GME605 6-Axis Digital e-Compass

General Introduction

GME605 is a 6-axis digital e-Compass ideal for consumer applications like smart phone, tablet, and game controllers. The footprint and pin-out are compatible with GMA305 3-axis accelerometer for easy in-situ sensor upgrade.

GME605 integrated a 3-axis accelerometer and a 3-axis magnetometer in a compact 3×3×1 mm^3 package. It is a multi-chip module (MCM) consisting of a MEMS acceleration sensing element, an acceleration conditioning IC and a highly sensitive Hall-effect geomagnetic sensor IC in a single LGA package. The magnetometer has large ±4914uT dynamic range, which together with the small footprint can give extra room to developers for easy sensor placement. The accelerometer has a 13-bit, high resolution ADC with ±16g dynamic range. It is embedded with motion detection function to facilitate motion-enabled applications.

The terrestrial magnetism detected by the magnetometer can be fused with the accelerometer reading to provide precise navigation heading. GMEMS can provide further software support for such fusion application.

Features

- 3-axis accelerometer and 3-axis magnetometer in single MCM
- Operation voltage: +2.5V ~ +3.6V; IO interface voltage: +1.8V ~ +3.6V
- 16-pin LGA lead-free package. Footprint: 3mm × 3mm, height: 1mm.
- RoHS compliance

ACCELEROMETER Features

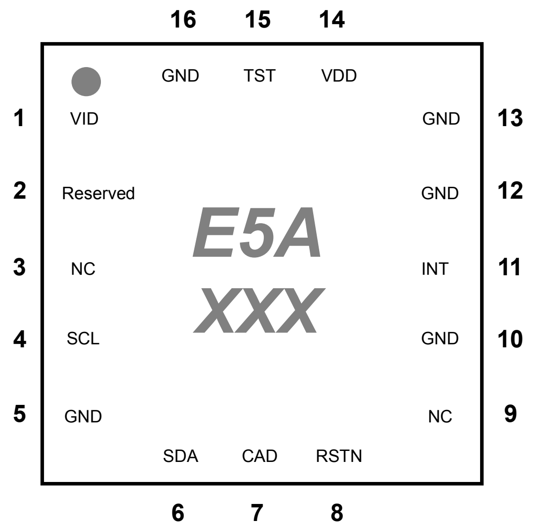
- Tri-axial digital accelerometer with ±16g dynamic range
- 13 bit ADC resolution with sensitivity 256 LSB/g
- Digital I2C interface supporting both standard (100kHz), and fast (400kHz) mode
- Temperature sensor for internal compensation and capable of digital output
- Power consumption:
  - Continuous mode (CM): typical 140uA to 250uA for 128Hz ODR
  - Non-Continuous mode (NCM): typical 85uA to 100uA for 1~8Hz ODR
  - Suspend current < 1uA
- One interrupt pin with selectable polarity and push-pull/open-drain option
- Built-in functions:
  - Data-ready interrupt
  - Motion detection: normal and differential modes
  - Auto-Wake/Sleep transition
  - 4-tap moving average filter with high-/low-pass option
- 5000g shock tolerance

MAGNETOMETER Features

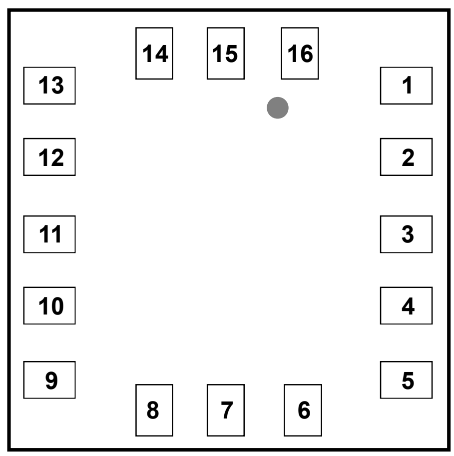
- Tri-axial geomagnetic sensor for consumer e-compass application
- Built-in 14-bit ADC with sensitivity 0.6μT/LSB
- Extended dynamic range of ±4914uT gives extra large room for the sensor placement
- I2C digital interface supporting standard (100kHz), fast (400kHz) and high-speed (3.4MHz) mode
- Power consumption:
  - Continuous measurement: typical 650uA@10Hz ODR / 3.0mA@100HZ ODR
  - Power down current < 1uA
- Various operation modes including the power-down mode , single mode and continuous measurement mode
- Self-test function with internal magnetic source

Applications

Navigation heading, gaming, augmented reality and LBS applications, smart user interface, motion detection and analysis



Top View



Bottom View

Specifications

Table 1: Pin Descriptions

Pin#	Name	Description
1	VID	IO voltage, 1.8~3.6V
2	Reserved	Reserved pin, keep unconnected
3	NC	No connection inside
4	SCL	I2C serial clock
5	GND	Ground
6	SDA	I2C serial data
7	CAD	MAGNETOMETER slave address select
8	RSTN	MAGNETOMETER reset pin
9	NC	No connection inside
10	GND	Ground
11	INT	ACCELEROMETER interrupt output
12	GND	Ground
13	GND	Ground
14	VDD	Operation voltage, 2.5~3.6V
15	TST	MAGNETOMETER test pin
16	GND	Ground

Table 2: Operating Range

Parameter	Symbol	Min.	Typ.	Max.	Unit
Operation voltage	VDD	2.5	3.0	3.6	V
IO voltage	VID	1.8	—	VDD	V
Operating range	Ta	-30	—	+85	°C

Table 3: Absolute Maximum Rating

Parameter	Symbol	Min.	Max.	Unit
Power supply voltage	VDD, VID	-0.3	4.0	V
Signal input voltage	VIS	-0.3	VDD/VID + 0.3	V
Signal input current	IIS	—	±10	mA
ESD (HBM)	—	—	2	kV
Mechanical shock (unpowered)	—	—	5,000 g for 0.2ms	—
Freefall on concrete surface	—	—	1.5	m
Storage temperature	TST	-40	+125	°C

Note: Stress above the absolute maximum rating as listed in Table 3 may cause permanent damage to the device

Table 4: ACCELEROMETER Characteristics

Operation voltage VDD = 3V, environment temperature T_a = 25°C if not specified otherwise

Parameter	Conditions	Min.	Typ.	Max.	Unit
Dynamic range		—	±16	—	g
Sensitivity		230	256	282	LSB/g
Zero-g offset, calibrated		—	±60	—	mg
Sensitivity to temp. dependency	T_a = -30°C ~ +85°C	—	±0.08	—	%/°C
Zero-g offset temp. dependency	T_a = -30°C ~ +85°C	—	±2	—	mg/°C
Nonlinearity		—	±2	—	%FS
Cross axis sensitivity		—	2	—	%
Noise		—	1.1	—	mg/√Hz

