS1_2 default value

0	0	0	0	0	0	0	0

8.51 MASK2_B (79h)

Axis and sign mask (swap) for SM2 motion detection operation.

Table 92. MASK2_B axis and sign mask register

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V

Table 93. MASK2_B register description

P_X	0=X + disabled, 1=X + enabled
N_X	0=X - disabled, 1=X – enabled
P_Y	0=Y + disabled, 1=Y + enabled
N_Y	0=Y - disabled, 1=Y – enabled
P_Z	0=Z + disabled, 1=Z + enabled
N_Z	0=Z - disabled, 1=Z – enabled

Table 93. MASK2_B register description

P_V	0=V + disabled, 1=V + enabled
N_V	0=V - disabled, 1=V – enabled

8.52 MASK2_A (7Ah)

Axis and sign mask (default) for SM2 motion detection operation.

Table 94. MASK2_A axis and sign mask register

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V

Table 95. MASK2_B register description

P_X	0=X + disabled, 1=X + enabled
N_X	0=X - disabled, 1=X – enabled
P_Y	0=Y + disabled, 1=Y + enabled
N_Y	0=Y - disabled, 1=Y – enabled
P_Z	0=Z + disabled, 1=Z + enabled
N_Z	0=Z - disabled, 1=Z – enabled
P_V	0=V + disabled, 1=V + enabled
N_V	0=V - disabled, 1=V – enabled

8.53 SETT2 (7Bh)

Setting of threshold, peak detection and flags for SM2 motion detection operation.

Table 96. SETT2 register

P_DET	THR3_SA	ABS	-	-	THR3_MA	R_TAM	SITR

Table 97. SETT2 register description

P_DET	SM2 peak detection. Default value: 0 0=peak detection disabled, 1=peak detection enabled
THR3_SA	Default value: 0 0=no action, 1=threshold 3 limit value for axis and sign mask reset (MASK2_B)
ABS	Default value: 0 0=unsigned thresholds, 1=signed thresholds
THR3_MA	Default value: 0 0=no action, 1=threshold 3 limit value for axis and sign mask reset (MASK2_A)

Table 97. SETT2 register description

R_TAM	Next condition validation flag. Default value:0 0=no valid next condition found, 1=valid next condition found and reset
SITR	Default value: 0 0=no actions, 1=program flow can be modified by STOP and CONT commands

8.54 PR2 (7Ch)

Program and reset pointer for SM2 motion detection operation.

Table 98. PR2 register

PP3	PP2	PP1	PP0	RP3	RP2	RP1	RP0

Table 99. PR2 register description

PP3-PP0	SM2 program pointer address
RP3-RP0	SM2 reset pointer address

8.55 TC2 (7Dh-7E)

16-bit general timer (unsigned output value) for SM2 operation timing.

Table 100. TC2_L default value

0	0	0	0	0	0	0	0

Table 101. TC2_H default value

0	0	0	0	0	0	0	0

8.56 OUTS2 (7Fh)

Output flags on axis for interrupt SM2 management.

Table 102. OUTS2 register

P_X	N_X	P_Y	N_Y	P_Z	N_Z	P_V	N_V

Read action of this register, depending on the flag affects SM2 interrupt functions.

Table 103. OUTS2 register description

P_X	0=X + no show, 1=X + show
N_X	0=X - no show, 1=X – show

Table 103. OUTS2 register description

P_Y	0=Y + no show, 1=Y + show
N_Y	0=Y - no show, 1=Y – show
P_Z	0=Z + no show, 1=Z + show
N_Z	0=Z - no show, 1=Z – show
P_V	0=V + no show, 1=V + show
N_V	0=V - no show, 1=V – show

8.57 PEAK2 (1Ah)

Peak detection value register for SM2 operation.

Table 104. PEAK2 default value

0	0	0	0	0	0	0	0

Peak detected value for next condition SM2.

8.58 DES2 (78h)

Decimation counter value register for SM2 operation.

Table 105. DES2 default value

0	0	0	0	0	0	0	0

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.

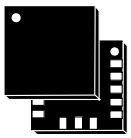
9 Package information

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. ECOPACK is an ST trademark.

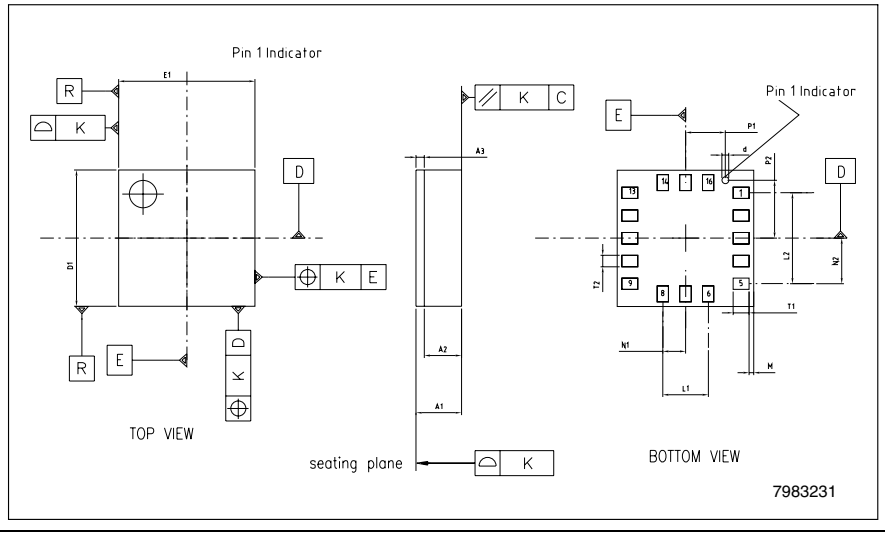
Figure 12. LGA-16: mechanical data and package dimensions

Ref.	Dimensions					
	mm			inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A1			1.000			0.0394
A2		0.785			0.0309	
A3		0.200			0.0079	
D1	2.850	3.000	3.150	0.1122	0.1181	0.1240
E1	2.850	3.000	3.150	0.1122	0.1181	0.1240
L1		1.000	1.060		0.0394	0.0417
L2		2.000	2.060		0.0787	0.0811
N1		0.500			0.0197	
N2		1.000			0.0394	
M	0.040	0.100	0.160	0.0016	0.0039	0.0063
P1		0.875			0.0344	
P2		1.275			0.0502	
T1	0.290	0.350	0.410	0.0114	0.0138	0.0161
T2	0.190	0.250	0.310	0.0075	0.0098	0.0122
d		0.150			0.0059	
k		0.050			0.0020	

Outline and mechanical data



LGA-16 (3x3x1.0mm)
Land Grid Array Package



10 Revision history

Table 106. Document revision history

Date	Revision	Changes
26-Oct-2011	1	Initial release.

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST’s terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST’S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY TWO AUTHORIZED ST REPRESENTATIVES, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER’S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com