SURE electronics

Dual-axis Magnetic Sensor Module with I^{2}C Interface User's Guide

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NOTES:

Product Version	**:**	**Ver1.0**
Document Version	**:**	**Ver 1.0**

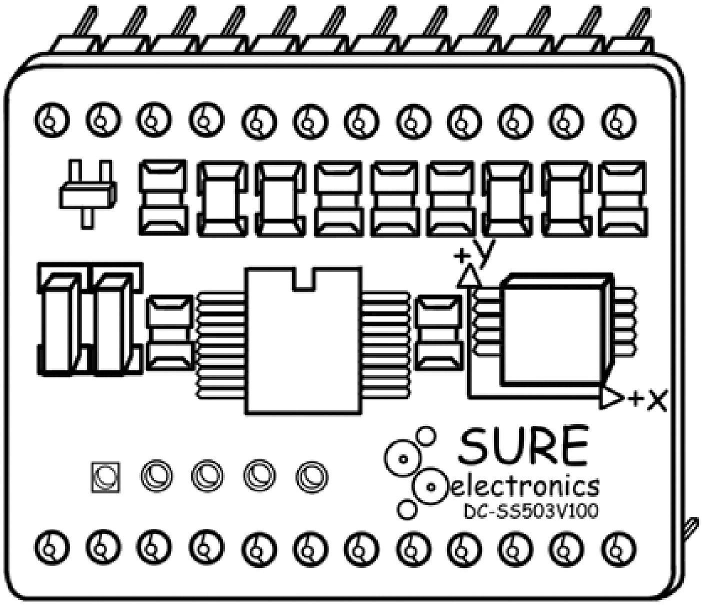
DUAL-AXIS MAGNETIC SENSOR MODULE WITH I^2C INTERFACE USER'S GUIDE

Chapter 1. Overview

1.1 Overview

Thanks for purchasing the dual-axis magnetic sensor module by Sure Electronics. It employs an accurate dual-axis magnetic sensor IC MMC2120MG which integrates I^2C bus, allowing the device to be connected directly to a microprocessor eliminating the need for A/D converters or timing resources. Our sensor module adopts a DIP-like design which facilitates system integration.

FIGURE 1-1 OVERVIEW



1.2 Features

DC: 3.3V or 5V power supply

I^2C interface:

- Slave, FAST (≤400 KHz) mode
- Pull-up resistor embedded (4.7K)

High measurement accuracy and stability

DIP-like packaging facilitate integration

1.3 Applications

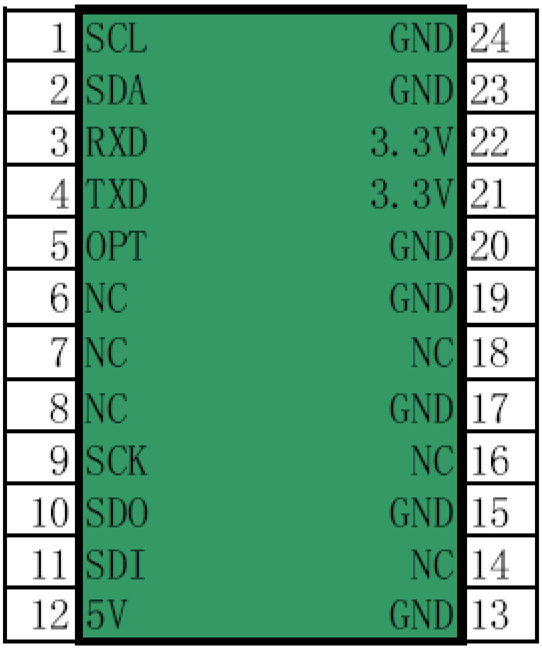
Electronic Compass

GPS Navigation

Position Sensing

Vehicle Detection

1.4 PIN DESCRIPTIONS



TOP View

Pin#	Label	Function
1	SCL	I²C serial clock
2	SDA	I²C serial data
12	5V	DC 5V input
13,15,17,19,20,23,24	GND	Ground
21, 22	3.3V	DC 3.3V input
Other pins	Reserved	Reserved