Table 5: MAGNETOMETER Characteristics

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
X, Y, Z Digital output	DBW		—	14	—	bits
Measurement time	TMEAS	Time for single x, y and z axis measurement	—	—	9.9	ms
Magnetic field resolution	BRES		—	0.6	—	uT/LSB
Magnetic field range	BRAN		-4914	—	+4914	uT

Table 6: DC Characteristics

Parameter	Symbol	Pin	Note	Min.	Typ.	Max.	Unit
Input high level voltage	VIH	RSTN		0.7×VID	—	VID+0.3	V
		SCL SDA		0.7×VID	—	VID+0.3	
		TST CAD		0.7×VDD	—	VDD+0.3	
Input low level voltage	VIL	RSTN SCL SDA		-0.3	—	0.3×VID	V
		TST CAD		-0.3	—	0.3×VDD	V

Input current	IIN	RSTN SCL SDA	Vin=VSS or VID	-10	—	10	uA
		CAD	Vin=VSS or VDD				
		TST	Vin = VDD				
Input hysteresis voltage	VHYS	SCL	VID>2V	5%VID	—	—	V
		SDA	VID<2V	10%VID	—	—	
Output low level voltage	VOL	SDA	IOL≦3mA, VID>2V	—	—	0.4	V
			IOL≦3mA, VID<2V	—	—	20%VID	
Accelerometer operating current in CM mode	IDDA1	VDD VID	128 Hz, low power 128 Hz, low noise 128 Hz, high resolution	—	140 180 250	—	uA
Accelerometer operating current in NCM mode	IDDA2	VDD VID	ODR = 8 Hz ODR = 4 Hz ODR = 2 Hz ODR = 1 Hz	85	—	100	uA
Magnetometer operating current	IDDM1	VDD VID	Power-down mode VDD=VID=3V RSTN="L"	—	1	—	uA
	IDDM2		During magnetic sensor is operating	—	3	—	mA
	IDDM3		During self-test mode	—	5	—	mA

Table 7: AC Characteristics

Parameter	Symbol	Pin	Description	Min.	Typ.	Max.	Unit
Supply voltage rise time	TRISE	VDD VID	From VOFF to VDD/VID	—	—	50	ms
Initialization time	TINIT		From time VDD reaches its level to time the IC completes entering the power-down mode by POR circuits	—	—	100	us
Supply of voltage	VOFF	VDD VID	VDD/VID voltage to ensure the POR circuits to restart	—	—	0.2	V
Supply volt. off duration	TOFF	VDD VID	Duration of supply off voltage to ensure the POR circuits to restart	100	—	—	us
Wait time between mode setting change	TWAIT			100	—	—	us
ON time difference between VDD and VID	TVDON	VDD VID	ON timing difference between VDD and VID	0	—	—	us
OFF time difference between VDD and VID	TVDOFF	VDD VID	OFF timing difference between VDD and VID	0	—	—	us
Reset pulse width	TRST	RSTN	Reset pulse width	5	—	—	us

