



# ±8 Gauss, High Performance 3-axis Magnetic Sensor

## MMC5983MA

### FEATURES

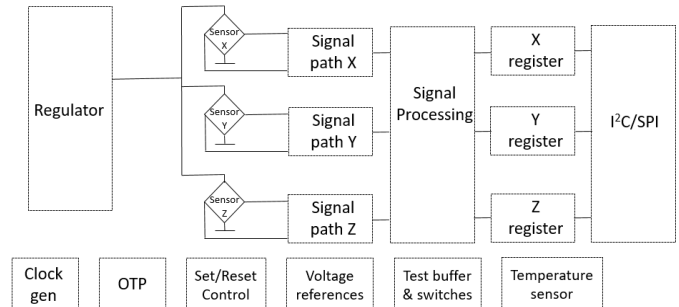
- Fully integrated 3-axis magnetic sensor and electronic circuits requiring fewer external components
- Superior dynamic range and accuracy:
  - ✓ ±8G FSR
  - ✓ 18bits operation
  - ✓ 0.4mG total RMS noise
  - ✓ Enables heading accuracy of ±1°
- Max output data rate of 1000Hz
- Industrial standard low profile package  
3.0mm x 3.0mm x 1.0mm
- Degaussing with built-in SET/RESET function
  - ✓ Eliminates thermal variation induced offset error (Null field output)
  - ✓ Clears the residual magnetization resulting from strong external fields
- On-chip sensitivity compensation
- On-chip temperature sensor
- Data\_Ready Interrupt
- Low power consumption
- 1µA power down current
- I<sup>2</sup>C Slave, FAST(≤400KHz) mode
- 3.0V single low power supply
- SPI interface available
- RoHS compliant

### APPLICATIONS

- Electronic Compass & Navigation
- Position Sensing
- General Purpose Magnetic Field Measurements

### DESCRIPTION

The MMC5983MA is an AEC-Q100 qualified complete 3-axis magnetic sensor with on-chip signal processing and integrated I<sup>2</sup>C/SPI bus suitable for use in automotive applications. The device can be connected directly to a microprocessor, eliminating the need for A/D converters or timing resources.



### FUNCTIONAL BLOCK DIAGRAM

It can measure magnetic fields within the full scale range of ±8 Gauss (G), with 0.25mG/0.0625mG per LSB resolution at 16bits/18bits operation mode and 0.4 mG total RMS noise level, enabling heading accuracy of ±0.5° in electronic compass applications.

An integrated SET/RESET function provides for the elimination of error due to Null Field output change with temperature. Temperature information from the integrated temperature sensor is available over the I<sup>2</sup>C Interface. The SET/RESET function can be performed for each measurement, periodically, or when the temperature changes by a predetermined amount as the specific application requires.

In addition, the SET/RESET function clears the sensors of any residual magnetic polarization resulting from exposure to strong external magnets.

The MMC5983MA is packaged in a low profile LGA package and an operating temperature range from -40°C to +105°C.

The MMC5983MA provides an I<sup>2</sup>C digital output with 400 KHz, fast mode operation, and a 10MHz SPI digital output.

Information furnished by MEMSIC is believed to be accurate and reliable.

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**SPECIFICATIONS** (Measurements @ 25°C, unless otherwise noted; V<sub>DD</sub>=3.0V unless otherwise specified)

Parameter	Conditions	Min	Typ	Max	Units
Field Range (Each Axis)	Total applied field		±8		G
Supply Voltage	VDD	2.8	3.0	3.6	V
	VDDIO(I <sup>2</sup> C interface and INT)	2.8	3.0	3.6	V
Supply Voltage Rise Time				5.0	ms
Supply Current <sup>1,2</sup> (7 measurements/second)	BW=00		450		µA
	BW=01		225		µA
	BW=10		112.5		µA
	BW=11		32		µA
Power Down Current <sup>2</sup>			1.0		µA
Operating Temperature		-40		105	°C
Storage Temperature		-55		125	°C
Linearity Error <sup>2</sup> (Best fit straight line)	FS=±8G H <sub>applied</sub> =±4G		0.1		%FS
Hysteresis <sup>2</sup>	3 sweeps across ±8G		0.01		%FS
Repeatability Error <sup>2</sup>	3 sweeps across ±8G		0.1		%FS
Alignment Error			±1.0	±3.0	Degrees
Transverse Sensitivity			±0.8		%
Total RMS Noise <sup>2</sup>	BW=00		0.4		mG
	BW=01		0.6		mG
	BW=10		0.8		mG
	BW=11		1.2		mG
Output Resolution			18		Bits
Max Output data rate <sup>2</sup>	BW=00		100		Hz
	BW=01		200		Hz
	BW=10		400		Hz
	BW=11		1000		Hz
Heading Accuracy <sup>3</sup>			±1.0		Degrees
Sensitivity Accuracy <sup>4,5</sup>	±8 G		±5		%
	With 16bits operation		4096		Counts/G
	With 18bits operation		16384		Counts/G
Sensitivity Change Over Temperature	-40~105 °C Delta from 25 °C, ±8 G		±5		%
Null Field Output <sup>5</sup>			±0.5		G
	With 16bits operation		32768		Counts
	With 18bits operation		131072		Counts
Null Field Output Change Over Temperature using SET/RESET	-40~105 °C Delta from 25 °C		±3		mG
Temperature Sensor Output			0.8		°C/Count
Disturbing Field <sup>6</sup>			10		G
Maximum Exposed Field				10,000	G
SET/RESET Repeatability			±1		mG

1. Supply current is proportional to how many measurements performed per second, it will be 2x with Cmm\_en=1 and Auto\_SR\_en=1.

2. Based on 3lots characterization result.

3. MEMSIC product enables users to utilize heading accuracy to be 1.0 degree typical when using MEMSIC's proprietary software or algorithm.

4. Sensitivity of the orthogonal axes is analytically derived from raw data and is subsequently processed by MEMSIC software drivers.

5. Based on shipment test result.

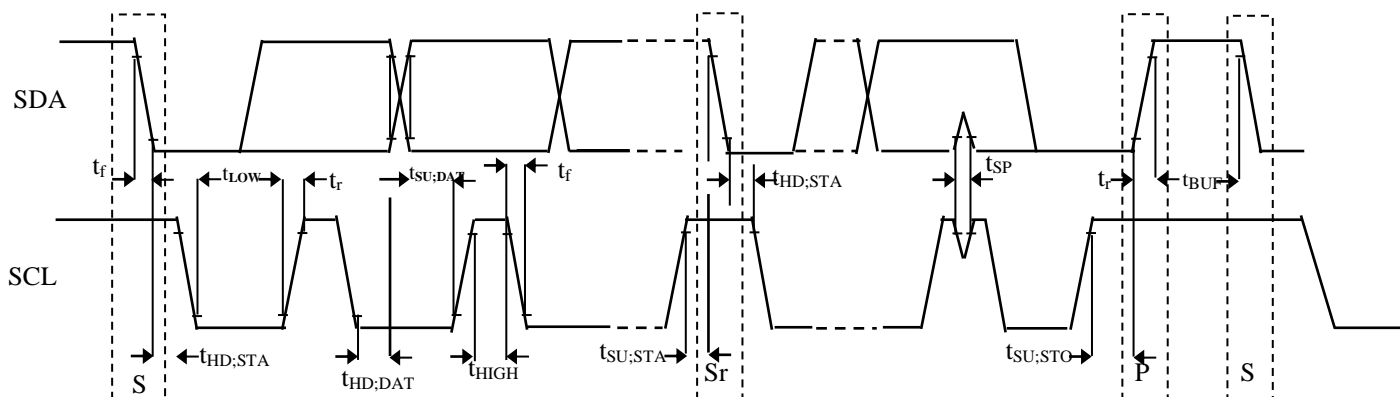
6. This is the magnitude of external field that can be tolerated without changing the sensor characteristics. If the disturbing field is exceeded, a SET/RESET operation is required to restore proper sensor operation.

