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LSM303DLH

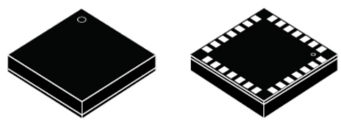
Sensor module: 3-axis accelerometer and 3-axis magnetometer

Features

- Analog supply voltage: 2.5 V to 3.3 V
- Digital supply voltage IOs: 1.8 V
- Power-down mode
- 3 magnetic field channels and 3 acceleration channels
- ±1.3 to ±8,1 gauss magnetic field full-scale
- ±2 *g*/±4 *g*/±8 *g* dynamically selectable full-scale
- 16-bit data out
- I^{2}C serial interface
- 2 independent programmable interrupt generators for free-fall and motion detection
- Embedded self-test
- Accelerometer sleep-to-wakeup function
- 6D orientation detection
- ECOPACK® RoHS and “Green” compliant (see *Section 10*)

Applications

- Compensated compassing
- Map rotation
- Position detection
- Motion-activated functions
- Free-fall detection
- Intelligent power-saving for handheld devices
- Display orientation
- Gaming and virtual reality input devices
- Impact recognition and logging
- Vibration monitoring and compensation



LGA-28L (5x5x1.0 mm)

Description

The LSM303DLH is a system-in-package featuring a 3D digital linear acceleration sensor and a 3D digital magnetic sensor. The various sensing elements are manufactured using specialized micromachining processes, while the IC interfaces are realized using a CMOS technology that allows the design of a dedicated circuit which is trimmed to better match the sensing element characteristics. The LSM303DLH has a linear acceleration full-scale of ±2 *g* / ±4 *g* / ±8 *g* and a magnetic field full-scale of ±1.3 / ±1.9 / ±2.5 / ±4.0 / ±4.7 / ±5,6 / ±8.1 gauss, both fully selectable by the user. The LSM303DLH includes an I^{2}C serial bus interface that supports standard mode (100 kHz) and fast mode (400 kHz). The internal self-test capability allows the user to check the functioning of the whole module in the final application. The system can be configured to generate an interrupt signal by inertial wakeup/free-fall events, as well as by the position of the device itself. Thresholds and timing of interrupt generators are programmable on the fly by the end user. Magnetic and accelerometer parts can be enabled or put in power-down mode separately. The LSM303DLH is available in a plastic land grid array (LGA) package, and is guaranteed to operate over an extended temperature range from -30 to +85 °C.

Table 1. Device summary

Part number	Temp. range [°C]	Package	Packing
LSM303DLH	-30 to +85	LGA-28	Tray
LSM303DLHTR			Tape and reel