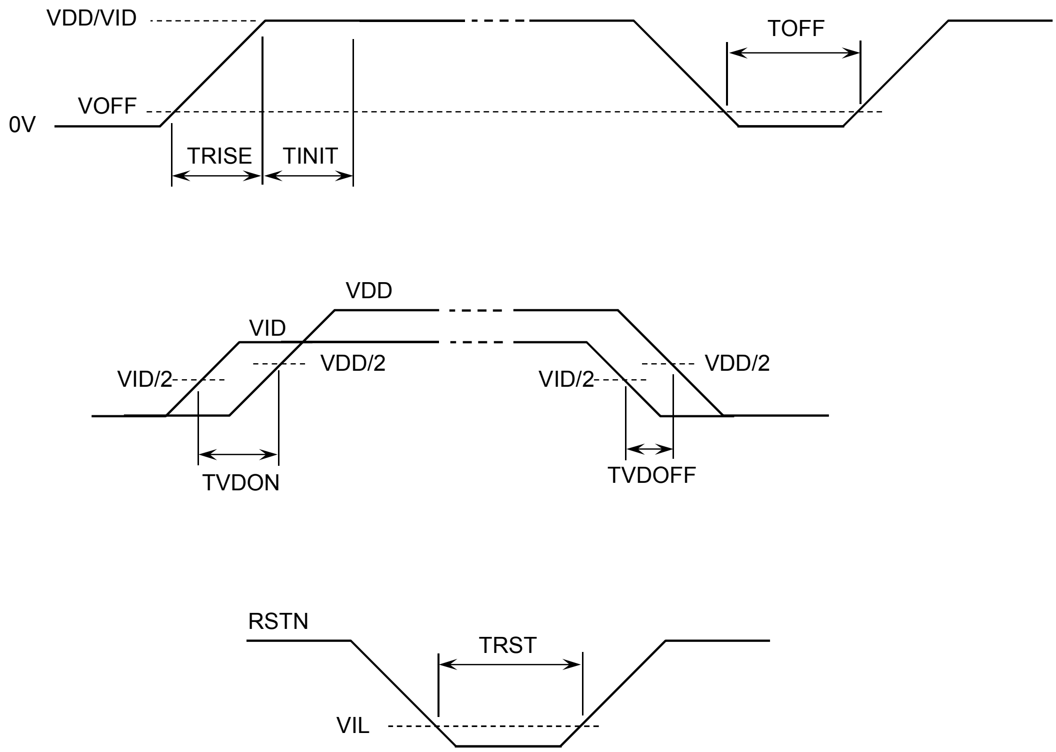


Figure 1: AC Characteristics

Block Diagram and Connection

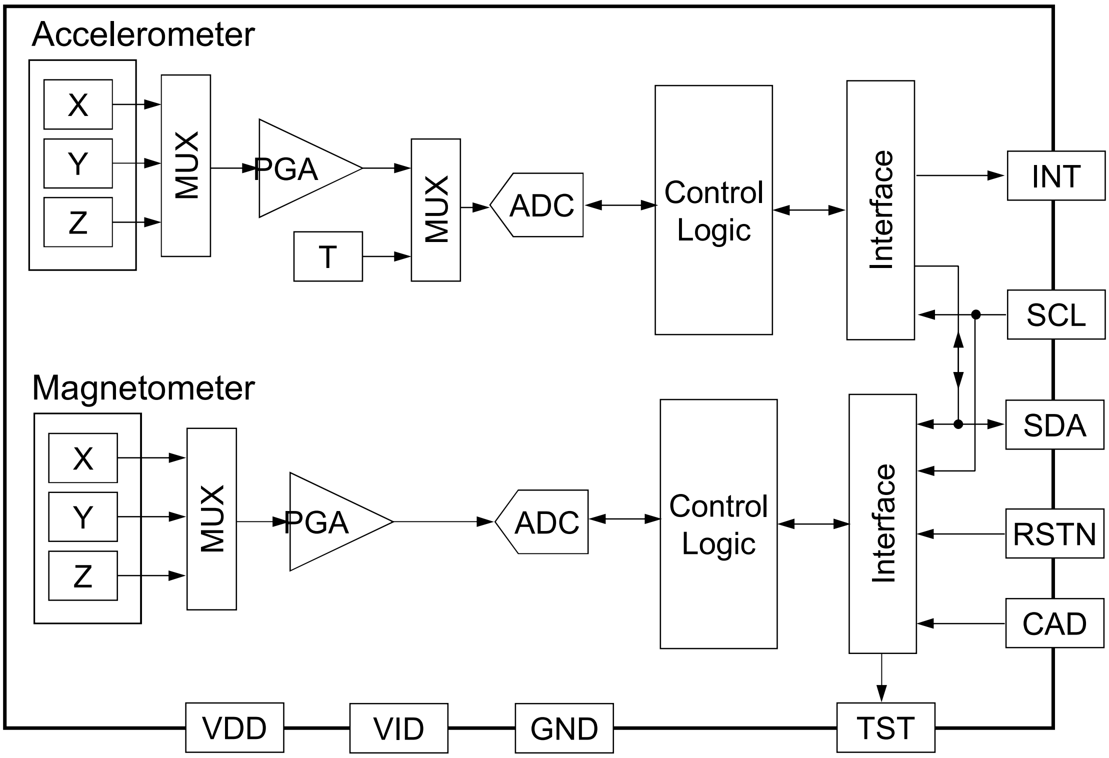


Figure 2: GME605 Block Diagram

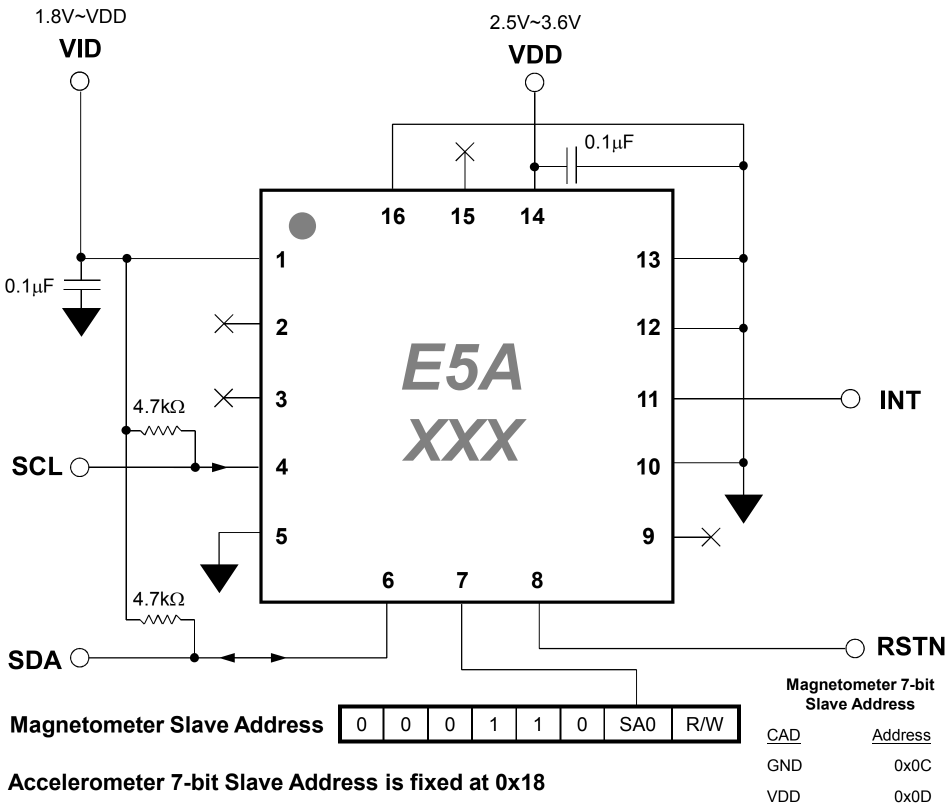


Figure 3: GME605 I2C Connection Example

ACCELEROMETER General Operation

ACCELEROMETER Initialization

GME605 ACCELEROMETER will automatically initialize to continuous mode (CM) upon power-up. Acceleration data is available without further setup. Nevertheless the following steps are provided as a reference for further customization. The register description section has more detail information on individual register settings.

Step1. Read the Register 00h (PID) for product ID. The PID value should be 0x05. Check the I2C connections if the report value is otherwise.

Step2. Write 0x40 to Register 18h. This will turn on the offset temperature compensation.

Step3. Write 0x2A to Register 15h. This will turn on the data ready interrupt and configure the INT pin to active high, push-pull type.

Step4. By default the low-pass filter is turned on. Depending on the application, user may set 0x00 to Register 16h to turn it off, or set 0x02 to 16h to turn on the high-pass filter instead.

Step5. The default power scheme is high resolution scheme. Depending on the need, user may set 0x5F to Register 38h to the low noise scheme, or set 0x9F to 38h to the low power scheme.

ACCELEROMETER Operation Modes

GME605 ACCELEROMETER provides two operation modes: the continuous mode (CM) and non-continuous mode (NCM). GME605 ACCELEROMETER will automatically power-up to CM. The CM ODR is fixed at 128Hz. The NCM ODR has options of 1/2/4/8Hz, and can be selected by NCLK bits of Register 17h. To switch between these two modes, follow below steps:

- Switch from CM to NCM: Write the byte sequence 0x02, 0x00, 0x08, 0x00 to Register 02h in one I2C transaction. This will first stop DSP and then enter the non-continuous mode.
- Switch from NCM to CM: Write the byte sequence 0x02, 0x00, 0x04, 0x00 to Register 02h in one I2C transaction. This will first stop DSP and then enter the continuous mode.

ACCELEROMETER Power-Down Modes

There are two power-down modes: the standby and suspend mode. The DSP is stopped at standby mode, but all register are accessible and their values will be kept intact. The suspend mode will cut most of the chip power, so all registers except Register 01h are not accessible and values may be corrupted after leaving the suspend mode. Follow the steps to switch between power-down and operation modes:

- Switch from operation to standby mode: Write byte sequence 0x02, 0x00 to Register 02h. This will stop DSP to enter the standby mode.
- Switch from standby mode to operation mode: Write byte sequence 0x04, 0x00 to Register 02h to switch to CM, or write byte sequence 0x08, 0x00 to Register 02h to NCM.
- Switch from operation mode to suspend mode: Write 0x05 to Register 01h. This will power down the on-chip LDO and band-gap circuit.
- Switch from suspend mode to operation mode: Write 0x02 to Register 01h. This will power up the on-chip LDO and band-gap circuit, and reset the chip. Do the usual initialization steps

after leaving the suspend mode.