### DIGITAL INTERFACE (VIO=3.0V)

Symbol	Parameter (Units)	Minimum	Typical	Maximum
V <sub>IH</sub>	High Level Input Voltage (Volts)	0.7*V <sub>IO</sub>		
V <sub>IL</sub>	Low Level Input Voltage (Volts)			0.3*V <sub>IO</sub>
V <sub>HYS</sub>	Hysteresis of Schmitt Trigger Input (Volts)	0.2		
I <sub>IL</sub>	Input Leakage, All Inputs (uA)	-10		10
V <sub>OH</sub>	High Level Output Voltage (Volts)	0.8*V <sub>IO</sub>		
V <sub>OL</sub>	Low Level Output Voltage (Volts)			0.2*V <sub>IO</sub>

### I<sup>2</sup>C INTERFACE I/O CHARACTERISTICS (VIO=3.0V)

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Logic Input Low Level	V <sub>IL</sub>		-0.5		0.3* V <sub>IO</sub>	V
Logic Input High Level	V <sub>IH</sub>		0.7*V <sub>IO</sub>		V <sub>IO</sub>	V
Hysteresis of Schmitt Input	V <sub>hys</sub>		0.2			V
Logic Output Low Level	V <sub>OL</sub>				0.6	V
Input Leakage Current	I <sub>i</sub>	0.1V <sub>IO</sub> <V <sub>in</sub> <0.9V <sub>IO</sub>	-10		10	μA
SCL Clock Frequency	f <sub>SCL</sub>		0		400	kHz
START Hold Time	t <sub>HD,STA</sub>		0.6			μS
START Setup Time	t <sub>SU,STA</sub>		0.6			μS
LOW period of SCL	t <sub>LOW</sub>		1.3			μS
HIGH period of SCL	t <sub>HIGH</sub>		0.6			μS
Data Hold Time	t <sub>HD,DAT</sub>		0		0.9	μS
Data Setup Time	t <sub>SU,DAT</sub>		0.1			μS
Rise Time	t <sub>r</sub>	From V <sub>IL</sub> to V <sub>IH</sub>			0.3	μS
Fall Time	t <sub>f</sub>	From V <sub>IH</sub> to V <sub>IL</sub>			0.3	μS
Bus Free Time Between STOP and START	t <sub>BUF</sub>		1.3			μS
STOP Setup Time	t <sub>SU,STO</sub>		0.6			μS

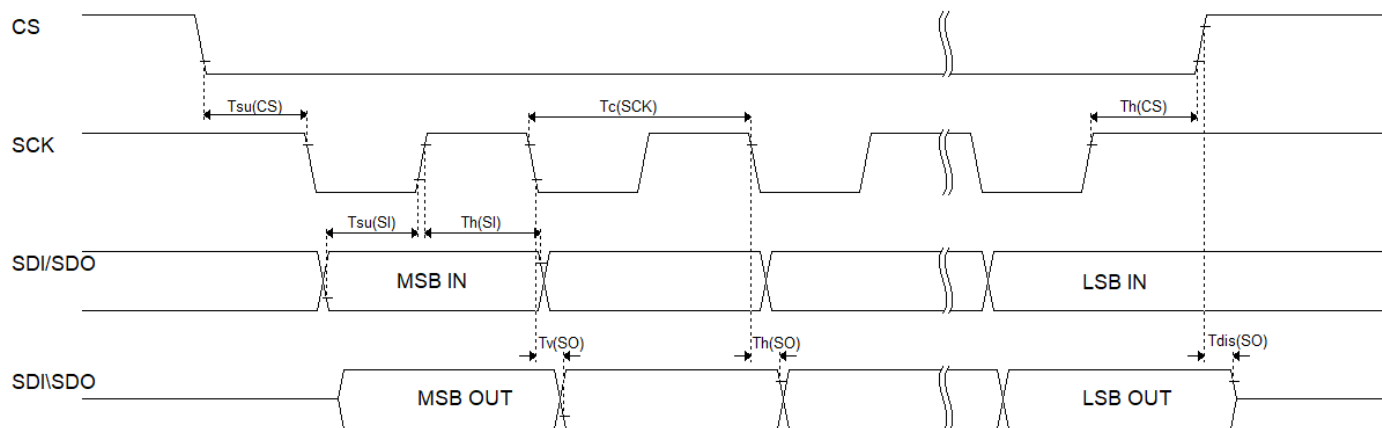


Timing Definition

### SPI INTERFACE I/O CHARACTERISTICS (VIO=3.0V)

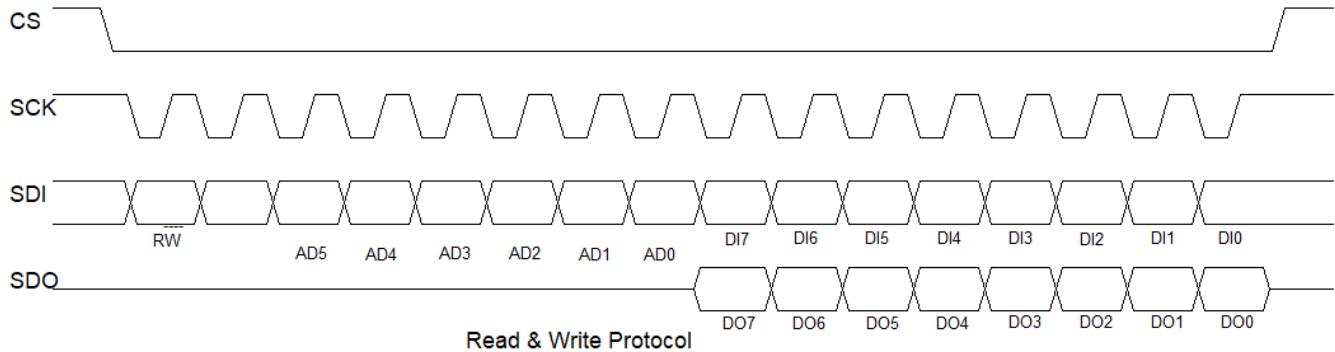
Parameter	Symbol	Value <sup>1</sup>			Unit
		Min.	Typ.	Max.	
SPI clock cycle	$t_{c(SCK)}$	100			ns
SPI clock frequency	$f_{c(SCK)}$			10	MHz
CS setup time	$t_{su(CS)}$	6			ns
CS hold time	$t_{h(CS)}$	8			
SDI input setup time	$t_{su(SI)}$	5			
SDI input hold time	$t_{h(SI)}$	15			
SDO valid output time	$t_{v(SO)}$			50	
SDO output hold time	$t_{h(SO)}$	9			
SDO output disable time	$t_{dis(SO)}$			50	

1. Values are guaranteed at 10 MHz clock frequency for SPI, based on characterization results, not tested in production.



**Timing Definition**

## SPI Read and Write protocol



CS (SPI\_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.

SCK (SPI\_SCK) is the serial port clock and it is controlled by the SPI master. It is stopped high when CS is high (no transmission).

SDI (SPI\_SDI) and SDO (SPI\_SDO) are respectively the serial port data input and output. Those lines are driven at the falling edge of SCK and should be captured at the rising edge of SCK.

Both the Read Register and Write Register commands are completed in 16 clocks pulses or in multiple of 8 in case of multiple byte read/write. Bit duration is the time between two falling edges of SCK. The first bit (bit 0) starts at the first falling edge of SCK after the falling edge of CS while the last bit (bit 15, bit 23, ...) starts at the last falling edge of SCK (SPI\_CS) just before the rising edge of CS.

bit 0: RW bit. When 0, the data DI(7:0) is written into the device. When 1, the data DO(7:0) from the device is read. In latter case, the chip will drive SDO at the start of bit 8.