Contents

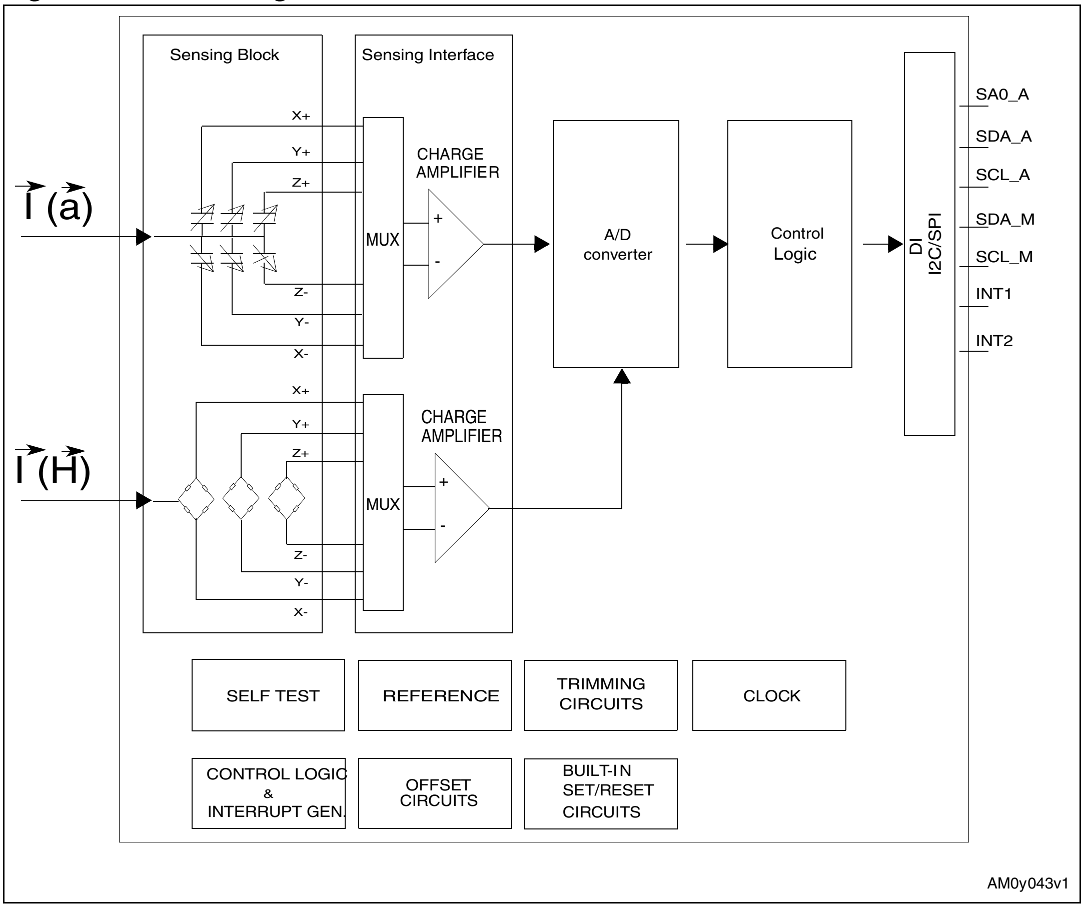
List of tables

List of figures

1 Block diagram and pin description

1.1 Block diagram

Figure 1. Block diagram



1.2 Pin description

Figure 2. Pin connection

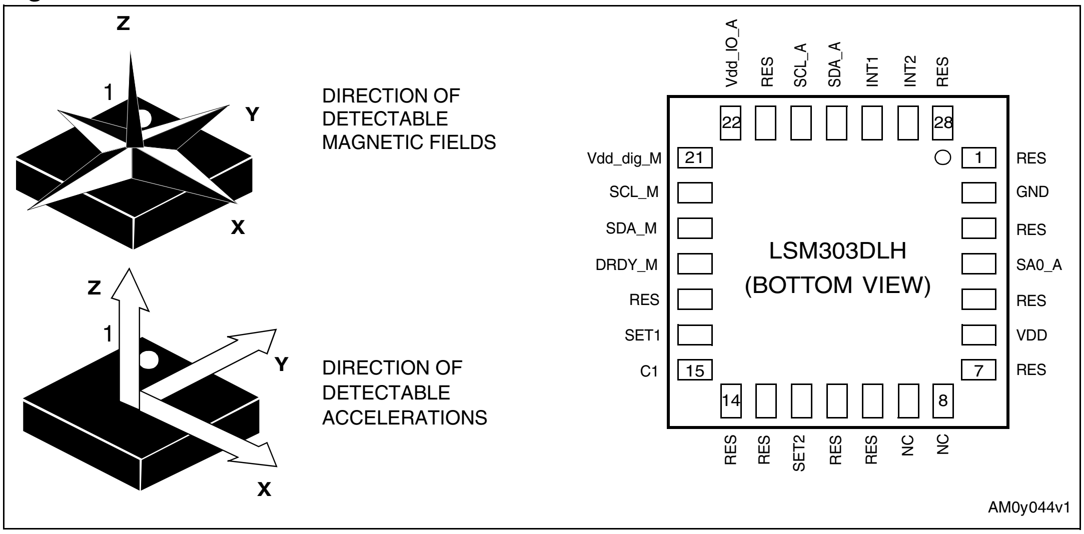


Table 2. Pin description

Pin#	Name	Function
1	Reserved	Connect to GND
2	GND	0 V supply
3	Reserved	Connect to GND
4	SA0_A	Linear acceleration signal I^2C less significant bit of the device address (SA0)
5	Reserved	To be connected to Vdd I^2C bus
6	Vdd	Power supply
7	Reserved	Connect to Vdd
8	NC	Not connected
9	NC	Not connected
10	Reserved	Leave unconnected
11	Reserved	Leave unconnected
12	SET2	S/R capacitor connection (C2)
13	Reserved	Leave unconnected
14	Reserved	Leave unconnected
15	C1	Reserved capacitor connection (C1)
16	SET1	S/R capacitor connection (C2)
17	Reserved	Connect to GND
18	DRDY_M	Magnetic signal interface data ready - test point
19	SDA_M	Magnetic signal interface I^2C serial data (SDA)
20	SCL_M	Magnetic signal interface I^2C serial clock (SCL)
21	Vdd_dig_M	Magnetic sensor digital power supply
22	Vdd_IO_A	Linear acceleration signal interface power supply for I/O pins
23	Reserved	Connect to Vdd_IO_A
24	SCL_A	Linear acceleration signal interface I^2C serial clock (SCL)
25	SDA_A	Linear acceleration signal interface I^2C serial data (SDA)
26	INT1	Inertial interrupt 1
27	INT2	Inertial interrupt 2
28	Reserved	Connect to GND

2 Module specifications

2.1 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
LA_FS	Linear acceleration measurement range[(2)]	FS bit set to 00		±2.0		g
		FS bit set to 01		±4.0		
		FS bit set to 11		±8.0		
M_FS	Magnetic measurement range	GN bits set to 001		±1.3		gauss
		GN bits set to 010		±1.9		
		GN bits set to 011		±2.5		
		GN bits set to 100		±4.0		
		GN bits set to 101		±4.7		
		GN bits set to 110		±5.6		
		GN bits set to 111		±8.1		
LA_So	Linear acceleration sensitivity	FS bit set to 00 12 bit representation	0.9	1	1.1	m*g*/digit
		FS bit set to 01 12 bit representation	1.8	2	2.2	
		FS bit set to 11 12 bit representation	3.5	3.9	4.3	