ACCELEROMETER Power Schemes for Power-Noise Optimization

GME605 ACCELEROMETER power scheme can be configured to optimize the trade-off between power and noise. GME605 ACCELEROMETER provide low power scheme that can be achieved by reducing the oversampling ratio. On the other hand by selecting high oversampling ratio, the noise can be suppressed to improve resolution. GME605 ACCELEROMETER provides three oversampling ratios of 64/32/16 that can be configured by the Register 38h. Below table summarizes the settings for the three power schemes. Please refer to register description for more details.

Table 8: ACCELEROMETER Power Scheme Settings

Register 38h	Oversampling Ratio	Power Schemes
0x1F	64	High resolution
0x5F	32	Low noise
0x9F	16	Low power

ACCELEROMETER Motion Detection Function

Motion detection is used to detect the event when the acceleration reading from any of three axes exceeds a preset threshold. It can be enabled in both CM and NCM operation modes. Interrupt signal can be enabled as well.

Motion detection works in two favors: normal and differential style. In normal detection style, the acceleration reading is checked against the preset threshold directly. When the reading is larger than the threshold value, motion detection is asserted. On the contrary, the differential detection style compares the difference between the current and the previous reading with the threshold value. The detection is asserted when the *difference* is larger than the threshold.

Below summarizes the steps to use motion detection function. For more information on the mentioned registers, see the respective register description.

Step1. Set the threshold value to Register 03h. The scale factor for the setting is 1 threshold code = 0.25g.

Step2. Select the detection favor between normal and differential styles. For differential style, set 1'b1 to MM_CM or MM_NCM bits of Register 16h for CM and NCM mode respectively. Set 1'b0 to MM_CM or MM_NCM for normal style instead.

Step3. Turn on the motion detection interrupt enable. Set 1'b1 to IMEN_CM or IMEN_CM of Register 15h for CM and NCM mode respectively.

ACCELEROMETER Auto Wake-up/Sleep

GME605 ACCELEROMETER can be configured to automatically transit between CM and NCM mode based on the motion detection function. When the system is not used and does not require high sampling rate, a preset timeout put GME605 ACCELEROMETER in sleep/NCM mode to save precious power. It automatically wake-up to CM/high data-rate mode when motion is detected, which usually implies the system begin being used.

Below summarizes the steps to setup auto wake-up/sleep function. For more information on the mentioned registers, see the respective register description.

Step1. Set the timeout value to TOCT bits of Register 17h. The timeout to auto-transit from NCM/sleep to CM/wake-up mode can be set from 0.5 to 6.0 sec.

Step2. Enable the motion detection function following the steps described in the "Motion Detection Function" section. The motion detection is used to enable transition from NCM to CM, so be sure to turn on the motion detection function at NCM.

Step3. Set 1'b1 to MO_EN bit of Register 16h to enable the auto-transit from NCM to CM.

Step4. Set 1'b1 to TO_EN bit of Register 16h to enable the auto timeout transition from CM to NCM.

ACCELEROMETER Low-/High-pass Filter

GME605 ACCELEROMETER has built-in low-pass and high-pass filter. Use the low-pass filter to remove high-frequency noise, which is particular useful for static acceleration application like e-Compass tilt compensation. The high-pass filter can be used to eliminate the DC offset and low-frequency disturbance, which is helpful in transient application like motion detection. Below summarizes the steps to setup low-/high pass filter. For more information on the mentioned registers, see the respective register description.

- Low-pass filter:
  - Set 1'b1 to MVE_CM or MVE_NCM of Register 16h to turn on the 4-tap moving average filer for CM and NCM respectively.
  - Set 1'b0 to HP_CM or HP_NCM of Register 16h to turn off the high-pass option and make it low-pass for CM and NCM respectively.
- High-pass filter:
  - Set 1'b1 to MVE_CM or MVE_NCM of Register 16h to turn on the 4-tap moving average filer for CM and NCM respectively.
  - Set 1'b1 to HP_CM or HP_NCM of Register 16h to turn on the high-pass option and make it high-pass for CM and NCM respectively.

ACCELEROMETER User Registers

ACCELEROMTER User Register Map

Table 9: ACCELEROMETER User Register Map Table

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
00h	PID[7:0]								R	0x05
01h	**Reserved**					PD_BG	RST	PD_LDO	R/W	0x00
02h	**Reserved**		Not used		ACTR[3:0]				R/W	0x00
03h	Not used			MTHR[4:0]					R/W	0x1F
04h	STADR[7:0]								R	0x0055
	STADR[15:8]									
05h	RST_DP	PG_DONE	RD_DONE	OTP_VALID	Motion	CM	DAOW	DRDY	R	NA
06h	DX[6:0]							Not used	R	NA
07h	DX[14:7]								R	NA
08h	DY[6:0]							Not used	R	NA
09h	DY[14:7]								R	NA
0Ah	DZ[6:0]							Not used	R	NA
0Bh	DZ[14:7]								R	NA
0Ch	DT[7:0]								R	NA
0Dh	DT[15:8]								R	NA
0E~15h	**Reserved**								—	—
15h	Not used	IMEN_NCM	IDEN_NCM	ITYPE_NCM	IPOL	IMEN_CM	IDEN_CM	ITYPE_CM	R/W	0x11
16h	MO_EN	TO_EN	MM_NCM	HP_NCM	MVE_NCM	MM_CM	HP_CM	MVE_CM	R/W	0x00
17h	**Reserved**	TOCT[2:0]			NCLK[1:0]		**Reserved**		R/W	0xF0
18h	OFFSEL[1:0]		**Reserved**		MACT[3:0]				R/W	0x00
19~37h	**Reserved**								—	—
38h	OSM[1:0]		**Reserved**						R/W	0x1F
39~3Ch	**Reserved**								—	—

ACCELEROMETER Description of Registers

Register 00h: Product identification

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
00h	PID[7:0]								R	0x05

The register contains the GME605 ACCELEROMETER product identification code. Always read to be 0x05.

Register 01h: Power down control

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
01h	**Reserved**					PD_BG	RST	PD_LDO	R/W	0x00

PD_BG and PD_LDO bits manage the on-chip power. When set to 1’b1, the band-gap and LDO will be shut down respectively. All registers values except 01h are lost.

RST is used to reset the chip. When set to 1’b1, core logics will be reset and registers values will return to the default values.

Register 02h: Action register

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
02h	**Reserved**		Not used		ACTR[3:0]				R/W	0x00

1’b1 bit set to the ACTR[3:0] bits will trigger the following actions respectively:

Bit Set	Action
ACTR[0]	Reset DSP and AFE
ACTR[1]	Stop DSP
ACTR[2]	Enter continuous mode
ACTR[3]	Enter non-continuous mode

Register 03h: Motion threshold

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
03h	Not used			MTHR[4:0]					R/W	0x1F

MTHR[4:0] is used to set the threshold for the built-in motion detect function. The scale factor for the setting is 1 threshold code = 0.25g. Thus the full range of the threshold setting is from 0.25 to 7.75g.