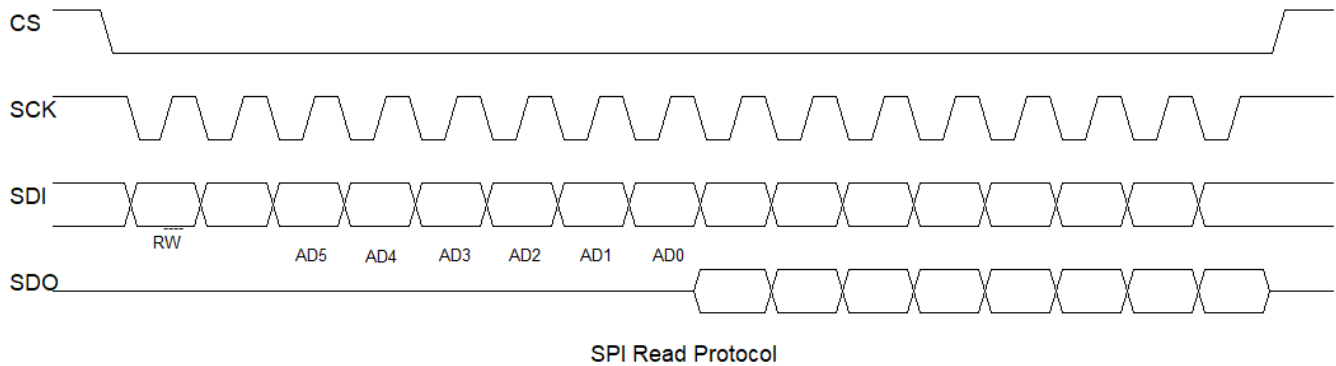
bit 1: Don't care.

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

bit 8-15: Data DI(7:0) (write mode). This is the data that will be written into the device (MSB first) (MSB first). bit 8-15: data DO(7:0) (read mode). This is the data that will be read from the device (MSB first).

In multiple read/write commands further blocks of 8 clock periods will be added.

## SPI Read



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

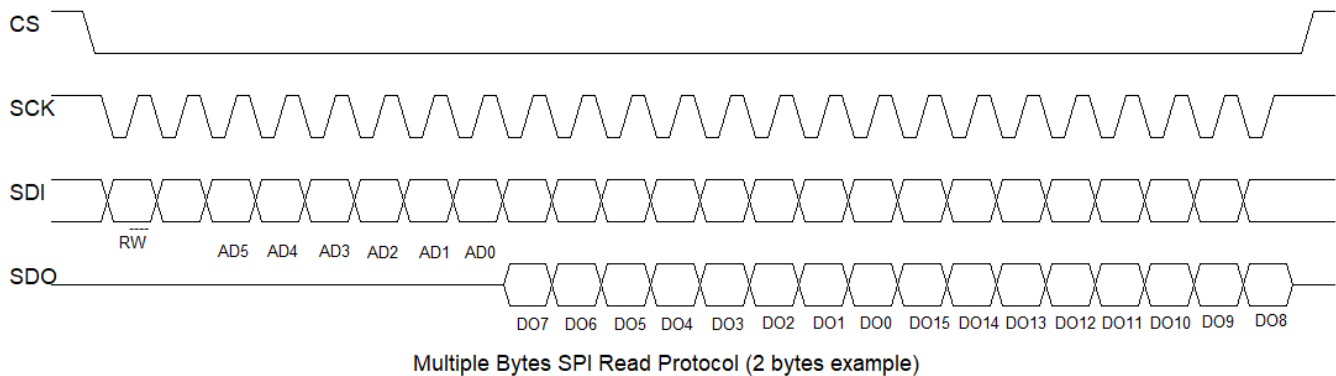
bit 0: READ bit. The value is 1.

bit 1: don't care.

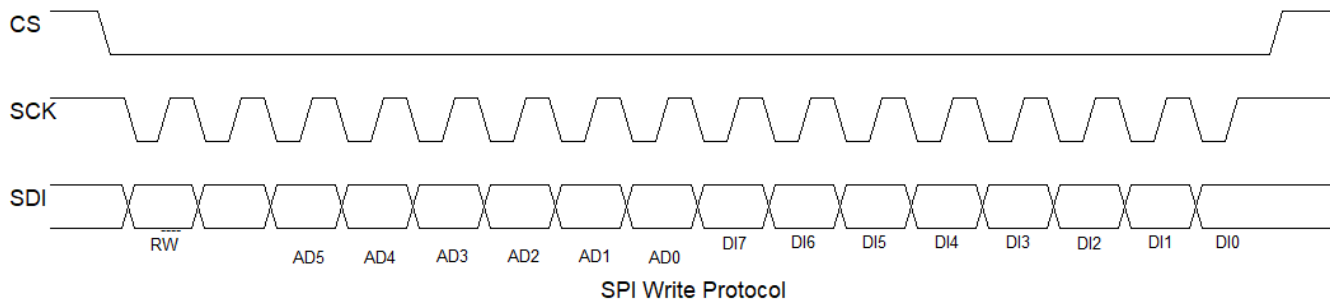
bit 2-7: address AD(5:0). This is the address field of the indexed register.

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

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



## SPI Write



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

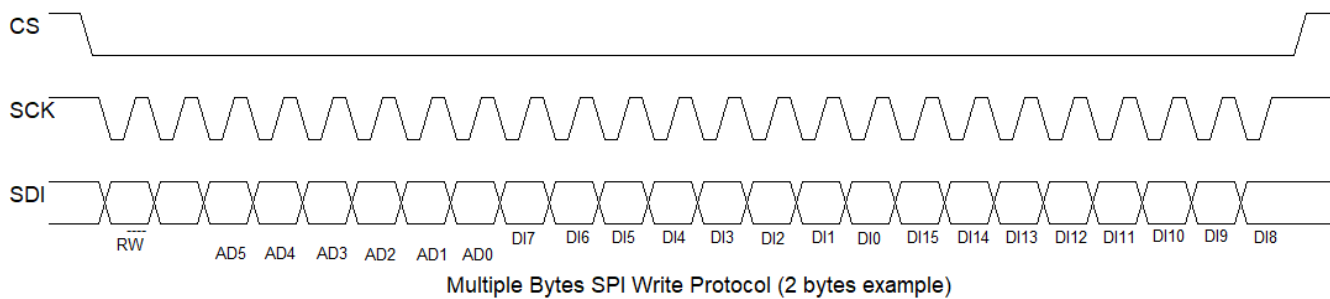
bit 0: WRITE bit. The value is 0.

bit 1: don't care

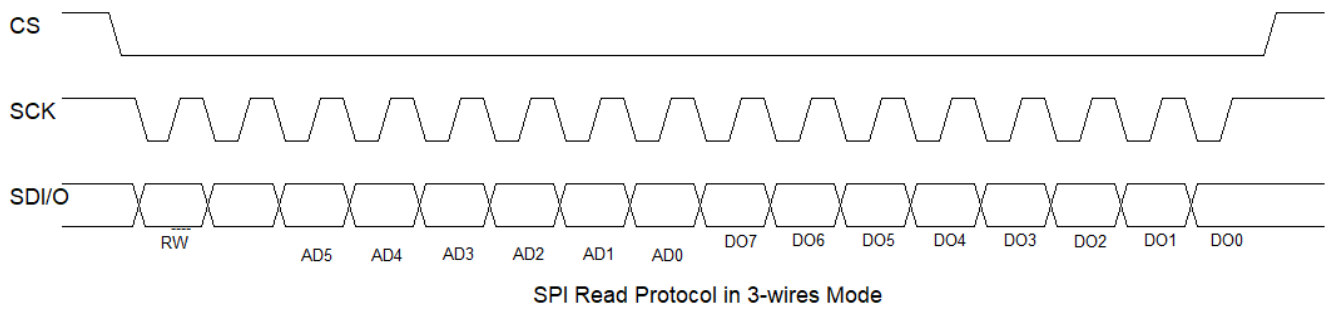
bit 2 -7: address AD(5:0). This is the address field of the indexed register.

bit 8-15: data DI(7:0) (write mode). This is the data that will be written inside the device (MSB first).