M_GN	Magnetic gain setting	GN bits set to 001 (X,Y)		1055		LSB/ gauss
		GN bits set to 001 (Z)		950		
		GN bits set to 010 (X,Y)		795		
		GN bits set to 010 (Z)		710		
		GN bits set to 011 (X,Y)		635		
		GN bits set to 011 (Z)		570		
		GN bits set to 100 (X,Y)		430		
		GN bits set to 100 (Z)		385		
		GN bits set to 101 (X,Y)		375		
		GN bits set to 101 (Z)		335		
		GN bits set to 110 (X,Y)		320		
		GN bits set to 110 (Z)		285		
		GN bits set to 111[(2)] (X,Y)		230		
		GN bits set to 111[(2)] (Z)		205		

a. The product is factory calibrated at 2.5 V. The operational power supply range is from 2.5 V to 3.3 V.

Table 3. Mechanical characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.(1)	Max.	Unit
LA_TCSo	Linear acceleration sensitivity change vs. temperature	FS bit set to 00		±0.01		%/°C
LA_TyOff	Linear acceleration typical zero-*g* level offset accuracy(3),(4)	FS bit set to 00		±20		m*g*
LA_TCOff	Linear acceleration zero-*g* level change vs temperature	Max delta from 25 °C		±0.1		m*g*/°C
LA_An	Acceleration noise density	FS bit set to 00		218		μ*g*/√Hz
LA_Vst	Linear acceleration self-test output change(5),(6),(7)	FS bit set to 00 X axis		300		LSb
		FS bit set to 00 Y axis		-300		LSb
		FS bit set to 00 Z axis		350		LSb
M_CAS	Magnetic cross-axis sensitivity	Cross field = 0.5 gauss Happlied = ±3 gauss		±1		%FS/ gauss
M_EF	Maximum exposed field	No permitting effect on zero reading			10000	gauss
M_ST	Magnetic self test	Positive bias mode, GN bits set to 100 on X, Y axis		270		LSB
		Positive bias mode, GN bits set to 100 on Z axis		255		LSB
M_R	Magnetic resolution	Vdd = 3 V		8		mgauss
M_DF	Disturbing field	Sensitivity starts to degrade. User S/R pulse to restore sensitivity			20	gauss
Top	Operating temperature range		-30		+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 the CTRL_REG4 STsign bit (*Table 29*), 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=4*g*/4096 at 12bit representation, ±2 *g* full-scale
7. Output data reach 99% of final value after 1/ODR+1ms when enabling self-test mode, due to device filtering

