Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

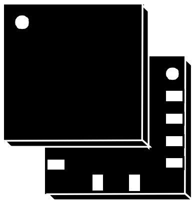
Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

ISM303DAC

High-performance, low-power, compact 3D accelerometer and 3D magnetometer module

Datasheet - production data



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

Features

- 3 magnetic field channels and 3 acceleration channels
- Up to ±50 gauss magnetic dynamic range
- ±2/±4/±8/±16 *g* selectable acceleration full scales
- Dynamic switching between high-resolution, high-frequency and low-power modes
- 16-bit data output
- SPI / I^2C serial interfaces
- Analog supply voltage 1.71 V to 1.98 V
- Programmable interrupt generators for free-fall, motion and magnetic field detection
- Embedded self-test both for the accelerometer and magnetometer
- Embedded 256-level FIFO
- Embedded temperature sensor
- ECOPACK®, RoHS and “Green” compliant

Applications

- Dual mode anti-tampering in smart meters
- Antenna pointing
- Motion tracking
- Robotics and appliances
- Positioning and navigation systems
- Positional and distance sensor

Description

The ISM303DAC is a high-performance, low-power system-in-package featuring a 3D digital linear acceleration sensor and a 3D digital magnetic sensor.

The ISM303DAC has user-selectable linear acceleration full scales of ±2*g*/±4*g*/±8*g*/±16 *g* and is capable of measuring accelerations with output data rates from 1 Hz to 6400 Hz. The device has a magnetic field dynamic range of up to ±50 gauss with output data rates from10 Hz to 150 Hz. The ISM303DAC includes an I^2C serial bus interface that supports standard, fast mode, fast mode plus, and high-speed (100 kHz, 400 kHz, 1 MHz, and 3.4 MHz) and an SPI serial standard interface.

The ISM303DAC has an integrated 256-level first-in, first-out (FIFO) buffer for the accelerometer data which can be used to limit the intervention of the host processor.

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

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

The ISM303DAC is available in a plastic land grid array package (LGA) and is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

Table 1. Device summary

Part number	Temp. range [°C]	Package	Packaging
ISM303DACTR	-40 to +85	LGA-12	Tape and reel