Note: Do not use 5V and 3.3V pin for power supply simultaneously

Chapter 2. Characteristics

2.1 Features

TABLE 2-1 FEATURES

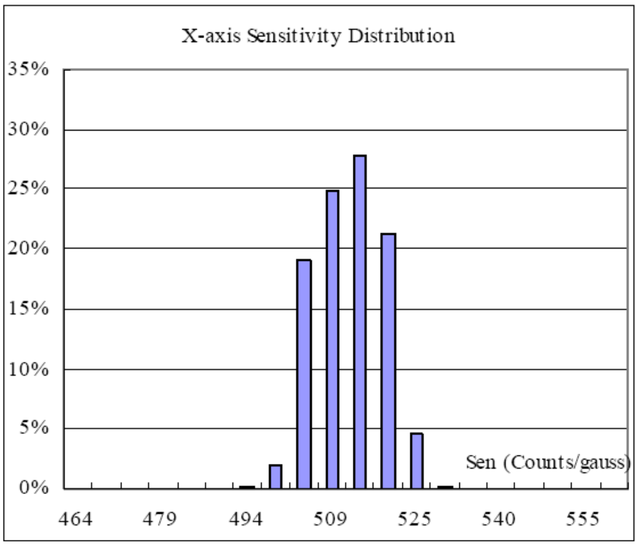
(Measurements @ 25℃, unless otherwise noted; Vcc= 3.3V unless otherwise specified)

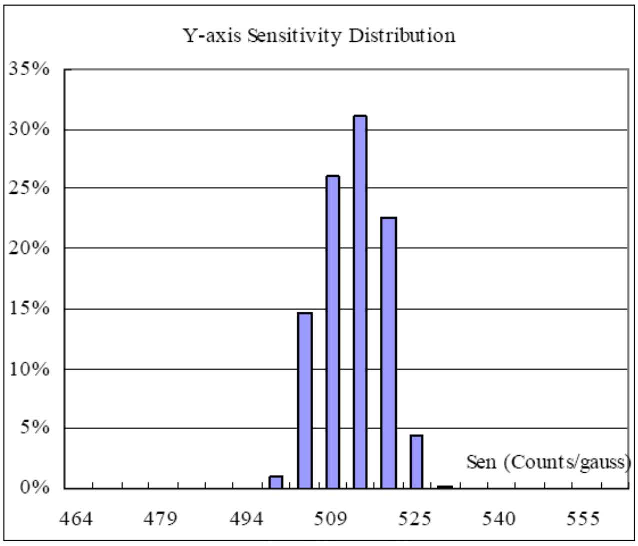
Parameter	Conditions	Min	Typ	Max	Units
Field Range (Each Axis)	Total applied field	-2		+2	gauss
Supply Voltage	+5V	4.7	5.0	5.3	V
	+3.3V	2.7	3.0	3.6	V
Supply Current	50 measurements/second		0.4		mA
Power Down Current				1.0	uA
Operating Temperature		-40		85	℃
Storage Temperature		-55		125	℃
Linearity Error (Best fit straight line)	±1 gauss		0.1		%FS
	±2 gauss		0.5		%FS
Hysteresis	3 sweeps across ±2 gauss		0.05		%FS
Repeatability Error	3 sweeps across ±2 gauss		0.1		%FS
Alignment Error			±1.0	±3.0	degrees
Transverse Sensitivity			±2.0	±5.0	%
Noise Density	1~25Hz, RMS		600		ugauss
Accuracy[1]			±2	±5	deg
Bandwidth			25		Hz
Sensitivity		-10		+10	%
		461	512	563	counts/gauss
Sensitivity Change Over Temperature			±1100		ppm/°C
Null Field Output		-0.2		+0.2	gauss
			2048		counts
Null Field Output Change Over Temperature [2]	Without Set/Reset		±0.4		mgauss/°C
	With Set/Reset		1/50		Ratio to the result without set/reset
Disturbing Field	Sensitivity start to degrade, use Set/Reset pulse to restore	5.5			gauss
Maximum Exposed Field				10000	gauss