2.2 Electrical characteristics

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

Table 4. Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.[1]	Max.	Unit
Vdd	Supply voltage		2.5		3.3	V
Vdd_IO_A	Accelerometer module power supply for I/O		1.71	1.8	Vdd+0.1	V
Vdd_dig_M	Magnetic module digital power supply		1.71	1.8	2.0	V
Vdd I2C Bus	Magnetic module I^2C bus power supply		1.71	1.8	Vdd+0.1	V
Idd	Current consumption in normal mode[2]			0.83		mA
IddPdn	Current consumption in power-down mode	T = 25°C		3		µA
Top	Operating temperature range		-30		+85	°C

1. Typical specifications are not guaranteed.
2. Magnetic sensor setting ODR = 7.5 Hz. Accelerometer sensor ODR = 50 Hz.

2.3 Communication interface characteristics

2.3.1 Accelerometer sensor I²C - inter IC control interface

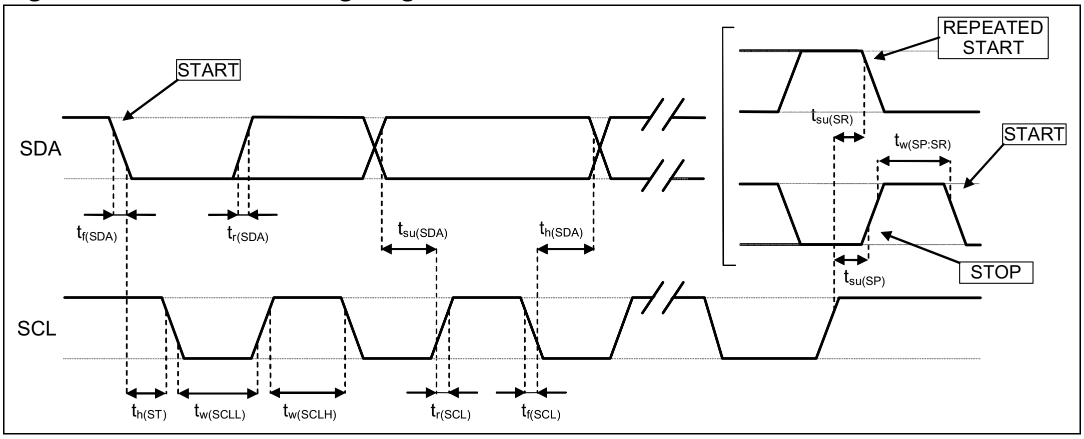
Subject to general operating conditions for Vdd and top.

Table 5. 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		μs
$t_{su(SDA)}$	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	ns
$t_{h(ST)}$	START condition hold time	4		0.6		μs
$t_{su(SR)}$	Repeated START condition setup time	4.7		0.6		μs
$t_{su(SP)}$	STOP condition setup time	4		0.6		μs
$t_{w(SP:SR)}$	Bus free time between STOP and START condition	4.7		1.3		μs

1. Data based on standard I²C protocol requirement, not tested in production.
2. Cb = total capacitance of one bus line, in pF.

Figure 3. I²C slave timing diagram (b)



b. Measurement points are done at 0.2·Vdd_IO and 0.8·Vdd_IO, for both port.

2.3.2 Magnetic field sensing I^2C digital interface

This magnetic sensor IC has a 7-bit serial address and supports I^2C protocols with standard and fast modes (100 kHz and 400 kHz, respectively), but does not support high-speed mode (Hs).

External pull-up resistors are required to support the standard and fast modes. Depending on the application, the internal pull-ups may be used to support slower data speeds than specified by I^2C standards.

This device does not contain 50 ns spike suppression, as required by fast mode operation in the I^2C bus specification.

Activities required by the master (register read and write) have priority over internal activities, such as measurement. The purpose of this priority is to prevent the master waiting and the I^2C bus being engaged for longer than necessary.