This is information on a product in full production. www.st.com

Contents

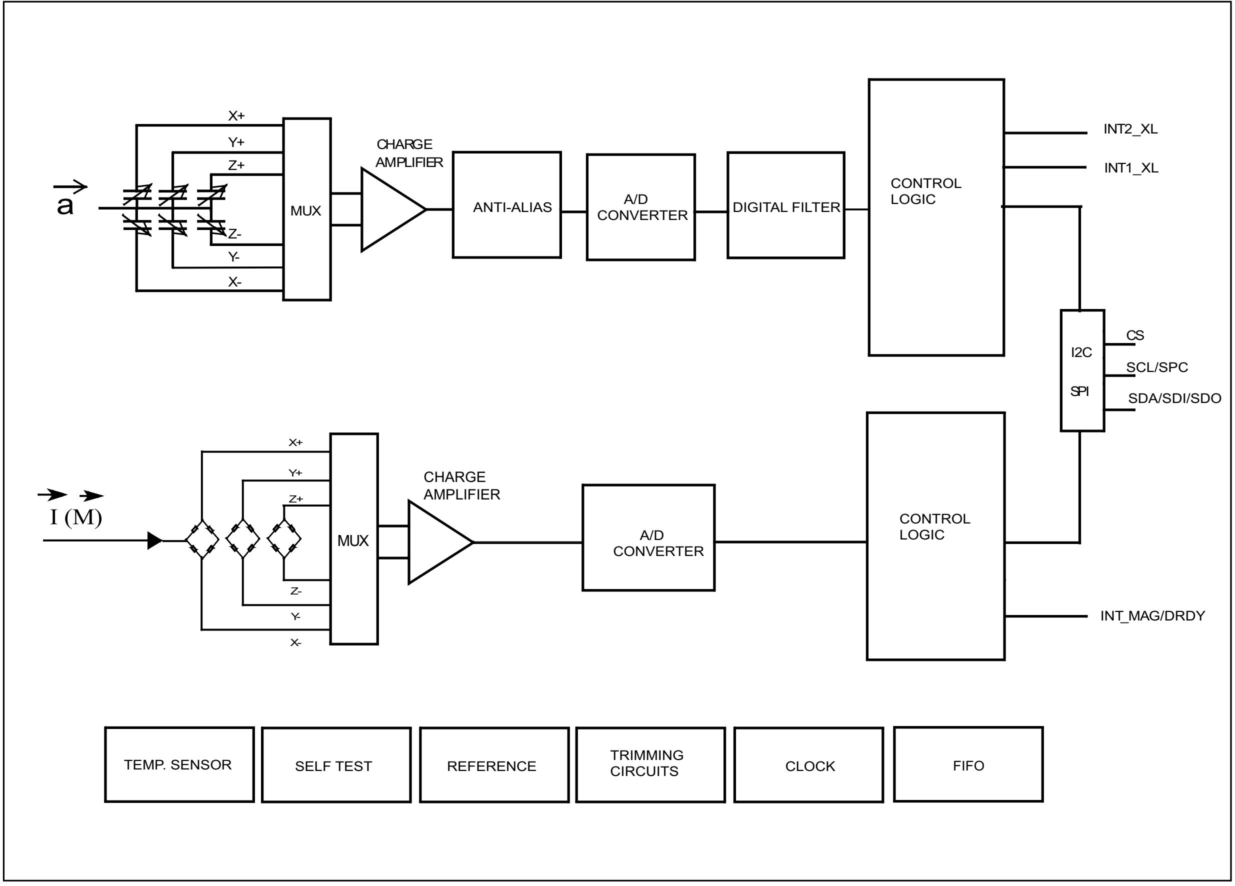
List of tables

List of figures

1 Block diagram and pin description

1.1 Block diagram

Figure 1. Block diagram



1.2 Pin description

Figure 2. Pin connections

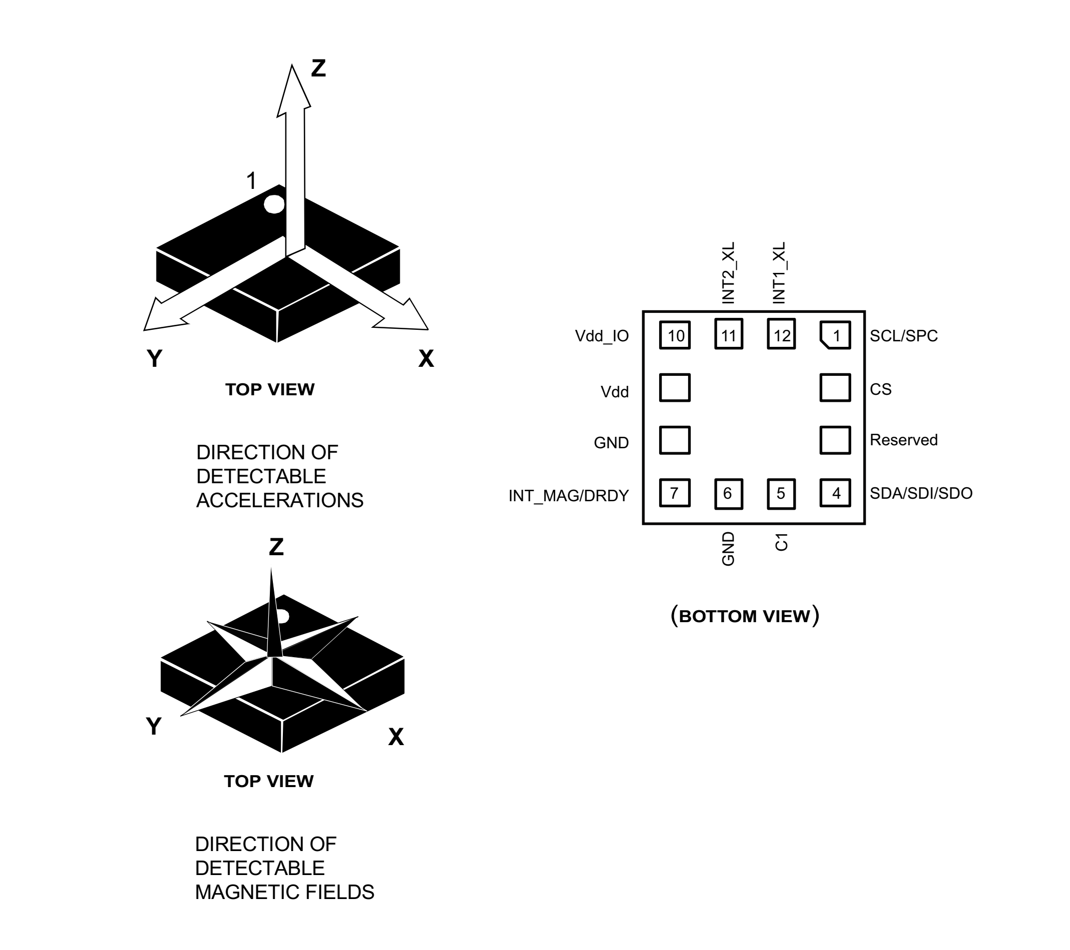


Table 2. Pin description

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

2 Module specifications

2.1 Sensor characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted [a].

Noise density is the same for all ODR.

Table 3. Sensor characteristics

Symbol	Parameter	Test conditions	Min.(1)	Typ.(2)	Max.(1)	Unit
LA_FS	Linear acceleration measurement range			±2		*g*
				±4		
				±8		
				±16		
M_FS	Magnetic dynamic range(3)		±25	±49.152		gauss
LA_So	Sensitivity 16-bit(4)(5)	@ FS ±2 *g*	-7%	0.061	+7%	m*g*/digit
		@ FS ±4 *g*	-7%	0.122	+7%	
		@ FS ±8 *g*	-7%	0.244	+7%	
		@ FS ±16 *g*	-7%	0.488	+7%	
M_So	Magnetic sensitivity(5)		-10%	1.5	+10%	mgauss/ LSB
LA_TCSo	Linear acceleration sensitivity change vs. temperature(6)			0.01		%/°C