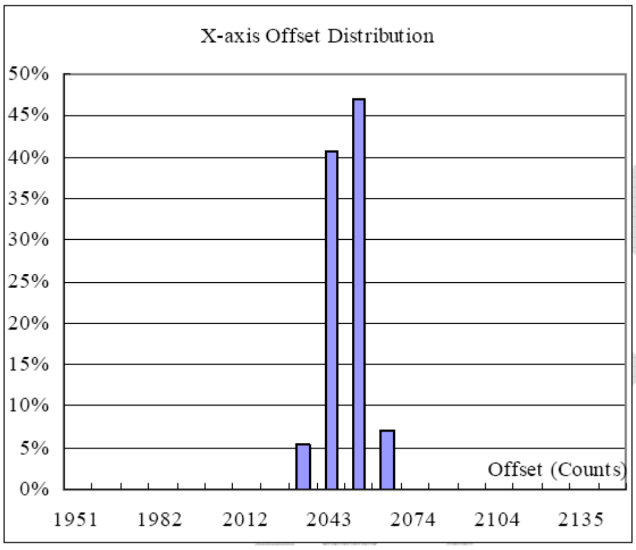
Note:
1: Accuracy is dependent on system design, calibration and compensation algorithms used.
2: By design.

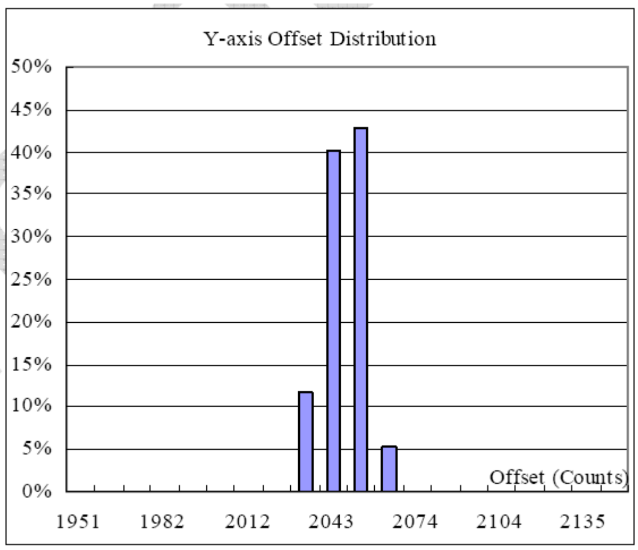
2.2 Typical Characteristics

TYPICAL CHARACTERISTICS, % OF UNITS (@ 25℃, V_{DD} = 3.3V)