3 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 6. Absolute maximum ratings

Symbol	Ratings	Maximum value	Unit
Vin	Input voltage on any control pin (SCL, SDA)	-0.3 to Vdd_IO +0.3	V
A_{POW}	Acceleration (any axis, powered, Vdd = 2.5 V)	3,000 for 0.5 ms	*g*
		10,000 for 0.1 ms	*g*
A_{UNP}	Acceleration (any axis, unpowered)	3,000 for 0.5 ms	*g*
		10,000 for 0.1 ms	*g*
T_{OP}	Operating temperature range	-30 to +85	°C
T_{STG}	Storage temperature range	-40 to +125	°C

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.

4 Terminology

4.1 Linear acceleration sensitivity

Linear acceleration sensitivity describes the gain of the accelerometer sensor and can be determined e.g. by applying 1 *g* acceleration to it. Because the sensor can measure DC accelerations, this can be done easily by pointing the selected axis towards the ground, noting the output value, rotating the sensor 180 degrees (pointing towards the sky) and noting the output value again. By doing so, a ±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 over time. The sensitivity tolerance describes the range of sensitivities of a large number of sensors.

4.2 Zero-*g* level

Zero-*g* level Offset (LA_TyOff) describes the deviation of an actual output signal from the ideal output signal if no linear acceleration is present. A sensor in a steady state on a horizontal surface will measure 0 g on both the X and Y axes, whereas the Z axis will measure 1 *g*. Ideally, the output is 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 the MEMS sensor and therefore the offset can slightly change after mounting the sensor onto a printed circuit board or exposing it to extensive mechanical stress. Offset changes little over temperature; see "Linear acceleration zero-*g* level change vs temperature" (LA_TCOff) in *Table 3.* The Zero-*g* level tolerance (TyOff) describes the standard deviation of the range of Zero-*g* levels of a group of sensors.

4.3 Sleep-to-wakeup

The "sleep-to-wakeup" function, in conjunction with low-power mode, allows further reduction of system power consumption and the development of new smart applications. The LSM303DLH may be set to a low-power operating mode, characterized by lower date rate refreshing. In this way the device, even if sleeping, continues sensing acceleration and generating interrupt requests.

When the sleep-to-wakeup function is activated, the LSM303DLH is able to automatically wake up as soon as the interrupt event has been detected, increasing the output data rate and bandwidth. With this feature the system may be efficiently switched from low-power mode to full-performance depending on user-selectable positioning and acceleration events, thus ensuring power-saving and flexibility.

5 Functionality

The LSM303DLH is a system-in-package featuring a 3D digital linear acceleration and 3D digital magnetic field detection sensor.

The system includes specific sensing elements and an IC interfaces capable of measuring both the linear acceleration and magnetic field applied to it, and to provide a signal to the external world through an I^2C serial interface with separated digital ouput.

The sensing system is manufactured using specialized micromachining processes, while the IC interfaces are realized using a CMOS technology that allows the design of a dedicated circuit which is trimmed to better match the sensing element characteristics.

The LSM303DLH features two data-ready signals (RDY) which indicate when a new set of measured acceleration data and magnetic data are available, thus simplifying data synchronization in the digital system that uses the device.

The LSM303DLH may also be configured to generate an inertial *wakeup* and *free-fall* interrupt signal according to a programmed acceleration event along the enabled axes. Both free-fall and wakeup can be used simultaneously on two different accelerometer interrupts.

5.1 Factory calibration

The IC interface is factory calibrated for linear acceleration sensitivity (LA_So), and linear acceleration Zero-*g* level (LA_TyOff).

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

5.2 Linear acceleration self-test operation

Self-test allows the checking of sensor functionality without moving it. The self-test function is off when the self-test bit (ST) of CTRL_REG4_A (control register 4) is programmed to ‘0‘. When the self-test bit of CTRL_REG4_A is programmed to ‘1‘ an actuation force is applied to the sensor, simulating a definite input acceleration. In this case the sensor outputs will exhibit a change in their DC levels which are related to the selected full-scale through the device sensitivity. When 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.