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



## SPI Read in 3-wires mode



The part can be configured as 3-wires SPI read mode, by write "1" to Internal Control Register 3 (0CH), bit 6 before reading command.

The SPI Read command is performed with 16 clocks pulses:

bit 0: READ bit. The value is 1.

bit 1: don't care.

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

bit 8-15: data DO(7:0) (read mode). This is the data that will be read from the device (MSB first). Multiple write command is also available in 3-wires mode.



### ABSOLUTE MAXIMUM RATINGS\*

Supply Voltage -0.5 to +3.6V

Storage Temperature -55°C to +125°C

Maximum Exposed Field 10000 G

**\*Note:** Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; the functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect the device's reliability.

### Pin Description: LGA Package

Pin	Name	Description	I/O
1	SCL/SPI_SCK	Serial Clock Line for I <sup>2</sup> C/SPI bus	I
2	VDD	Power Supply	P
3	NC	Not Connected	NC
4	SPI_CS	Chip Select line for SPI (active low). Tie to VDDIO for I <sup>2</sup> C Interface	I
5	SPI_SDO	SPI Serial Data Out	O
6	NC	Not Connected	NC
7	NC	Not Connected	NC
8	NC	Not Connected	NC
9	GND	Connect to Ground	P
10	CAP	Connect a 10uF capacitor for SET/RESET	P
11	GND	Connect to Ground	P
12	NC	Not Connected	NC
13	VDDIO	Power supply for I <sup>2</sup> C and INT	P
14	NC	Not Connected	NC
15	INT	Interrupt Output	O
16	SDA/SPI_SDI	Serial Data Line for I <sup>2</sup> C/SPI bus	I/O

All parts are shipped in tape and reel packaging with 5000pcs per 13" reel.

### Caution:

This is an Electro-Static Discharge (ESD) sensitive device.

### Ordering Guide:

MMC598xMA

Package type:

Code	Type
A	LGA16 RoHS compliant

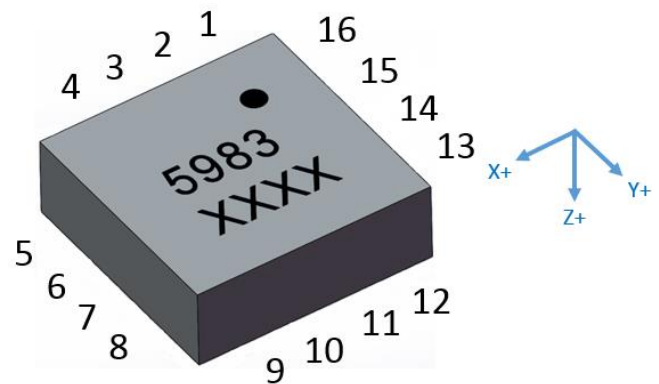
Performance Grade:

Code	Performance Grade
M	Industrial Grade

I<sup>2</sup>C address

Code	7bits address
1	0110001
2	0110010
3	0110000
4	0110100
5	0110101
6	0110110
7	0110111
9	0110011

### Marking illustration:



**Note:** Coordinates shown above indicate polarity after a SET operation.

The black dot on top-right marks the location of pin one (1). The 1<sup>st</sup> line represents the device's Name. The 2<sup>nd</sup> line represents the device's Lot Number.

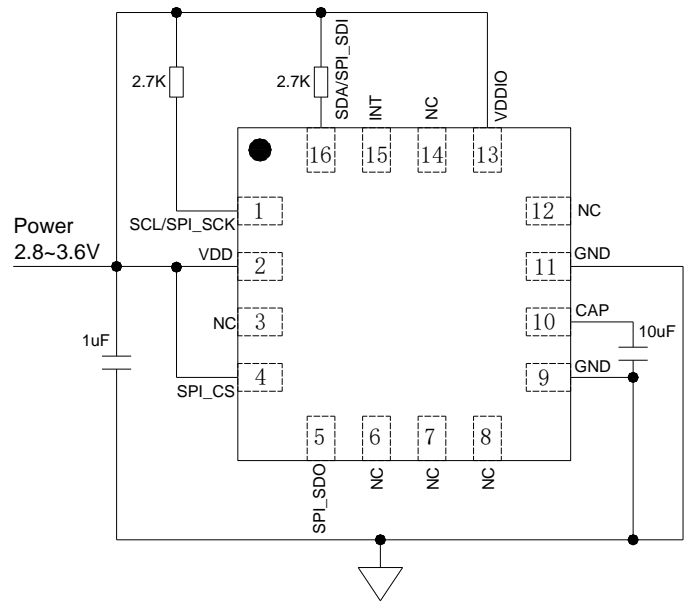
## THEORY OF OPERATION

The Anisotropic Magneto-Resistive (AMR) sensors are special resistors made of permalloy thin film deposited on a silicon wafer. During manufacturing, a strong magnetic field is applied to the film to orient its magnetic domains in the same direction, establishing a magnetization vector. Subsequently, an external magnetic field applied perpendicularly to the sides of the film causes the magnetization to rotate and change angle. This effect causes the film's resistance to vary with the intensity of the applied magnetic field. The MEMSIC AMR sensor is incorporated into a Wheatstone bridge configuration to maximize Signal to Noise ratio. A change in magnetic field produces a proportional change in differential voltage across the Wheatstone bridge.

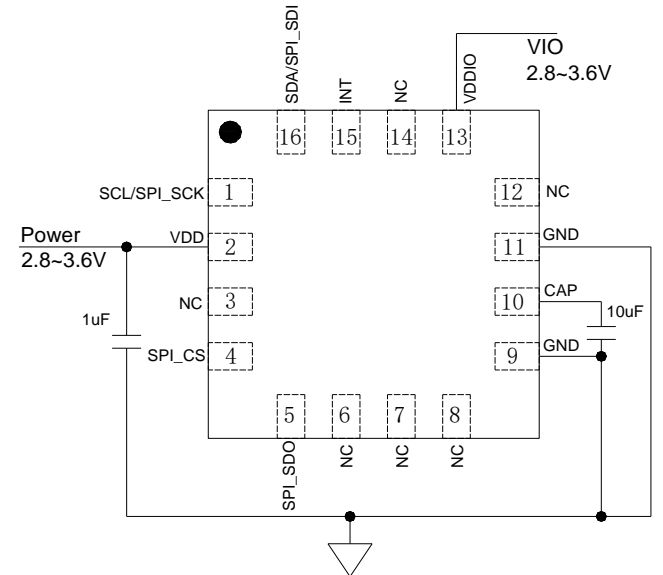
However, the influence of a strong magnetic field (more than 10 G) in any direction could upset, or flip, the polarity of the film, thus changing the sensor characteristics. A strong restoring magnetic field must be applied momentarily to restore, or set, the sensor characteristics. The MEMSIC magnetic sensor has an on-chip magnetically coupled strap: a SET/RESET strap pulsed with a high current, to provide the restoring magnetic field

## EXTERNAL CIRCUITRY CONNECTION

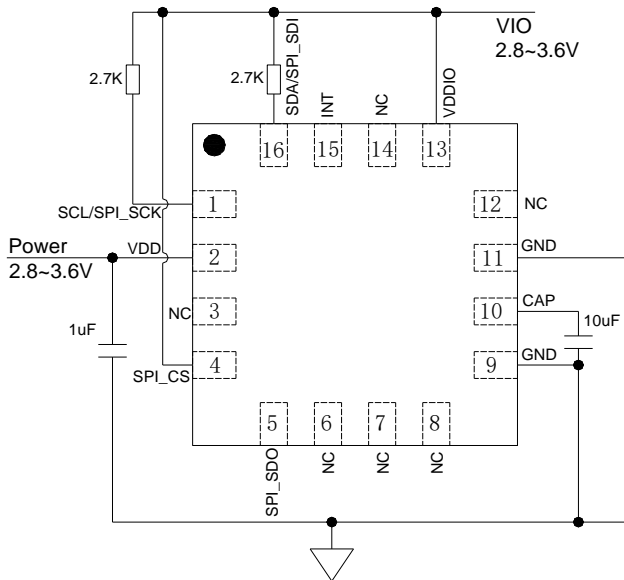
The MMC5983MA was designed for flexible power connections to support existing and new designs. It can operate from a single 2.8V to 3.6V supply or from dual supplies using a 2.8V to 3.6V VDD supply and a 2.8V to 3.6V VDDIO supply. The circuit connection diagrams below illustrate power supply connection options.