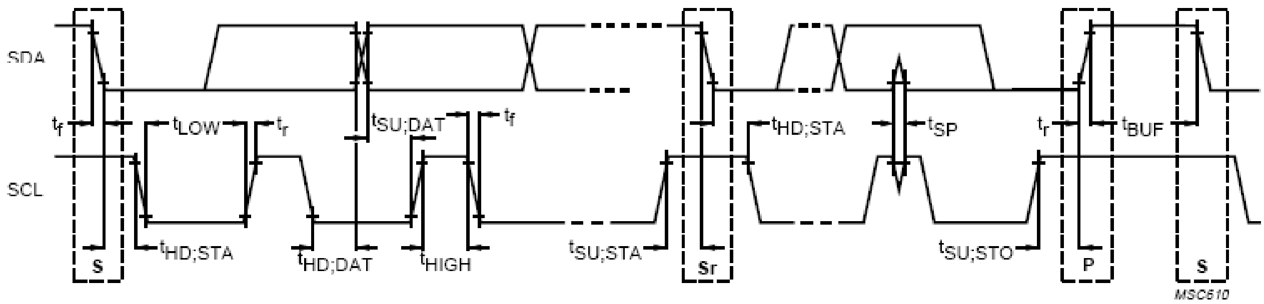


2.3 I²C Interface Description

TABLE 2-2 I²C INTERFACE DESCRIPTION

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Logic Input Low Level	V_{IL}		-0.5		0.3* V_{DD}	V
Logic Input High Level	V_{IH}		0.7*V_{DD}		V_{DD}	V
Hysteresis of Schmitt input	V_{hys}		0.2			V
Logic Output Low Level	V_{OL}				0.4	V
Input Leakage Current	I_I	$0.1V_{DD}<V_{IN}<0.9V_{DD}$	-10		10	uA
SCL Clock Frequency	f_{SCL}		0		400	kHz
START Hold Time	$t_{HD;STA}$		0.6			uS
START Setup Time	$t_{SU;STA}$		0.6			uS
LOW period of SCL	t_{LOW}		1.3			uS
HIGH period of SCL	t_{HIGH}		0.6			uS
Data Hold Time	$t_{HD;DAT}$		0		0.9	uS
Data Setup Time	$t_{SU;DAT}$		0.1			uS
Rise Time	t_r	From V_{IL} to V_{IH}			0.3	uS
Fall Time	t_f	From V_{IH} to V_{IL}			0.3	uS
Bus Free Time Between STOP and START	t_{BUF}		1.3			uS
STOP Setup Time	$t_{SU;STO}$		0.6			uS

FIGURE 2-1 TIMING DEFINITION

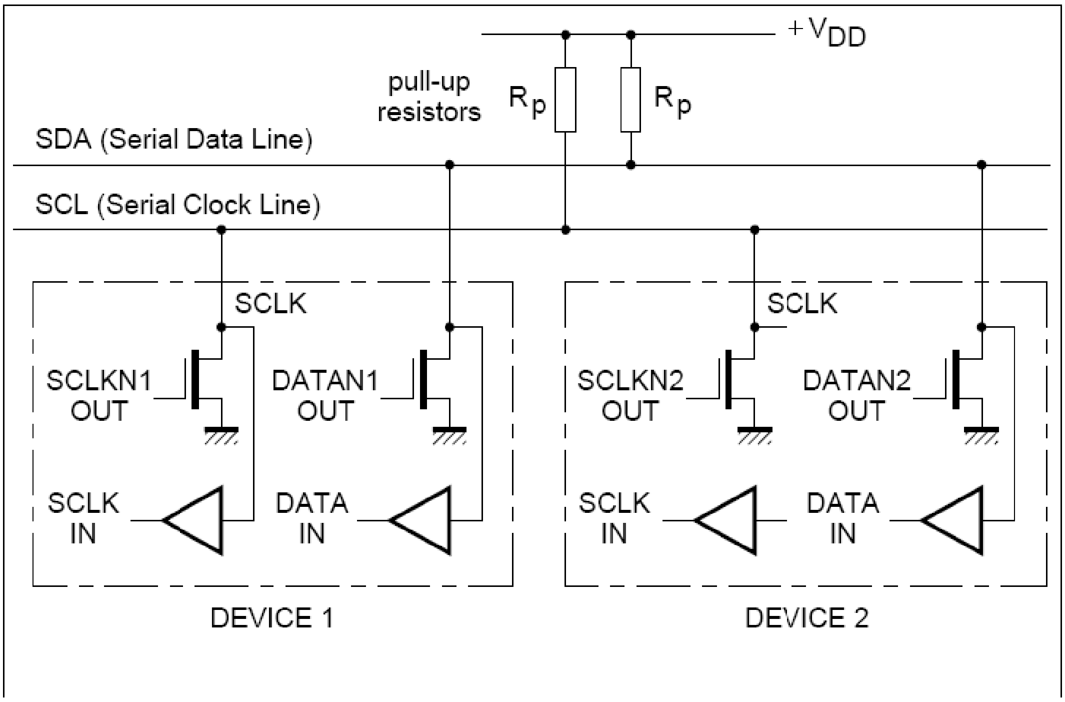


A slave mode I²C circuit has been implemented into the Magnetic Sensor Module as a standard interface for customer applications. The I²C (or Inter IC bus) is an industry standard bidirectional two-wire interface bus. A master I²C device can operate READ/WRITE controls to an unlimited number of devices by device addressing. The Magnetic Sensor Module operates only in a slave mode, i.e. only responding to calls by a master device.

Chapter 3. I2C Bus Communication Protocol

3.1 I2C BUS Characteristics

FIGURE 3-1 I2C BUS



The two wires in I2C 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.

3.2 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 SCL line is HIGH. All data transfer in I2C system is 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, master device calls specific slave device, in our case, a Magnetic Sensor Module with a 7-bit device address "[0110000]". Following the 7-bit address, the 8th bit determines the direction of data transfer: [1] for READ and [0] for WRITE. After being addressed, available Magnetic Sensor Module being called should respond by an "Acknowledge" signal, which is pulling SDA line LOW. In order to read sensor signal, master device should operate a WRITE action with a code of [xxxxxxx1] into Magnetic Sensor Module 8-bit internal register. Note that this action also serves as a "wake-up" call.