5.3 Magnetic self-test operation

To check the magnetic sensor for proper operation, a self-test feature is incorporated in which the sensor offset straps are excited to create a nominal field strength (bias field) to be measured. To implement this self-test, the least significant bits (MS1 and MS0) of configuration register A are changed from 00 to 01 (0x12 or 0b000xxx01).

By placing the mode register into single-conversion mode (0x01), two data acquisition cycles are made on each magnetic vector.

The first acquisition is a set pulse followed shortly by measurement data of the external field. The second acquisition has the offset strap excited in the positive bias mode to create about a 0.6 *gauss* self-test field plus the external field. The first acquisition values are subtracted from the second acquisition, and the net measurement is placed into the data output registers.

To leave self-test mode, change the MS1 and MS0 bits of the configuration register A back to 0x00. Also, change the mode register if single-conversion mode is not the intended next mode of operation.

Table 7. Magnetic ST (positive bias)

Symbol	GN bits setting	Test axis	Min.	Typ.(1)	Max.	Unit
ST_M	GN bits set to 001	X,Y axis		655		LSB
		Z axis		630		
	GN bits set to 010	X,Y axis		495		
		Z axis		470		
	GN bits set to 011	X,Y axis		395		
		Z axis		375		
	GN bits set to 100	X,Y axis		270		
		Z axis		255		
	GN bits set to 101	X,Y axis		235		
		Z axis		225		
	GN bits set to 110	X,Y axis		200		
		Z axis		190		
	GN bits set to 111(2)	X,Y axis		140		
		Z axis		135		