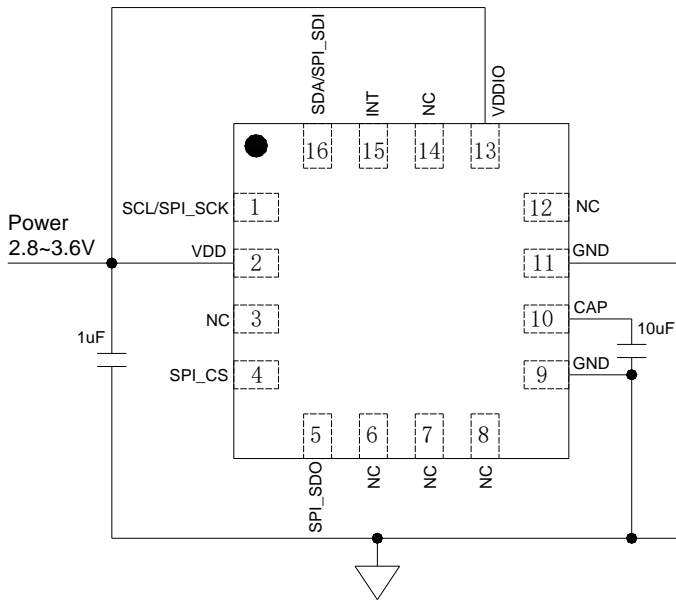
<Top View>  
I<sup>2</sup>C Single Supply Connection



<Top View>  
SPI Dual Supply Connection



<Top View>  
I<sup>2</sup>C Dual Supply Connection



**<Top View>  
SPI Single Supply Connection**

### PIN DESCRIPTIONS

**CAP**– This is the supply input for SET/RESET coil. MEMSIC recommends a minimum 10 uF low ESR capacitor placed in close proximity to the CAP pin.

**GND**– This is the ground pin for the magnetic sensor.

**SDA/SPI\_SDI** – This pin is the I<sup>2</sup>C/SPI serial data line, and operates in I<sup>2</sup>C FAST (400 KHz)/SPI mode.

**SCL/SPI\_SCK**– This pin is the I<sup>2</sup>C/SPI serial clock line, and operates in FAST (400 KHz)/SPI mode.

**SPI\_CS** – This pin is chip select line for SPI (active low). Tie to VDDIO for I<sup>2</sup>C Interface.

**SPI\_SDO** – This pin the SPI serial data out line.

**VDD**–This pin is the power supply of the ASIC.

**VDDIO**–This pin is the power supply of the digital interface of the ASIC.

**INT**– This pin is Interrupt output. Active High. It is held as hi-Z until an interrupt function is enabled.

Note: VDD and CAP pins are shorted together inside the device.

## HARDWARE DESIGN CONSIDERATIONS

- ✓ Provide adequate separation distance to devices that contain permanent magnets or generate magnetic fields (e.g. speakers, coils, inductors) The combined magnetic field to be measured and interference magnetic field should be less than the full scale range of the MMC5983MA.
- ✓ Provide adequate separation distance to current carrying traces. Do not route current carrying traces under the sensor or on the other side of the PCB opposite to the device.
- ✓ Do not cover the sensor with magnetized material or materials that may become magnetized, (e.g., shield box, LCD, battery, iron bearing materials).
- ✓ Do not place the device opposite to magnetized materials or materials that may become magnetized located on the other side of the PCB.

Please refer to MEMSIC magnetic sensor layout guideline.

## POWER CONSUMPTION

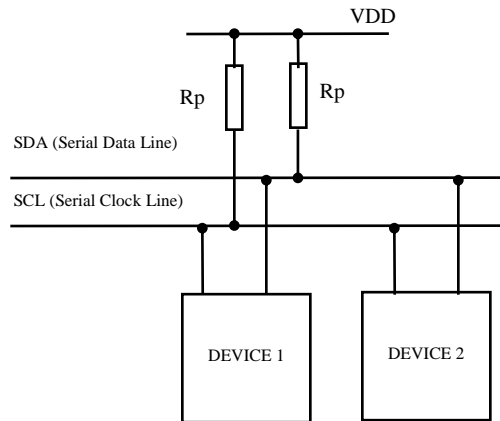
The power consumed by the device is proportional to the number of measurements taken per second. For example, when  $BW<1:0> = 00$ , which is 16-bit mode with 10ms per measurement, MMC5983MA consumes 450  $\mu\text{A}$  (typical) at 3.0 V with 7 measurements per second. If only 2 measurements are performed per second, the current will be  $450 * 2 / 7 = 128 \mu\text{A}$ .

## I<sup>2</sup>C INTERFACE DESCRIPTION

A slave mode I<sup>2</sup>C circuit has been implemented into the MEMSIC magnetic sensor as a standard interface for customer applications. The A/D converter functionality has been added to the MEMSIC sensor, thereby increasing ease-of-use, and lowering power consumption, footprint and total solution cost.

The I<sup>2</sup>C (or Inter IC bus) is an industry standard bi-directional two-wire interface bus. A master I<sup>2</sup>C device can operate READ/WRITE and control up to 128 devices by device addressing. The MEMSIC magnetic sensor operates only in a slave mode, i.e. only responding to calls by a Master device to its address.

## I<sup>2</sup>C BUS CHARACTERISTICS



The two wires in the I<sup>2</sup>C bus are called SDA (serial data line) and SCL (serial clock line). In order for a data transfer to start, the bus has to be free, which is defined by both wires in a HIGH output state. Due to the open-drain / pull-up resistor structure and wired Boolean “AND” operation, any device on the bus can pull lines low and overwrite a HIGH signal. The data on the SDA line has to be stable during the HIGH period of the SCL line. In other words, valid data can only change when the SCL line is LOW.

Note: Rp selection guide: 2.7K ohm for an I<sup>2</sup>C bus less than 10 cm length, and 10K ohm for a bus length less than 5 cm.

## REGISTER MAP

Register Name	Address	Description
Xout0	00H	Xout [17:10]
Xout1	01H	Xout [9:2]
Yout0	02H	Yout [17:10]
Yout1	03H	Yout [9:2]
Zout0	04H	Zout [17:10]
Zout1	05H	Zout [9:2]
XYZout2	06H	Xout[1:0], Yout[1:0], Zout[1:0]
Tout	07H	Temperature output
Status	08H	Device status
Internal control 0	09H	Control register 0
Internal control 1	0AH	Control register 1
Internal control 2	0BH	Control register 2
Internal control 3	0CH	Control register 3
Product ID 1	2FH	Product ID

### Register Details

#### Xout0, Xout1, XYZout2

Xout0	7	6	5	4	3	2	1	0
Addr: 00H	Xout[17:10]							
Mode	R							

Xout1	7	6	5	4	3	2	1	0
Addr: 01H	Xout[9:2]							
Mode	R							

XYZout2	7	6	5	4	3	2	1	0
Addr: 06H	Xout[1:0]		Yout[1:0]		Zout[1:0]		0	0
Mode	R							

X-axis output, unsigned format.