Bit	Name	Function
0	TM (Take Measurements)	Initiate measurement sequence for "1", this bit will be cleared by circuit outside of I2C core after measurement and A/D are finished. More specifically, it will be automatically cleared by TM_DONE signal after the action is finished.
1	SET (Set Coil)	Writing "1" will set the MR by passing a large current through Set/Reset Coil. It will be automatically cleared by SETRESET_DONE signal after the action is finished.
2	RESET (Reset Coil)	Writing "1" will reset the MR by passing a large current through Set/Reset Coil in a reversed direction. It will be automatically cleared by SETRESET_DONE signal after the action is finished.
3	Reserved	
4	Reserved	
5	Reserved	
6	Reserved	

After writing code of [xxxxxxx1] into control register and a zero memory address pointer is also written, and if a "READ" command is received, the Magnetic Sensor Module being called transfers 8-bit data to I2C bus. If "Acknowledge" by master device is received, Magnetic Sensor Module will continue to transfer next byte. The same procedure repeats until 5 byte of data are transferred to master device. Those 5 bytes of data are defined as following:

1. Internal register
2. MSB X-axis
3. LSB X-axis
4. MSB Y-axis
5. LSB Y-axis

Even though each axis consists two bytes, which are 16bits of data, the actual resolution is limited 12bits. Unused MSB should be simply filled by "0"s.

3.3 Power Down Mode

Magnetic Sensor Module will enter power down mode automatically after data acquisition is finished. A data acquisition is initiated when master writes in to the control register a code of [xxxxxxx1].

3.4 Example of Take Measurement

First cycle: START followed by a calling to slave address [0110000] to WRITE (8th SCL, SDA keep low).
0x60 is determined by factory programming, total 4 different addresses are available.
Second cycle: After a acknowledge signal is received by master device (Magnetic

Sensor Module pulls SDA line low during 9th SCL pulse), master device sends "[00000000]" as the target address to be written into. Magnetic Sensor Module should acknowledge at the end (9th SCL pulse). Note: since Magnetic Sensor Module has only one internal register that can be written into, so user should always indicate "[00000000]" as the write address.

Third cycle: Master device writes to internal Magnetic Sensor Module memory the code "[00000001]" as a wake-up call to initiate a data acquisition. Magnetic Sensor Module should send acknowledge.

A STOP command indicates the end of write operation.

A minimal 5ms wait should be given to Magnetic Sensor Module to finish a data acquisition and return a valid output. The TM bit (Take Measurement bit in control register) will be automatically reset to "0" after data from A/D converter is ready. The transition from "1" to "0" of TM bit also indicates "data ready". The device will go into sleep mode afterwards. Analog circuit will be powered off, but IC portion will continue be active and data will not be lost.

Fourth cycle: Master device sends a START command followed by calling Magnetic Sensor Module address with a READ (8th SCL cycle SDA line high). An 'Acknowledge' should be send by Magnetic Sensor Module at the end.

Fifth cycle: Master device cycles SCL line, MSB of X channel register data appears on SDA line, Master device should send 'Acknowledge' at the end.

Sixth cycle: LSB of X channel

Seventh cycle: MSB of Y channel.

Eighth cycle: LSB of Y channel.

Master ends communications by NOT sending 'Acknowledge' and also followed by a 'STOP' command.

3.5 Example of SET/RESET Coil

First cycle: START followed by a calling to slave address [0110000] to WRITE (8th SCL, SDA keep low).

0x60 is determined by factory programming, total 4 different addresses are available.

Second cycle: After a acknowledge signal is received by master device (Magnetic Sensor Module pulls SDA line low during 9th SCL pulse), master device sends "[00000000]" as the target address to be written into. Magnetic Sensor Module should acknowledge at the end (9th SCL pulse). Note: since Magnetic Sensor Module has only one internal register can be written into, user should always use "[00000000]" as the write address.