M_TCSo	Magnetic sensitivity change vs. temperature(6)			±0.03		%/°C
LA_TyOff	Typical zero-*g* level offset accuracy(7)(8)		-80	±30	+80	m*g*
M_TyOff	Magnetic sensor offset	With offset cancellation(9)(10)	-60	0	+60	mgauss
LA_TCOff	Zero-*g* level change vs. temp.(6)	Max. delta from 25 °C		±0.2		m*g*/°C
M_TCOff	Magnetic sensor offset change vs. temp.	With offset cancellation(9)	-0.3		+0.3	mgauss/ °C
LA_AN	Noise density - high-performance mode (HR or HF mode)(11)	@ FS ±2 *g*		120		µ*g*/√Hz
		@ FS ±4 *g*		150		
		@ FS ±8 *g*		200		
		@ FS ±16 *g*		300		
LA_RMS	RMS noise - low-power mode(12)	@ FS ±2 *g*		6.3		m*g*(RMS)
		@ FS ±4 *g*		8.2		
		@ FS ±8 *g*		11		
		@ FS ±16 *g*		17		

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

Table 3. Sensor characteristics (continued)

Symbol	Parameter	Test conditions	Min.(1)	Typ.(2)	Max.(1)	Unit
M_R	Magnetic RMS noise(13)	High-performance mode		3	5	mgauss (RMS)
ST	Self-test positive difference(14) (accelerometer only)		70		1500	m*g*
M_ST	Magnetic self-test(15)		15		500	mgauss
Top	Operating temperature range		-40		+85	°C