Register 04h: Start register for data reading

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
04h	STADR[7:0]								R	0x0055
	STADR[15:8]									

For sensor data output, users should read 11 bytes starting from 04h register (STADR) to 0Dh in one I2C transaction. Note the register has 2-byte word length and its value is fixed to 0x0055. When the I2C data read reach 0Dh, the I2C address pointer will automatically rewind to this start register.

Register 05h: Status register

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
05h	RST_DP	PG_DONE	RD_DONE	OTP_VALID	Motion	CM	DAOW	DRDY	R	NA

The status register indicates the interrupt and DSP status. The register value will be cleared after reading data by the procedure described in the Register 04h section. Descriptions when the bit is set are summarized below.

- RST_DP: DSP is stopped
- PG_DONE: programming OTP data is completed
- RD_DONE: loading OTP data to DSP is completed
- OTP_VALID: OTP data is valid when loading OTP to DSP
- Motion: motion interrupt is asserted
- CM: DSP is in continuous mode. Otherwise DSP is in the non-continuous mode.
- DAOW: data has been over-written before read. Otherwise data has not been over-written.
- DRDY: interrupt asserted by new data arrival

Register 06h~0Dh: Data registers

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
06h	DX[6:0]							Not used	R	NA
07h	DX[14:7]								R	NA
08h	DY[6:0]							Not used	R	NA
09h	DY[14:7]								R	NA
0Ah	DZ[6:0]							Not used	R	NA
0Bh	DZ[14:7]								R	NA
0Ch	DT[7:0]								R	NA
0Dh	DT[15:8]								R	NA

The data output is encoded to a 15-bit value and stored across two bytes. Data representation is 2's complement, i.e. MSB (bit 14) is the sign bit with 1'b1 representing negative value.

The acceleration sensing has dynamic range of ±16g with sensitivity of 256 LSB/g. The central value (0x00) stands for 0g.

The temperature sensor has sensitivity of 0.5 LSB/℃. The central value (0x00) stands for 25℃.

Typical acceleration reading when GME605 ACCELEROMETER is stationary under gravitational field is summarized in the following table and Figure.

Orientation	X	Y	Z
Orientation 1	+256	0	0
Orientation 2	0	+256	0
Orientation 3	-256	0	0
Orientation 4	0	-256	0
Orientation 5	0	0	-256
Orientation 6	0	0	+256

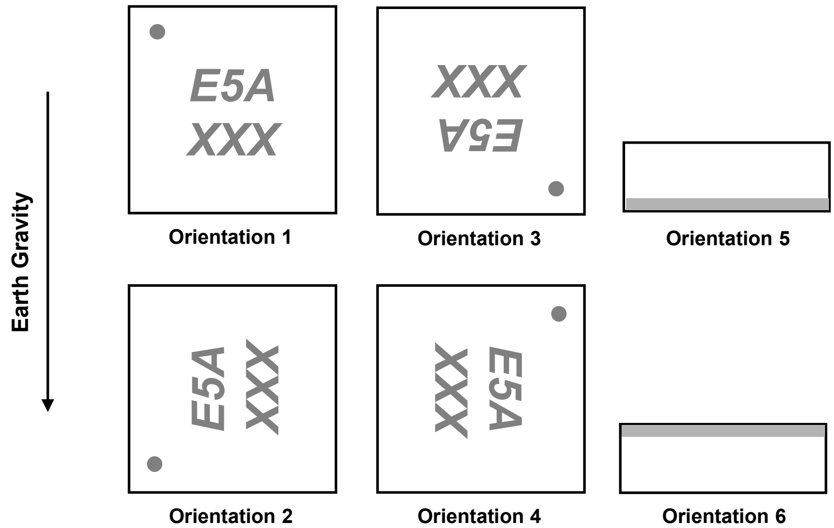


Figure 4: ACCELEROMETR typical stationary reading in gravity field

Register 15h: Interrupt configuration register

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
15h	Not used	IMEN_NCM	IDEN_NCM	ITYPE_NCM	IPOL	IMEN_CM	IDEN_CM	ITYPE_CM	R/W	0x11

The register configures the interrupt control.

- IPOL: control the polarity for the interrupt pin output. Set to 1'b1 for active high and to 1'b0 for active low.
- The other control bits are divided into two groups. Control bits end with _NCM control the designated features of NCM (non-continuous mode); while bits end with _CM control those of CM (continuous mode). The common designated features are described below.
  - IMEN: interrupt enable for motion detection. Set to 1'b0 to disenable motion interrupt; Set to 1'b1 to enable motion interrupt.
  - IDEN: interrupt enable for data ready. Set to 1'b0 to disenable data ready interrupt; Set to 1'b1 to enable data ready interrupt.
  - ITYPE: interrupt push-pull/open drain selection. 1'b0 for push-pull; 1'b0 for open drain.

Register 16h: Control register 1

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
16h	MO_EN	TO_EN	MM_NCM	HP_NCM	MVE_NCM	MM_CM	HP_CM	MVE_CM	R/W	0x00

The register controls the DSP configuration.

- MO_EN: enable the motion transition from NCM to CM.
- TO_EN: enable the timeout auto-transition from CM to NCM
- The other control bits are divided into two groups. Control bits end with _NCM control the designated features of NCM (non-continuous mode); while bits end with _CM control those of CM (continuous mode). The common designated features are described below.
  - MM: enable motion detection to the normal/differential mode. Set to 1'b0 to the normal motion detection mode, or to 1'b1 to the differential mode.
  - HP: enable the high pass filter. Set to 1'b0 to disenable and set to 1'b1 to enable the high-pass filter.
  - MVE: enable the 4-tap moving average. Set to 1'b0 to disenable and set to 1'b1 to enable the low-pass filter.

Register 17h: Control register 2

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
17h	Reserved	TOCT[2:0]			NCLK[1:0]		Reserved		R/W	0x00

TOCT[2:0] is used to set the timeout value for auto-transition from NCM to CM. The timeout values for TOCT setting are summarized below:

TOCT[2:0]	Timeout (Sec)
3'b000	0
3'b001	0
3'b010	0.5
3'b011	1.0
3'b100	1.5
3'b101	2.0
3'b110	2.5
3'b111	3.0

NCLK[1:0] is used to set the ODR in NCM mode as shown in the following:

NCLK[1:0]	Description
2'b00	1 Hz NCM ODR
2'b01	2 Hz NCM ODR
2'b10	4 Hz NCM ODR
2'b11	8 Hz NCM ODR

Register 18h: Control register 3

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
18h	OFFSEL[1:0]		**Reserved**		MACT[3:0]				R/W	0x00

OFFSEL[1:0] is used to control the offset temperature compensation.