Third cycle: Master device writes to internal Magnetic Sensor Module memory a code "[00000010]" as a wake-up call to initiate a SET action, or a code "[00000100]" to initiate a RESET action. Note that in low voltage mode, master need to issue SET command if the previous command is RESET, and issue a RESET command if the previous command is SET. In the case of a cold start (device just powered on), master should only issue SET command. The wait time from power on to SET command should be a minimal 10ms. Magnetic Sensor Module should send acknowledge. Note that SET and RESET bits should not be set to "1" at the same time.

In case of that happens, the device will only do a SET action. A STOP command indicates the end of write operation.

A minimal 50us wait period should be given to Magnetic Sensor Module to finish SET/RESET action before taking a measurement. The SET or RESET bit will be automatically reset to “0” after SET/RESET is done.

And the device will go to sleep mode afterwards.

In low voltage operation mode, SET/RESET commands have to alternate. In other words, one can not do a SET following a SET, same for RESET. The first command after initial power up should be SET. If RESET command is attempted as the first command, it will be ignored Between SET and RESET, a minimal 5ms need to be given for the voltage on capacitor to settle.

Note:

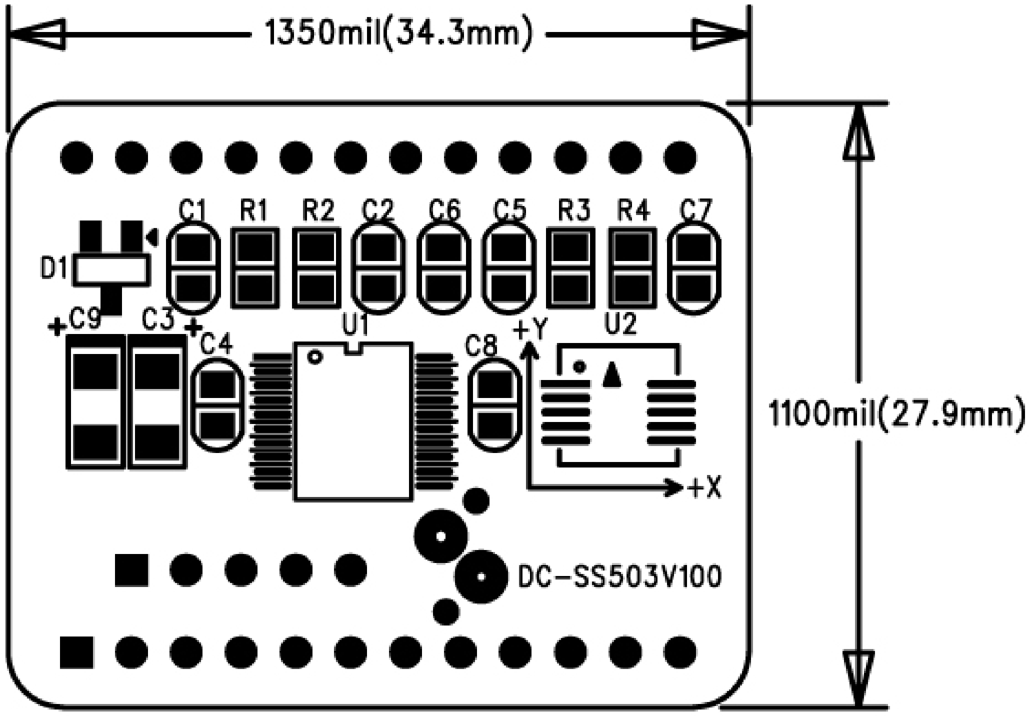
1. At power-on, internal register and memory address pointer are reset to “0”. Do not use 5V and 3.3V pin for power supply simultaneously.
2. In low voltage operation mode, device requires an additional capacitor to be able to do SET/RESET at lower supply voltage.

For further knowledge of magnetic sensor, please refer to the application file provided by MEMSIC:

1. AN-00MM-001_Magnetometer_Fundamentals_r1_2
2. AN-00MM-003_Magnetic_Sensor_Calibration_r1_1
3. AN-00MM-004_Electronic_Tilt_Compensation_r1_1
4. AN-00MM-005_Magnetic_Sensor_Placement_Guidelines_r1_1

Chapter 4. Mechanical Drawing

FIGURE 4-1 MECHANICAL DRAWING



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