X-axis output	Data
16bits operation mode	Xout[17:2]
18bits operation mode	Xout[17:0]

#### Yout0, Yout1, XYZout2

Yout0	7	6	5	4	3	2	1	0
Addr: 02H	Yout[17:10]							
Mode	R							

Yout1	7	6	5	4	3	2	1	0
Addr: 03H	Yout[9:2]							
Mode	R							

XYZout2	7	6	5	4	3	2	1	0
Addr: 06H	Xout[1:0]		Yout[1:0]		Zout[1:0]		0	0
Mode	R							

Y-axis output, unsigned format.

Y-axis output	Data
16bits operation mode	Yout[17:2]
18bits operation mode	Yout[17:0]

### Zout0, Zout1, XYZout2

<b>Zout0</b>	7	6	5	4	3	2	1	0
Addr: 04H	Zout[17:10]							
Mode	R							

<b>Zout1</b>	7	6	5	4	3	2	1	0
Addr: 05H	Zout[9:2]							
Mode	R							

<b>XYZout2</b>	7	6	5	4	3	2	1	0
Addr: 06H	Xout[1:0]	Yout[1:0]	Zout[1:0]	0	0			
Mode	R							

Z-axis output, unsigned format.

Z-axis output	Data
16bits operation mode	Zout[17:2]
18bits operation mode	Zout[17:0]

### Tout

<b>Tout</b>	7	6	5	4	3	2	1	0
Addr: 07H	Tout[7:0]							
Mode	R							

Temperature output, unsigned format. The range is -75~125°C, about 0.8°C/LSB, 00000000 stands for -75°C

### Status

<b>Device Status</b>	7	6	5	4	3	2	1	0
Addr: 08H	Reserved			OTP_Read_Done	Reserved		Meas_T_Done	Meas_M_Done
Reset Value	0	0	0	0	0	0	0	0
Mode	R/W							

Bit Name	Description
Meas_M_Done	Indicates a measurement event of magnetic field is completed. This bit should be checked before reading the output. When the new measurement command is occurred, this bit turns to "0". When the measurement is finished, this bit will remain "1" till next measurement. Writing 1 into this bit will clear the corresponding interrupt.
Meas_T_Done	Indicates a measurement event of temperature is completed. When the new measurement command is occurred, this bit turns to "0". When the measurement is finished, this bit will remain "1" till next measurement. Writing 1 into this bit will clear the corresponding interrupt.
OTP_Rd_Done	<a href="#">Indicates that the process of loading trimming data from the memory has been finished.</a>

### Internal Control 0

<b>Control Register 0</b>	7	6	5	4	3	2	1	0
Addr: 09H	Reserved	OTP Read	Auto_SR_en	Reset	Set	INT_meas_done_en	TM_T	TM_M
Reset Value	0	0	0	0	0	0	0	0
Mode	W	W	W	W	W	W	W	W

Bit Name	Description
TM_M	Take magnetic field measurement, set '1' will initiate measurement. This bit will be automatically reset to 0 at the end of each measurement.
TM_T	Take Temperature measurement, set '1' will initiate measurement. This bit will be automatically reset to 0 at the end of each measurement. This bit and TM_M cannot be high at the same time.

INT_meas_done_en	Writing "1" will enable the interrupt for completed measurements. Once a measurement is finished, either magnetic field or temperature, an interrupt will be sent to the host.
Set	Writing "1" will cause the chip to do the Set operation, which will allow large set current to flow through the sensor coils for 500ns. This bit is self-cleared at the end of Set operation.
Reset	Writing "1" will cause the chip to do the Reset operation, which will allow large reset current to flow through the sensor coils for 500ns. This bit is self-cleared at the end of Reset operation.
Auto_SR_en	Writing "1" will enable the feature of automatic set/reset.
OTP Read	Writing "1" will let the device to reload data from the memory. This bit will be automatically reset to 0 after the shadow registers for OTP are refreshed.

### Internal Control 1

<b>Control Register 1</b>	7	6	5	4	3	2	1	0	
Addr: 0AH	SW_RST	Reserved			YZ-inhibit		X-inhibit	BW1	BW0
Reset Value	0	0	0	0	0	0	0	0	
Mode	W	W	W	W	W	W	W	W	

Bit Name	Description			
BW0& BW1	Output resolution			
	BW1	BW0	Measurement Time	Bandwidth
	0	0	8ms	100Hz
	0	1	4ms	200Hz
	1	0	2ms	400Hz
1	1	0.5ms	1000Hz	
Note: X/Y/Z channel measurements are taken in parallel. These bandwidth selection bits adjust the length of the decimation filter. They control the duration of each measurement.				
X-inhibit	Writing "1" will disable X channel.			
Y/Z-inhibit	Writing "1" to the two bits will disable Y and Z channel. These two bits should be kept the same value, otherwise the output of Y and/or Z axes might be wrong.			
SW_RST	Writing "1" will cause the part to reset, similar to power-up. It will clear all registers and also re-read OTP as part of its startup routine. The power on time is 10mS.			

### Internal Control 2

<b>Control Register 2</b>	7	6	5	4	3	2	1	0
Addr: 0BH	En_prd_set	Prd_set[2:0]			Cmm_en	Cm_freq[2:0]		
Reset Value	0	0	0	0	0	0	0	0
Mode	W	W	W	W	W	W	W	W

Bit Name	Description																		
CM_Freq[2:0]	These bits determine how often the chip will take measurements in Continuous Measurement Mode. The frequency is based on the assumption that BW[1:0] = 00.																		
	<table border="1"> <thead> <tr> <th>CM_Freq [2:0]</th> <th>Frequency (Typical)</th> </tr> </thead> <tbody> <tr> <td>000</td> <td>Continuous Measurement Mode is off.</td> </tr> <tr> <td>001</td> <td>1Hz</td> </tr> <tr> <td>010</td> <td>10 Hz</td> </tr> <tr> <td>011</td> <td>20Hz</td> </tr> <tr> <td>100</td> <td>50 Hz</td> </tr> <tr> <td>101</td> <td>100 Hz</td> </tr> <tr> <td>110 (BW=01)</td> <td>200Hz</td> </tr> <tr> <td>111 (BW=11)</td> <td>1000 Hz</td> </tr> </tbody> </table>	CM_Freq [2:0]	Frequency (Typical)	000	Continuous Measurement Mode is off.	001	1Hz	010	10 Hz	011	20Hz	100	50 Hz	101	100 Hz	110 (BW=01)	200Hz	111 (BW=11)	1000 Hz
	CM_Freq [2:0]	Frequency (Typical)																	
	000	Continuous Measurement Mode is off.																	
	001	1Hz																	
	010	10 Hz																	
	011	20Hz																	
	100	50 Hz																	
	101	100 Hz																	
110 (BW=01)	200Hz																		
111 (BW=11)	1000 Hz																		
Cmm_en	Writing "1" will enable the continuous mode. In order to enter the continuous mode, CM_Freq[2:0] cannot be 000.																		
Prd_set[2:0]	These bits determine how often the chip will do a set operation. The device will perform a SET automatically per the setting in below table.																		
	<table border="1"> <thead> <tr> <th>Prd_set [2:0]</th> <th>Number of measurements for each set</th> </tr> </thead> <tbody> <tr> <td>000</td> <td>1</td> </tr> <tr> <td>001</td> <td>25</td> </tr> <tr> <td>010</td> <td>75</td> </tr> <tr> <td>011</td> <td>100</td> </tr> <tr> <td>100</td> <td>250</td> </tr> <tr> <td>101</td> <td>500</td> </tr> <tr> <td>110</td> <td>1000</td> </tr> <tr> <td>111</td> <td>2000</td> </tr> </tbody> </table>	Prd_set [2:0]	Number of measurements for each set	000	1	001	25	010	75	011	100	100	250	101	500	110	1000	111	2000
	Prd_set [2:0]	Number of measurements for each set																	
	000	1																	
	001	25																	
	010	75																	
	011	100																	
	100	250																	
	101	500																	
110	1000																		
111	2000																		
En_prd_set	Writing "1" will enable the feature of periodic set. This feature needs to work with both Auto_SR_en and Cmm_en bits set to 1.																		