OFFSEL[1:0]	Description
2'b00	Turn off offset temperature compensation
2'b01	Turn on offset temperature compensation
others	reserved

1'b1 bit set to the MACT[3:0] bits will trigger the following actions respectively:

Bit Set	Action
MACT[0]	Download OTP data into DSP
MACT[1]	Reserved
MACT[2]	Reserved
MACT[3]	Initialize oscillator

Register 38h: Oversampling mode register

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
38h	OSM[1:0]		**Reserved**						R/W	0x1F

OSM[1:0] selects which oversampling mode is to be used shown in the following Table. The output data rate is always 128Hz for continuous mode (CM). For non-continuous mode (NCM), the output data rate can be set to 1/2/4/8Hz, see Register 17h description for details.

OSM[1:0]	Oversampling Ratio	Power Scheme
2'b00	64	High resolution
2'b01	32	Low noise
2'b10	16	Low power
2'b11	Reserved	—

ACCELEROMETER Digital Interface

ACCELEROMETER I2C Interface General Description

The I2C interface is compliant with fast mode (400kHz) and normal mode (100 kHz) I2C standard. The 7-bit device slave address is fixed at 0x18.

The I2C bus takes master clock through SCL pin and exchanges serial data via SDA. SDA is a bidirectional (input/output) connection. Both are open-drain connection and must be connected externally to VDDIO via a pull-up resistor.

The I2C interface supports multiple read and write. When using multiple read/write, generally the internal I2C address pointer will automatically increase by 1 for the next access. But exceptions to this general rule are highlighted in the following table. For example, a multiple write to 01h (ACTR) will write multiple bytes sequence to 01h. This will make state transition easily.

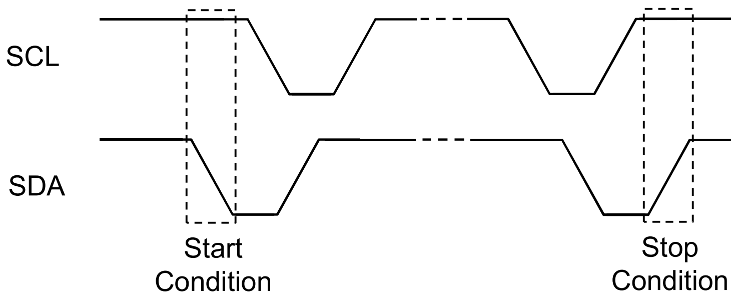
Multiple R/W	Current Address	Next Address
Multiple Write	01h	01h
Multiple Write	02h	02h
Multiple Read	0Dh	04h
Multiple Write	18h	18h

ACCELEROMETER I2C Access Format

One data bit is transferred for each SCL cycle. The SDA must not change level when the SCL is high. The level changes in SDA while SCL is high are reserved control signals. The SDA and SCL remain high when I2C bus is idle.

Data transfer begins by bus master indicating a start condition (ST) of a falling edge on SDA when SCL is high. The master terminates transmission and frees the bus by issuing a STOP condition (SP). Stop condition is a rising edge on SDA while SCL is high. The bus remains active if a repeated START (SR) condition is generated instead of a STOP condition. Figure 5 illustrates the START and STOP condition.

Figure 5: ACCELEROMETER I2C START and STOP condition



After a start condition (ST), the 7-bit slave address + RW bit must be sent by master. If the slave address does not match with GME605 ACCELEROMETER, there is no acknowledge and the following data transfer will not affect GME605 ACCELEROMETER. If the slave address corresponds to GME605 ACCELEROMETER, it will acknowledge by pulling SDA to low and the SDA line should be let free by bus master to enable the data transfer. The master should let the SDA high (no pull down) and generate a high SCL pulse for GME605 ACCELEROMETER acknowledge. Figure 6 illustrates the acknowledge signal sequence.

Figure 6: ACCELEROMETER acknowledge signal sequence

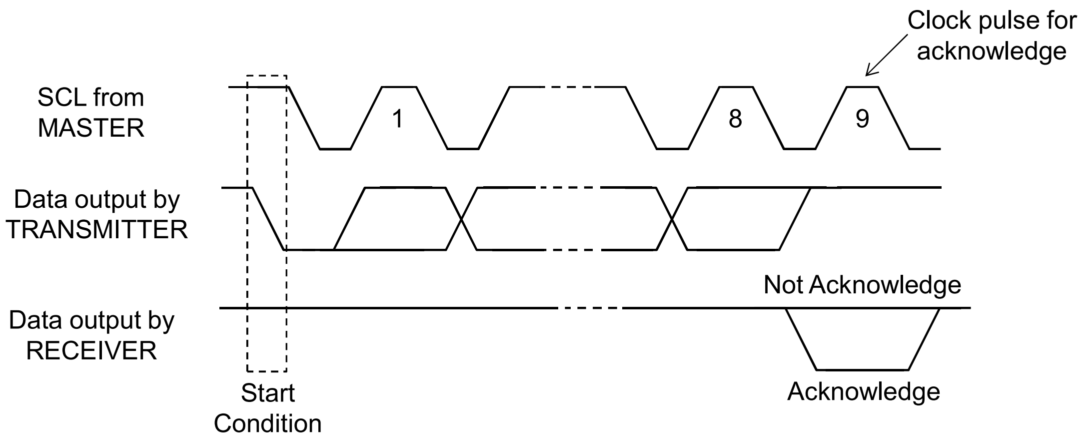
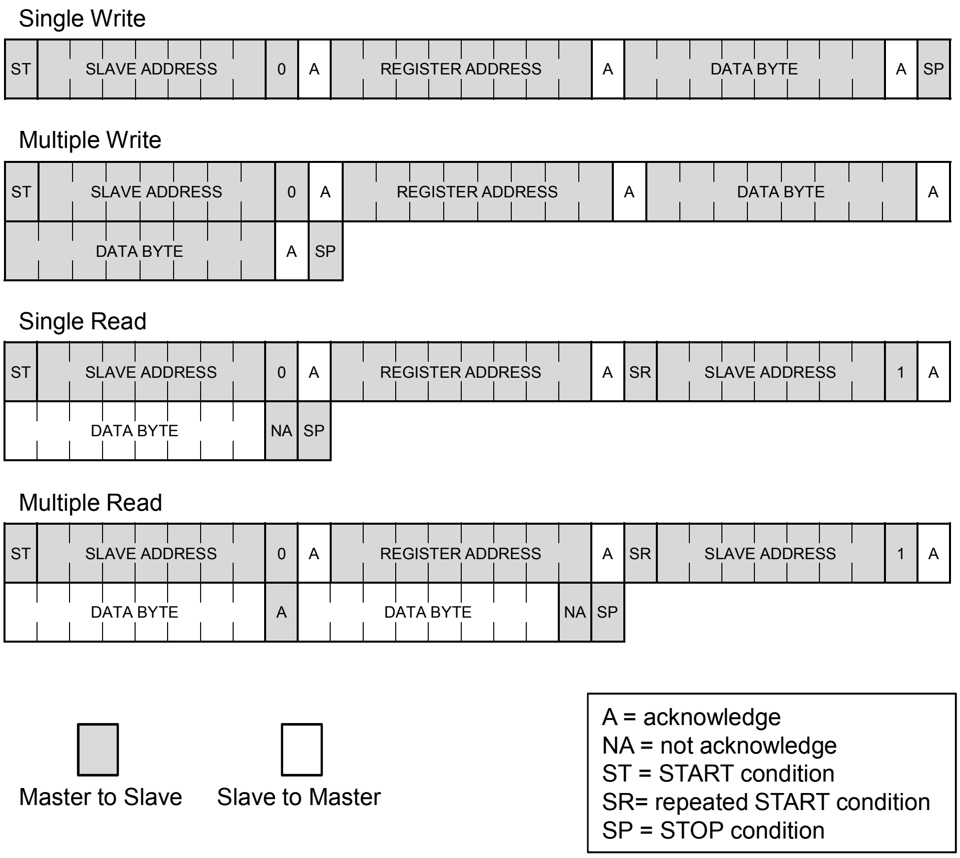