1. Min/Max values are based on characterization results, not tested in production and not guaranteed.
2. Typical specifications are not guaranteed.
3. The typical value of the magnetic dynamic range applies when the magnetic field is fully aligned with one of the sensitive axes. In presence of a stray field in the cross-axis direction, the magnetic dynamic range (max module) can decrease down to the min value.
4. Sensitivity calculated at 16-bit.
5. Values after calibration test and trimming.
6. Measurements are performed in a uniform temperature setup and they are based on characterization data in a limited number of samples, not measured during final test for production.
7. Typical zero-*g* level offset value after calibration and trimming.
8. Offset can be eliminated by enabling the slope filter.
9. Based on characterization data on a limited number of samples, not measured during final test for production.
10. Excluding drift due to magnetic shock.
11. Noise density is the same for all ODR.
12. RMS noise is the same for all ODR.
13. With low-pass filter or offset cancellation enabled.
14. “Self-test positive difference” is defined as: $OUTPUT[mg]_{(CTRL3\ ST2,\ ST1\ bits=01)} - OUTPUT[mg]_{(CTRL3\ ST2,\ ST1\ bits=00)}$.
15. Magnetic “self-test” is defined as $OUTPUT[gauss]_{(self\text{-}test\ enabled)} - OUTPUT[gauss]_{(self\text{-}test\ disabled)}$.

2.2 Temperature sensor characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted.[b]

Table 4. Temperature sensor characteristics

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

1. Typical specifications are not guaranteed.
2. 8-bit resolution.

2.3 Electrical characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted.[b]

Table 5. Electrical characteristics

Symbol	Parameter	Test conditions	Min.[1]	Typ.[2]	Max.[1]	Unit
Vdd	Supply voltage		1.71		1.98	V
Vdd_IO	Module power supply for I/O		1.71	1.8	Vdd+0.1	V
LA_Idd_HR	Accelerometer current consumption in high-resolution mode Magnetic sensor in power-down	12.5Hz-6400Hz ODR range		162		µA
LA_Idd_LP	Accelerometer current consumption in low-power mode Magnetic sensor in power-down.	100 Hz ODR		16		µA
		50 Hz ODR		10		µA
		12.5 Hz ODR		6		µA
		1 Hz ODR		4.5		µA
M_Idd_HR	Magnetic current consumption in high-resolution mode Accelerometer in power-down mode	ODR = 100 Hz		1180		µA
M_Idd_LP	Magnetic current consumption in low-power mode[3] Linear accel. in power-down mode	ODR = 10 Hz		25		µA
Idd_PD	Current consumption in power-down			2.5		µA
VIH	Digital high-level input voltage		0.8*Vdd_IO			V
VIL	Digital low-level input voltage				0.2*Vdd_IO	V
VOH	High-level output voltage	IOH = 4 mA	Vdd_IO - 0.2			V

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

Table 5. Electrical characteristics

Symbol	Parameter	Test conditions	Min.(1)	Typ.(2)	Max.(1)	Unit
VOL	Low-level output voltage	IOL = 4 mA			0.2	V
T_{OP}	Operating temperature range		-40		+85	°C

1. Min/Max values are based on characterization results, not tested in production and not guaranteed.
2. Typical specifications are not guaranteed.
3. Offset cancellation turned off.