1. Typical specifications are not guaranteed

6 Application hints

Figure 4. LSM303DLH electrical connection 1 - recommended for I²C fast mode

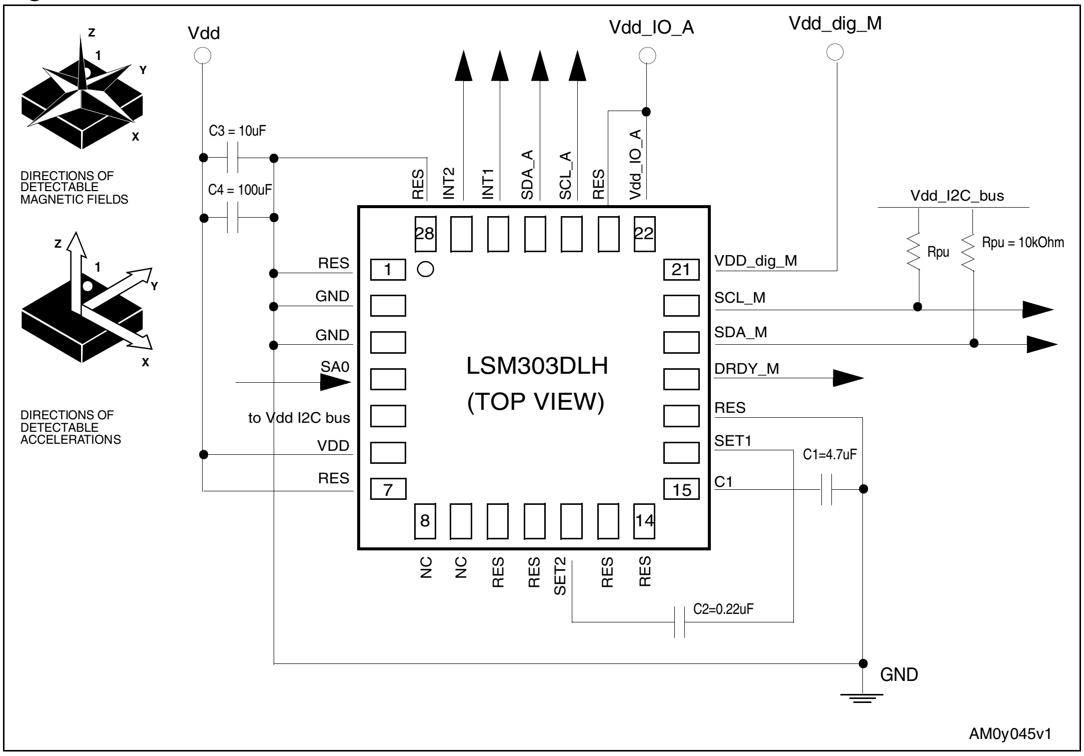
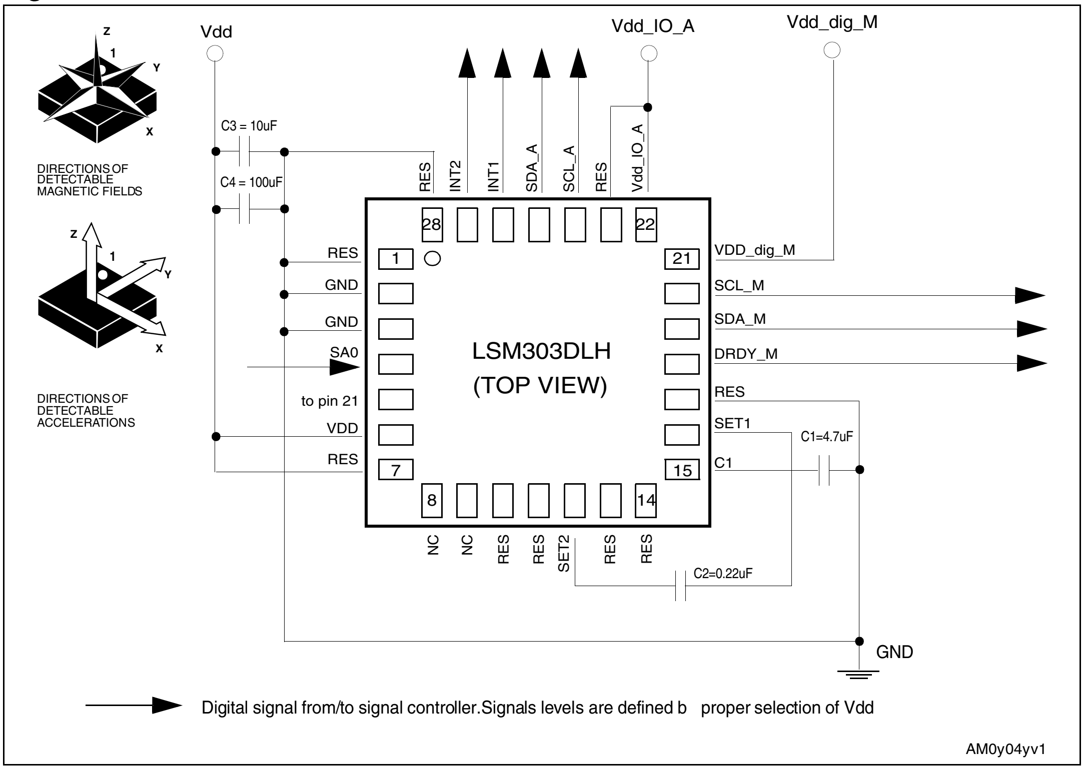


Figure 5. LSM303DLH electrical connection 2



6.1 External capacitors

The C1 and C2 external capacitors should have a low SR value ceramic type construction. Reservoir capacitor C1 is nominally 4.7 µF in capacitance, with the set/reset capacitor C2 nominally 0.22 µF in capacitance.

The device core is supplied through the Vdd line. Power supply decoupling capacitors (C4=100 *nF* ceramic, C3=10 *µF* Al) should be placed as near as possible to the supply pin of the device (common design practice). All the voltage and ground supplies must be present at the same time to obtain proper behavior of the IC (refer to *Figure 4*).

The functionality of the device and the measured acceleration/magnetic field data is selectable and accessible through the I^2C interface.

The functions, the threshold and the timing of the two interrupt pins (INT 1 and INT 2) can be completely programmed by the user through the I^2C interface.

6.2 Pull-up resistors

Pull-up resistors are placed on the two I^2C bus lines.

6.3 Digital interface power supply

This digital interface dedicated to the linear acceleration signal is capable of operating with a standard power supply (Vdd) or using a dedicated power supply (Vdd_IO_A).

This digital interface dedicated to the magnetic field signal requires a dedicated power supply (Vdd_dig_M).

The table below shows the modes available in the various power supply conditions.