Figure 7: ACCELEROMETER I2C access format



A write to GME605 ACCELEROMETER includes transmission of a START condition, the slave address with R/W bit=1'b0, one byte of data to specify the register address to write, subsequent one or more bytes of data, and finally a STOP condition. "Single Write" and "Multiple Write" in Figure 7 illustrates the frame format of single and multiple write to GME605

ACCELEROMETER respectively.

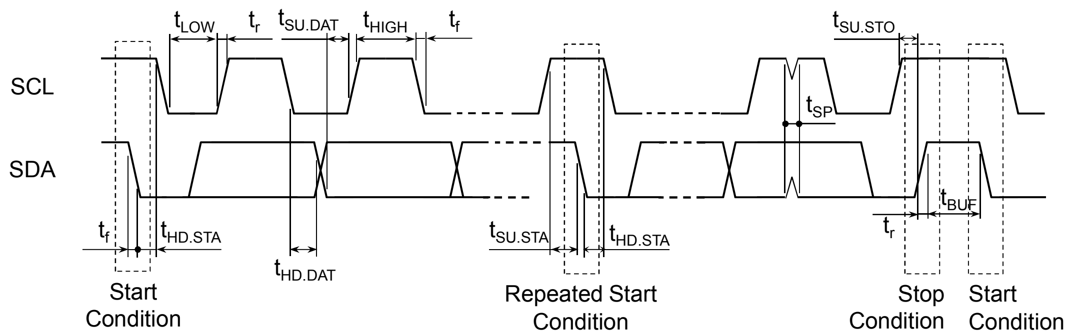
A read from GME605 ACCELEROMETER starts with transmission of a START condition, the slave address with R/W bit=1'b0, and one byte of data to specify the register address to read. A repeated START condition and the slave address with R/W bit=1'b1 are transmitted subsequently. The slave address with R/W bit=1'b1 initiates a read operation. GME605 ACCELEROMETER acknowledge receipt of the read operation command by pulling SDA low during the 9th SCL clock and begin transmitting the contents starting from the specified register address. The master must acknowledge all correctly received bytes except the last byte. The final byte must be followed by a not acknowledge from the master and the STOP condition. "Single Read" and "Multiple Read" in Figure 7 illustrates the frame format for reading single or multiple byte from GME605 ACCELEROMETER.

ACCELEROMTER I2C Specifications

Table 10: ACCELEROMETER I2C Timing Specification

Parameter	Symbol	Minimum	Typical	Maximum	Unit
SCL clock frequency	f_{SCL}	—	—	400	kHz
Clock low period	t_{LOW}	1.3	—	—	μs
Clock high period	t_{HIGH}	0.6	—	—	μs
Bus free to new start	t_{BUF}	1.3	—	—	μs
Start hold time	$t_{HD.STA}$	0.6	—	—	μs
Start setup time	$t_{SU.STA}$	0.6	—	—	μs
Data-in hold time	$t_{HD.DAT}$	0	—	—	μs
Data-in setup time	$t_{SU.DAT}$	100	—	—	ns
Stop setup time	$t_{SU.STO}$	0.6	—	—	μs
Rise time	t_r	—	—	0.3	μs
Fall time	t_f	—	—	0.3	μs
Spike width	t_{SP}	—	—	50	μs

Figure 8: ACCELEROMETER I2C Timing Diagram



MAGNETOMETER Functional Description

MAGNETOMETER Power States

When VDD and VID are turned on from VDD=OFF (0V) and VID=OFF (0V), all registers in GME605 MAGNETOMETER are initialized to default values by POR circuit and GME605 MAGNETOMETER transists to power-down mode.

All the states in the table below can be set, except the transition from state 2 to state 3 and the transition from state 3 to state 2 are prohibited.

Table 11: MAGNETOMETER Power States

State	VDD	VID	Power State
1	OFF (0V)	OFF (0V)	OFF (0V) It doesn't affect external interface. Digital input pins other than SCL and SDA pin should be fixed to "L" (0V).
2	OFF (0V)	1.65~3.6V	OFF (0V) It doesn't affect external interface.
3	2.5~3.6V	OFF (0V)	OFF (0V) It doesn't affect external interface. Digital input pins other than SCL and SDA pin should be fixed to "L" (0V).
4	2.5~3.6V	1.65V~VDD	ON

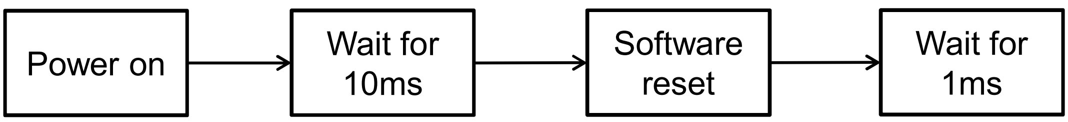
MAGNETOMETER Reset Functions

When the power state is set to ON, make sure VID is always no more than VDD. Power-on reset circuit (POR) will be active until VDD reaches the effective operation voltage, about 1.4V as taken from the design reference. After the POR circuit deactivate, all registers will be initialized to default values and then GME605 MAGNETOMETER transits to power-down mode.

GME605 MAGNETOMETER has three types of reset as summarized below.

- Power-on reset (POR): When VDD rise is detected, POR circuit kicks in to reset GME605 MAGNETOMETER.
- Reset pin (RSTN): GME605 MAGNETOMETER is reset when RSTN is "L". Connect RSTN to VID if this feature is not used.
- Software reset: GME605 MAGNETOMETER is reset by setting SRST bit. And the fuse ROM value will be automatically loaded.

Power on Sequence



MAGNETOMETER Operation Modes

GME605 MAGNETOMETER has the following eight operation modes, which can be set by the MODE[4:0] bits.