2.4 Communication interface characteristics

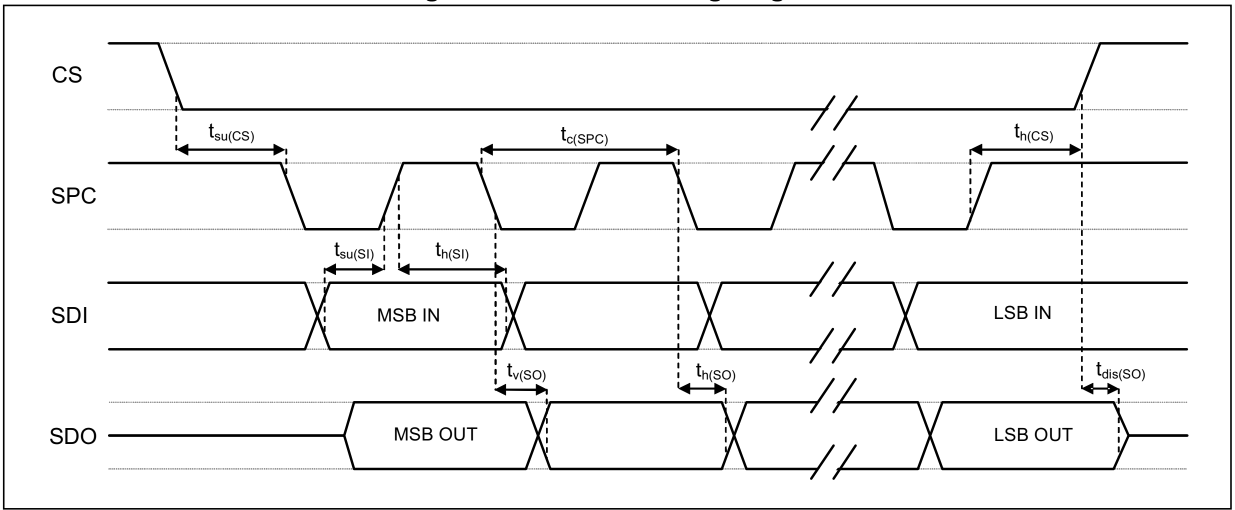
2.4.1 SPI - serial peripheral interface

Subject to general operating conditions for Vdd and Top.

Table 6. SPI slave timing values

Symbol	Parameter	Value (1)		Unit
		Min	Max	
$t_{c(SPC)}$	SPI clock cycle	100		ns
$f_{c(SPC)}$	SPI clock frequency		10	MHz
$t_{su(CS)}$	CS setup time	5		ns
$t_{h(CS)}$	CS hold time	20		
$t_{su(SI)}$	SDI input setup time	5		
$t_{h(SI)}$	SDI input hold time	15		
$t_{v(SO)}$	SDO valid output time		50	
$t_{h(SO)}$	SDO output hold time	5		
$t_{dis(SO)}$	SDO output disable time		50	

Figure 3. SPI slave timing diagram



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

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

2.4.2 I^2C - inter-IC control interface

Subject to general operating conditions for Vdd and Top.

Table 7. I^2C slave timing values (standard and fast mode)

Symbol	Parameter	I^2C standard mode (1)		I^2C fast mode (1)		Unit
		Min	Max	Min	Max	
$f_{(SCL)}$	SCL clock frequency	0	100	0	400	kHz
$t_{w(SCLL)}$	Low period of the SCL clock	4.7		1.3		µs
$t_{w(SCLH)}$	High period of the SCL clock	4.0		0.6		
$t_{su(SDA)}$	Data setup time	250		100		ns
$t_{h(SDA)}$	Data hold time	0	3.45	0	0.9	µs
$t_{h(ST)}$	START condition hold time	4		0.6		
$t_{su(SR)}$	Setup time for a repeated START condition	4.7		0.6		
$t_{su(SP)}$	Setup time for STOP condition	4		0.6		
$t_{w(SP:SR)}$	Bus free time between STOP and START condition	4.7		1.3		