Table 8. Operational mode and power supply for magnetic field sensing

Vdd_dig_M	Vdd	Mode supported	Description
High	High	All except off	Digital I/O pins: range from GND to Vdd_I2C_bus / Vdd_dig_M. Device fully functional. Digital logic blocks are powered from Vdd_dig_M supply, including all onboard clocks.
High	Low	Power down	Digital I/O pins: range from GND to Vdd_I2C_bus / Vdd_dig_M. Device measurement functionality not supported. Device I^2C bus and register access supported.

6.4 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/

6.5 High current wiring effects

High current in wiring and printed circuit traces can be the cause of errors in magnetic field measurements for compassing.

Conducto-generated magnetic fields add to earth's magnetic field, creating errors in compass heading computation.

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

7 Digital interfaces

The registers embedded inside the LSM303DLH are accessible through two separate I^2C serial interfaces: one for the accelerometer core and the other for the magnetometer core. The two interfaces can be connected together on the PCB.

Table 9. Serial interface pin description

Pin name	Pin description
SCL_A	I^2C serial clock (SCL) for accelerometer
SDA_A	I^2C serial data (SDA) for accelerometer
SCL_M	I^2C serial clock (SCL) for magnetometer
SDA_M	I^2C serial data (SDA) for magnetometer

7.1 I^2C serial interface

The LSM303DLH I^2C is a bus slave. The I^2C is employed to write the data into the 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 bidirectional line used for sending and receiving the data to/from the interface.

7.1.1 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 8th bit tells whether the master is receiving data from the slave or transmitting data to the slave. When an address is sent, each device in the system compares the first seven bits after a start condition with its address. If they match, the device considers itself addressed by the master.

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

The I²C embedded inside the LSM303DLH behaves like a slave device and the following protocol must be adhered to. After the start condition (ST) a slave address is sent. Once a slave acknowledge (SAK) has been returned, an 8-bit sub-address (SUB) is transmitted: the 7 LSb represent the actual register address while the MSB enables address auto-increment. If the MSb of the SUB field is '1', the SUB (register address) is automatically increased to allow multiple data read/write.

Table 11. Transfer when master is writing one byte to slave

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

Table 12. Transfer when master is writing multiple bytes to slave

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

Table 13. 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		

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 cannot 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 does not acknowledge the slave address (i.e. it is not able to receive because it is performing a 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.

7.1.2 Linear acceleration digital interface

For linear acceleration, the default (factory) 7-bit slave address is 001100xb. The **SDO/SA0** pad can be used to modify the least significant bit of the device address. If the SA0 pad is connected to voltage supply, LSb is ‘1’ (address 0011001b) otherwise if the SA0 pad is connected to ground, LSb value is ‘0’ (address 0011000b). This solution permits connecting and addressing two different accelerometers to the same I^2C lines.

The slave address is completed with a read/write bit. If the bit was ‘1’ (read), a repeated START (SR) condition will have to be issued after the two sub-address bytes; if the bit is ‘0’ (write) the master transmits to the slave with direction unchanged. *Table 14* explains how the SAD+Read/Write bit pattern is composed, listing all the possible configurations.

Table 14. 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)

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 the first register to be read.

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

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		

7.1.3 Magnetic field digital interface

The system communicates via a two-wire I^2C bus system as a slave device. The interface protocol is defined by the I^2C bus specification. The data rate is the standard mode 100 kbps or 400 kbps rates as defined by the I^2C bus specifications. The bus bit format is an 8-bit data/address send and a 1-bit acknowledge bit. The format of the data bytes (payload) shall be case-sensitive ASCII characters or binary data to the magnetic sensor slave, and binary data returned. Negative binary values will be in two’s complement form.

For magnetic sensor, the default (factory) 7-bit slave address is 0011110b (0x3C) for write operations, or 00111101b (0x3D) for read operations.

The Serial Clock (SCL_M) and Serial Data (SDA_M) lines have optional internal pull-up resistors, but require resistive pull-up (Rp) between the master device (usually a host microprocessor) and the LSM303DLH. Pull-up resistance values of about 10 kΩ are recommended with a nominal 1.8 V digital supply voltage (Vdd_dig_M).