### Internal Control 3

Control Register 3	7	6	5	4	3	2	1	0
Addr: 0CH	reserved	Spi_3w	reserved			St_enm	St_enp	reserved
Reset Value	0	0	0	0	0	0	0	0
Mode	W	W	W	W	W	W	W	W

Bit Name	Description
St_enp	Writing "1" will apply an extra current flowing from the positive end to the negative end of an internal coil and result in an extra magnetic field.
St_enm	Writing "1" will apply an extra current flowing from the negative end to the positive end of an internal coil and result in an extra magnetic field.
Spi_3w	Writing a 1 into this location will put the device into 3-wire SPI mode.

### Product ID1

Product ID 1	7	6	5	4	3	2	1	0
Addr: 2FH	Product ID1[7:0]							
Reset Value	0	0	1	1	0	0	0	0
Mode	R	R	R	R	R	R	R	R



## DATA TRANSFER

A data transfer is started with a “START” condition and ended with a “STOP” condition. A “START” condition is defined by a HIGH to LOW transition on the SDA line while SCL line is HIGH. A “STOP” condition is defined by a LOW to HIGH transition on the SDA line while the SCL line is held HIGH. All data transfer in I<sup>2</sup>C system are 8-bits long. Each byte has to be followed by an acknowledge bit. Each data transfer involves a total of 9 clock cycles. Data is transferred starting with the most significant bit (MSB).

After a START condition, the Master device calls a specific slave device by sending its 7-bit address with the 8<sup>th</sup> bit (LSB) indicating that either a READ or WRITE operation will follow, [1] for READ and [0] for WRITE. The MEMSIC device 7-bit device address is **[0110000]**.

The initial addressing of the slave is always followed by the master writing the number of the slave register to be read or written, so this initial addressing always indicates a WRITE operation by sending **[01100000]**. After being addressed, the MEMSIC device being called should respond by an “Acknowledge” signal by pulling SDA line LOW. Subsequent communication bytes can either be

- a) The data to be written to the device register, or
- b) Another START condition followed by the device address indicating a READ operation **[01100001]**, and then the master reads the register data.

Multiple data bytes can be written or read to numerically sequential registers without the need of another START condition. Data transfer is terminated by a STOP condition or another START condition. Two detailed examples of communicating with the MEMSIC device are listed below for the actions of acquiring a magnetic field measurement and magnetizing the sensor.

## EXAMPLE MEASUREMENT

**1<sup>st</sup> cycle:** A START condition is established by the Master device followed by a call to the slave address **[0110000]** with the eighth bit held low to indicate a WRITE request.

**2<sup>nd</sup> cycle:** After an acknowledge signal is received by the Master device (MEMSIC device pulls SDA line low during 9<sup>th</sup> SCL pulse), the Master device sends the address of Control Register 0 or **[00001001]** as the target register to be written. The MEMSIC device should acknowledge receipt of the address (9<sup>th</sup> SCL pulse, SDA pulled low).

**3<sup>rd</sup> cycle:** The Master device writes to the Internal Control Register 0 the code **[00000001]** (TM\_M high) to initiate data acquisition. The MEMSIC device should send an Acknowledge and internally initiate a measurement (collect x, y and z data). A STOP condition indicates the end of the write operation.

**4<sup>th</sup> cycle:** The Master device sends a START command followed by the MEMSIC device’s seven bit address, and finally the eighth bit set low to indicate a WRITE. An Acknowledge should be send by the MEMSIC device in response.

**5<sup>th</sup> cycle:** The Master device sends the MEMSIC device’s Status Register **[00001000]** as the address to read.

**6<sup>th</sup> cycle:** The Master device sends a START command followed by the MEMSIC device’s seven bit address, and finally the eighth bit set high to indicate a READ. An Acknowledge should be send by the MEMSIC device in response.

**7<sup>th</sup> cycle:** The Master device cycles the SCL line. This causes the Status Register data to appear on SDA line. Continuously read the Status Register until the Meas\_M\_Done bit (bit 0) is set to ‘1’.or check INT pin status. This indicates that data for the x, y, and z sensors is available to be read.

**8<sup>th</sup> cycle:** The Master device sends a START command followed by the MEMSIC device’s seven bit address, and finally the eighth bit set low to indicate a WRITE. An Acknowledge should be send by the MEMSIC device in response.

**9<sup>th</sup> cycle:** The Master device sends a **[00000000]** (Xout LSB register address) as the register address to read.

**10<sup>th</sup> cycle:** The Master device calls the MEMSIC device’s address with a READ (8<sup>th</sup> SCL cycle SDA line high). An Acknowledge should be send by the MEMSIC device in response.

**11<sup>th</sup> cycle:** Master device continues to cycle the SCL line, and each consecutive byte of data from the X, Y and Z registers should appear on the SDA line. The internal memory address pointer automatically moves to the next byte. The Master device acknowledges each. Thus:

**12<sup>th</sup> cycle:** Xout[17:10].

**13<sup>th</sup> cycle:** Xout[9:2].

**14<sup>th</sup> cycle:** Yout[17:10].

**15<sup>th</sup> cycle:** Yout[9:2].

**16<sup>th</sup> cycle:** Zout[17:10].

**17<sup>th</sup> cycle:** Zout[9:2].

**18<sup>th</sup> cycle:** Xout[1:0], Yout[1:0], Zout[1:0] for 18bits mode.

Master ends communications by NOT sending an ‘Acknowledge’ and also follows with a ‘STOP’ command.

## EXAMPLE OF SET

**1<sup>st</sup> cycle:** A START condition is established by the Master Device followed by a call to the slave address [0110000] with the eighth bit held low to indicate a WRITE request.

**2<sup>nd</sup> cycle:** After an acknowledge signal is received by the Master device (The MEMSIC device pulls the SDA line low during the 9<sup>th</sup> SCL pulse), the Master device sends [00001001] as the target address (Internal Control Register 0). The MEMSIC device should acknowledge receipt of the address (9<sup>th</sup> SCL pulse).

**3<sup>rd</sup> cycle:** The Master device writes to the MEMSIC device's Internal Control 0 register the code [00001000] (SET bit) to initiate a SET action. The MEMSIC device should send an Acknowledge.

## EXAMPLE OF RESET

**1<sup>st</sup> cycle:** A START condition is established by the Master device followed by a call to the slave address [0110000] with the eighth bit held low to indicate a WRITE request

**2<sup>nd</sup> cycle:** After an acknowledge signal is received by the Master device (The MEMSIC device pulls the SDA line low during the 9<sup>th</sup> SCL pulse), the Master device sends [00001001] as the target address (Internal Control Register 0). The MEMSIC device should acknowledge receipt of the address (9<sup>th</sup> SCL pulse).

**3<sup>rd</sup> cycle:** The Master device writes to the MEMSIC device's Internal Control 0 register the code [00010000] (RESET bit) to initiate a RESET action. The MEMSIC device should send an Acknowledge.

At this point, the MEMSIC AMR sensors have been conditioned for optimum performance and data measurements can commence.