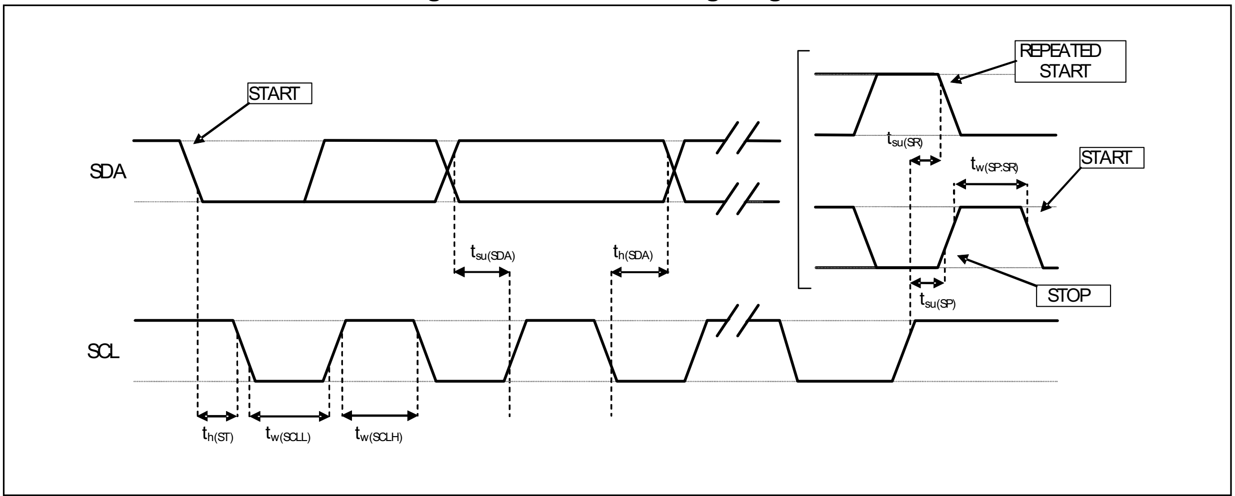
1. Data based on standard I^2C protocol requirement, not tested in production.

Table 8. I^2C slave timing values (fast mode plus and high speed)

Symbol	Parameter	I^2C fast mode plus(1)		I^2C high speed(1)		Unit
		Min	Max	Min	Max	
$f_{(SCL)}$	SCL clock frequency	0	1	0	3.4	MHz
$t_{w(SCLL)}$	Low period of the SCL clock	0.5		0.16		µs
$t_{w(SCLH)}$	High period of the SCL clock	0.26		0.06		
$t_{su(SDA)}$	Data setup time	50		10		ns
$t_{h(SDA)}$	Data hold time	0		0	0.07	µs
$t_{h(ST)}$	START condition hold time	0.26		0.16		
$t_{su(SR)}$	Setup time for a repeated START condition	0.26		0.16		
$t_{su(SP)}$	Setup time for STOP condition	0.26		0.16		
$t_{w(SP:SR)}$	Bus free time between STOP and START condition	0.5				

1. Data based on standard I^2C protocol requirement, not tested in production.

Figure 4. I²C slave timing diagram



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

2.5 Absolute maximum ratings

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

Table 9. Absolute maximum ratings

Symbol	Ratings	Maximum value	Unit
Vdd	Supply voltage	-0.3 to 2.2	V
Vdd_IO	I/O pins supply voltage	-0.3 to 2.2	V
Vin	Input voltage on any control pin (CS, SCL/SPC, SDA/SDI/SDO)	-0.3 to Vdd_IO +0.3	V
A_{POW}	Acceleration (any axis, powered, Vdd = 1.8 V)	3000 for 0.5 ms	*g*
		10000 for 0.2 ms	*g*
A_{UNP}	Acceleration (any axis, unpowered)	3000 for 0.5 ms	*g*
		10000 for 0.2 ms	*g*
M_{EF}	Maximum exposed field	10000	gauss
T_{OP}	Operating temperature range	-40 to +85	°C
T_{STG}	Storage temperature range	-40 to +125	°C
ESD	Electrostatic discharge protection (HBM)	2	kV

Note: Supply voltage on any pin should never exceed 2.2 V.

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

This device is sensitive to electrostatic discharge (ESD), improper handling can cause permanent damage to the part.

3 Terminology

3.1 Sensitivity

3.1.1 Linear acceleration sensor sensitivity

Sensitivity describes the gain of the sensor and can be determined by applying 1 *g* acceleration to it. As the sensor can measure DC accelerations this can be done easily by pointing the axis of interest towards the center of the Earth, noting the output value, rotating the sensor by 180 degrees (pointing to the sky) and noting the output value again. By doing so, ±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 time. The sensitivity tolerance describes the range of sensitivities of a large population of sensors.

3.1.2 Magnetic sensor sensitivity

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

3.2 Zero-*g* level

The zero-*g* level offset (LA_TyOff) describes the deviation of an actual output signal from the ideal output signal if no acceleration is present. A sensor in a steady state on a horizontal surface will measure 0 *g* on the X-axis and 0 *g* on the Y-axis whereas the Z-axis will measure 1 *g*. The output is ideally in the middle of the dynamic range of the sensor (content of OUT registers 00h, data expressed as two's complement number). A deviation from the ideal value in this case is called zero-*g* offset. Offset is to some extent a result of stress to MEMS sensor and therefore the offset can slightly change after mounting the sensor onto a printed circuit board or exposing it to extensive mechanical stress. Offset changes little with temperature, see *Table 3* "Zero-*g* level change vs. temperature" (LA_TCOff). The zero-*g* level tolerance (TyOff) describes the standard deviation of the range of zero-*g* levels of a population of sensors.

3.3 Zero-*gauss* level

Zero-*g*auss level offset (M_TyOff) describes the deviation of an actual output signal from the ideal output if no magnetic field is present.

3.4 Magnetic dynamic range

The magnetic dynamic range of the sensor can be fully exploited when the applied magnetic field is entirely aligned with one of the sensitive axes of the sensor.

In presence of a stray field in the cross-axis direction, the exploitable magnetic dynamic range (maximum module) can decrease.

4 Functionality

4.1 Magnetometer

4.1.1 Magnetometer power modes

The ISM303DAC magnetometer provides two different power modes: high-resolution and low-power modes.

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

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

Table 10. RMS noise of operating modes

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

Table 11. Current consumption of operating modes

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

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

Table 12. Operating mode and turn-on time

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

The ISM303DAC offers single measurement mode in both high-resolution and low-power modes.

Single measurement mode is enabled by writing bits MD[1:0] to '01' in *CFG_REG_A_M (60h)*.

In single measurement mode, once the measurement has been performed, the DRDY pin is set to high, data is available in the output register and the ISM303DAC is automatically configured in idle mode by setting the MD[1] bit to '1'.

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

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

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

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

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

(Current_consumption_10Hz - Current_consumption_in_power_down) / (10 Hz / ODR) + Current_consumption_in_power_down

Where Current_consumption_in_power_down and Current_consumption_10Hz can be found, respectively, in *Table 5* and *Table 11*.

4.1.2 Magnetometer offset cancellation

The ISM303DAC is based on AMR technology: a set pulse is needed to set an initial operating condition.

Offset cancellation is the result of performing a set and reset pulse in the magnetic sensor and it can be enabled to remove the intrinsic sensor offset.

The offset cancellation technique is defined as follows:

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

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

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

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

The offset is cancelled according to the offset cancellation technique:

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

If the device is operating in Continous mode, the offset cancellation is enabled by setting the OFF_CANC bit to 1 in *CFG_REG_B_M (61h)*. In this case, set/reset pulses are continuously performed; a set pulse is applied to one measurement, a reset pulse is applied to the next measurement. If the offset cancellation is disabled (OFF_CANC = 0) and Continuous mode is selected, the set pulse frequency can be configured by setting the Set_FREQ bit in *CFG_REG_B_M (61h)*. If Set_FREQ is set to 0, the set pulse is released every 63 ODR, otherwise if Set_FREQ is set to 1, the set pulse is released only at power-on from Idle mode (a set of the magnetic sensor is performed anyway, even if the offset cancellation is disabled).