**Note:** The RESET action can be skipped for most applications

## USING SET AND RESET TO REMOVE BRIDGE OFFSET

The integrated SET and RESET functions of the MMC5893VA enables the user to remove the error associated with bridge Offset change as a function of temperature, thereby enabling more precise heading measurements over a wider temperature than competitive technologies. The SET and RESET functions effectively alternately flip the magnetic sensing polarity of the sensing elements of the device.

1) The most accurate magnetic field measurements can be obtained by using the protocol described as follows: Perform SET. This sets the internal magnetization of the sensing resistors in the direction of the SET field.

2) Perform MEASUREMENT. This measurement will contain not only the sensors response to the external magnetic field, H, but also the Offset; in other words,

$$\text{Output1} = +H + \text{Offset.}$$

3) Perform RESET. This resets the internal magnetization of the sensing resistors in the direction of the RESET field, which is opposite to the SET field (180° opposed).

4) Perform MEASUREMENT. This measurement will contain both the sensors response to the external field and also the Offset. In other words,

$$\text{Output2} = -H + \text{Offset.}$$

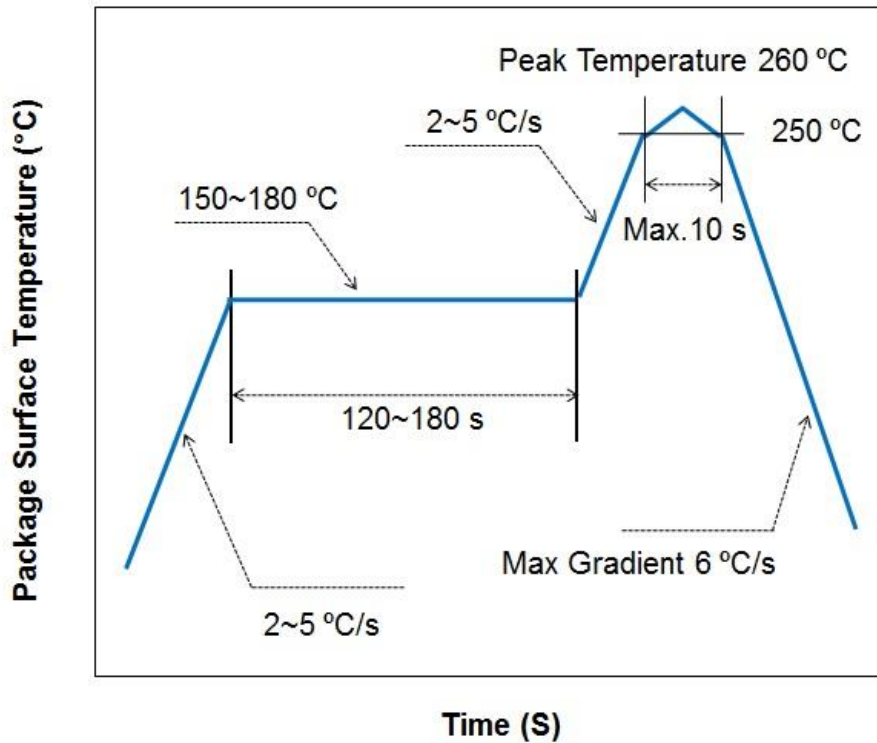
5) Finally, calculate H by subtracting the two measurements and dividing by 2. This procedure effectively eliminates the Offset from the measurement and therefore any changes in the Offset over temperature.

**Note:** To calculate and store the offset; add the two measurements and divide by 2. This calculated offset value can be subtracted from subsequent measurements to obtain H directly from each measurement.

## SOLDERING RECOMMENDATIONS

MEMSIC magnetic sensor is capable of withstanding an MSL3 / 260°C solder reflow. Following is the reflow profile:

**Note:**



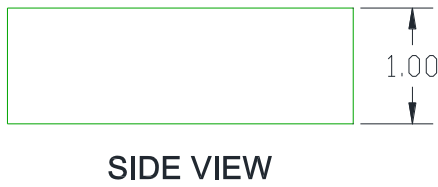
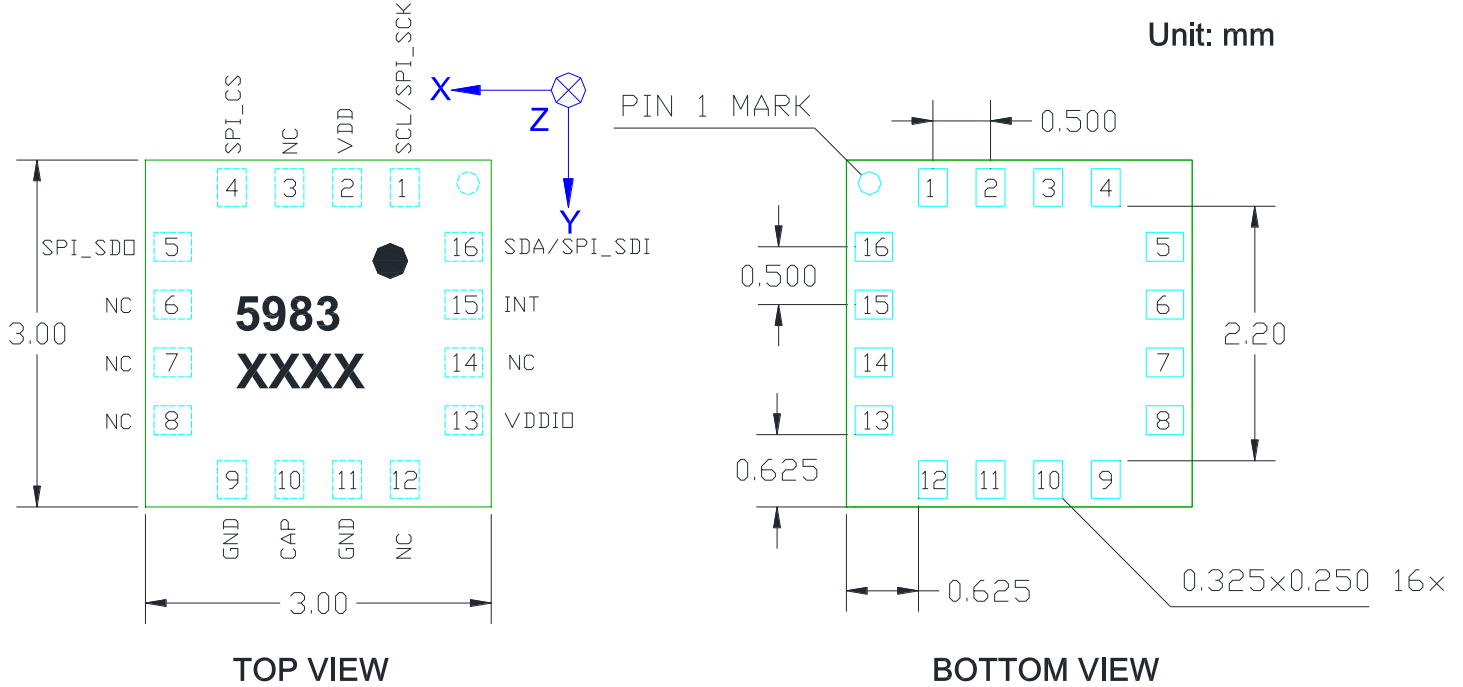
- This is the reflow profile for Pb free process
- The peak temperature on the sensor surface should be limited under 260°C for no more than 10 seconds.
- Reflow conditions recommended by solder paste should be followed to get the best SMT quality.
- Maximum 3 SMT cycles
- Second and third reflow cycle should be applied after device has cooled down to 25°C (room temperature)
- If the part is mounted manually, please ensure the temperature does not exceed 260°C for 10 seconds.

## END of LIFE DISPOSAL

End-of-life products should be disposed/ recycled properly in accordance to National and local regulation.

# PACKAGE DRAWING (LGA package)

Unit: mm



## LAND PATTERN

Unit: mm