If the device is operating in Single mode, in order to enable the offset cancellation, both OFF_CANC and OFF_CANC_ONE_SHOT bits must be set to 1 in *CFG_REG_B_M (61h)*. Enabling these bits, the impulse polarity is inverted between a single read and the next one. While offset cancellation is automatically managed by the device in Continuous mode, if this feature is enabled in Single mode, the user has to remove the offset manually using the formula below:

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

Offset cancellation using single reads is effective only if the reads are close in time, thus ensuring the offset does not drift between two consecutive reads.

4.1.3 Magnetometer interrupt

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

To enable the interrupt function, in INT_CTRL_REG_M register (63h) the "IEN" bit must be set to '1'.

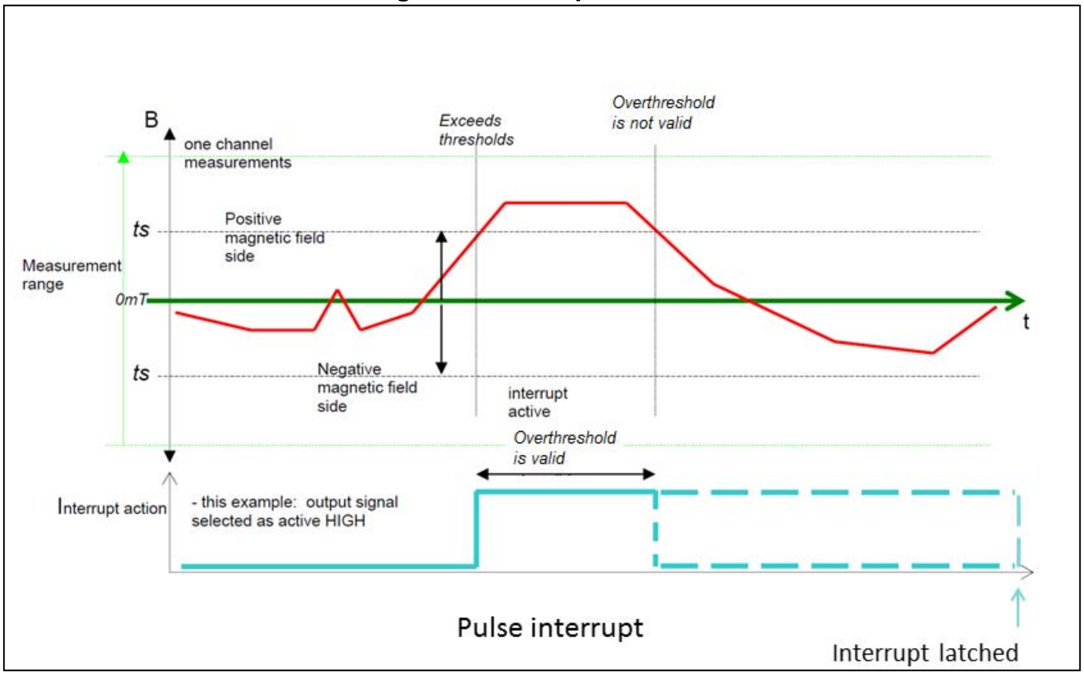
In the LSM303AH the user can select the axis/axes in which the interrupt function can be enabled. In order to do this, the XIEN, YIEN, and ZIEN bits in *INT_CTRL_REG_M (63h)* need be set properly.

The threshold value can be programmed by setting the *INT_THS_L_REG_M (65h)* and *INT_THS_H_REG_M (66h)* registers.

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

When magnetic data exceeds the positive or the negative threshold, the interrupt signal is generated and the information about the type of interrupt is stored in the *INT_SOURCE_REG_M (64h)* register. In particular, when magnetic data exceeds the positive threshold the P_TH_S_axis bit is set to '1', while if data exceeds the negative threshold the N_TH_S_axis bit is set to '1'. If magnetic data lay between the positive and the negative thresholds, no interrupt signal is released.

Figure 5. Interrupt function



Two different approaches for the interrupt function are available:

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

These approaches are configurable by setting the INT_on_DataOFF bit in *CFG_REG_B_M (61h)*.