1. Power-down mode: MODE[4:0] = "00h"
   - When power is turned ON, sensor is put in power-down mode..
   - Return to power-down mode before changing operation mode.
2. Single measurement mode: MODE[4:0] = "01h"
   - Sensor will take one-time measurement and returns to power-down mode automatically.
3. Continuous measurement mode 1: MODE[4:0] = "02h"
   - Sensor will take periodic measurement at 10Hz ODR.
4. Continuous measurement mode 2: MODE[4:0] = "04h"
   - Sensor will take periodic measurement at 20Hz ODR.
5. Continuous measurement mode 3: MODE[4:0] = "06h"
   - Sensor will take periodic measurement at 50Hz ODR.
6. Continuous measurement mode 4: MODE[4:0] = "08h"
   - Sensor will take periodic measurement at 100Hz ODR.
7. Self-test mode: MODE[4:0] = "10h"
   - Sensor will activate self-test and output the result before automatically returning to power-down mode.
8. Fuse ROM access mode: MODE[4:0] = "1Fh"
   - Download all data from Fuse ROM to registers automatically.

When power is turned ON, MODE[4:0] is reset to "00h" and GME605 MAGNETOMETER is in power-down mode. When a specified value is set to MODE[4:0], GME605 MAGNETOMETER transits to the specified mode and starts operation. If user wants to change operation mode, user needs to return to power-down mode and wait at least for at 100us (TWAIT) before setting another mode. An operation mode transition is shown below.

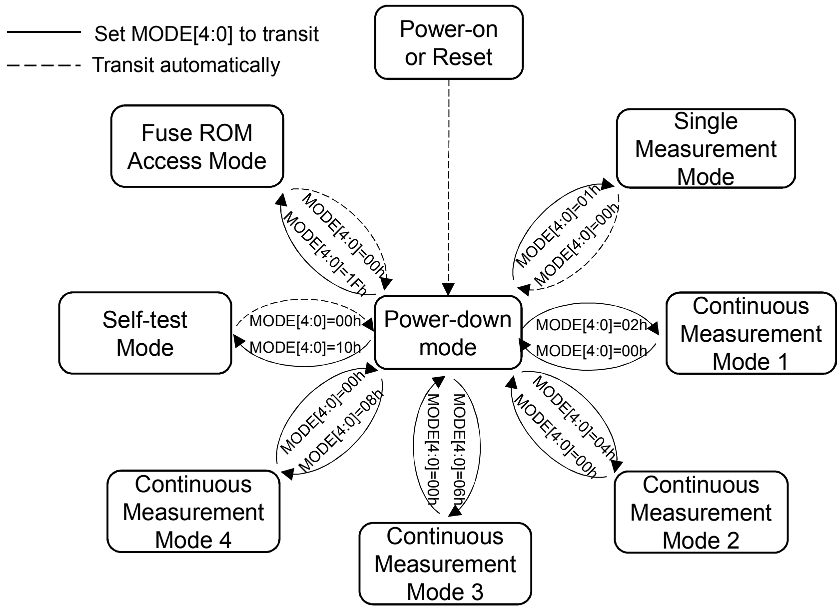


Figure 9: MAGNETOMETER State Transition Diagram

MAGNETOMETER User Registers

MAGNETOMETER User Register Map

Table 12: MAGNETOMETER User Register Map Table

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
00h	CMPID	CMPID[7:0]								R	0x48
01h	DEVID	DEVID[7:0]								R	0x05
02h	INFO1	INFO1[7:0]								R	0x00
03h	INFO2	INFO2[7:0]								R	0x00
10h	ST1	HSM	0	0	0	0	0	DOR	DRDY	R	NA
11h	HXL	HX[7:0]								R	NA
12h	HXH	HX[15:8]								R	NA
13h	HYL	HY[7:0]								R	NA
14h	HYH	HY[15:8]								R	NA
15h	HZL	HZ[7:0]								R	NA
16h	HZH	HZ[15:8]								R	NA
17h	TMPS	Reserved								R	0x00
18h	ST2	0	0	0	0	HOFL	0	0	0	R	NA
30h	CNTL1	Reserved								R/W	—
31h	CNTL2	0	0	0	MODE[4:0]					R/W	NA
32h	CNTL3	0	0	0	0	0	0	0	SRST	R/W	NA
33h	TS1	Reserved								R/W	—
60h	ASAX	COEFX[7:0]								R	NA
61h	ASAY	COEFY[7:0]								R	NA
62h	ASAZ	COEFZ[7:0]								R	NA

MAGNETOMETER Description of Registers

Register 00h & 01h: Product Identification Registers

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
00h	CMPID	CMPID[7:0]								R	0x48
01h	DEVID	DEVID[7:0]								R	0x05

CMPID and DEVID are product identification registers and are fixed to 0x48 and 0x05 respectively.

Register 02h & 03h: Information Registers

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
02h	INFO1	INFO1[7:0]								R	0x00
03h	INFO2	INFO2[7:0]								R	0x00

INFO1 and INFO2 are information registers storing miscellaneous device information.

Register 10h: Status Register 1

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
10h	ST1	HSM	0	0	0	0	0	DOR	DRDY	R	NA

DRDY is the magnetic measurement data ready bit. Bit set represents measurement results are ready to read. DRDY will be cleared when any of the data registers (HX to TMPS) or ST2 register is read. The measured data is stored to the data registers (HX to HZ) and DRDY bit is set when the measurement period complete, as illustrated in the Figure 10.

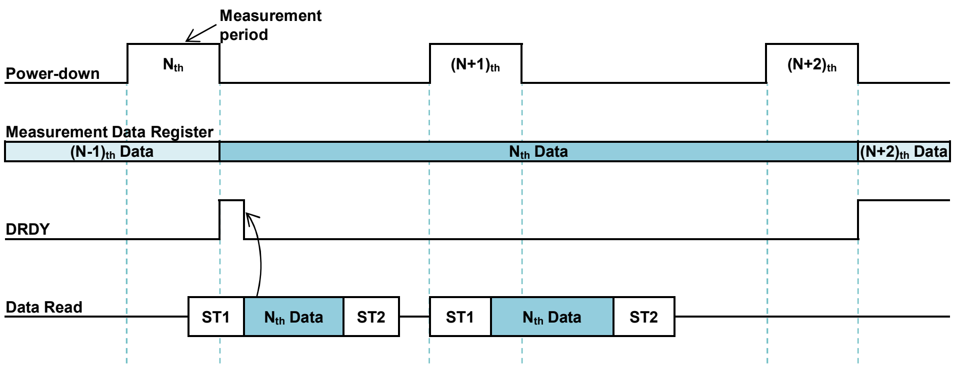


Figure 10: MAGNETOMETER DRDY bit and measurement data read

DOR is the data over-run/skip bit. Bit set represent magnetic measurement data is over-run or skipped. DOR will be cleared when any of the data registers (HX to TMPS) or ST2 register is read. As illustrated in the Figure 11, when N_{th} data is not read before the $(N+1)_{th}$ measurement complete, the DOR bit is set, indicating the Nth data is over-run by the $(N+1)_{th}$ measurement result.

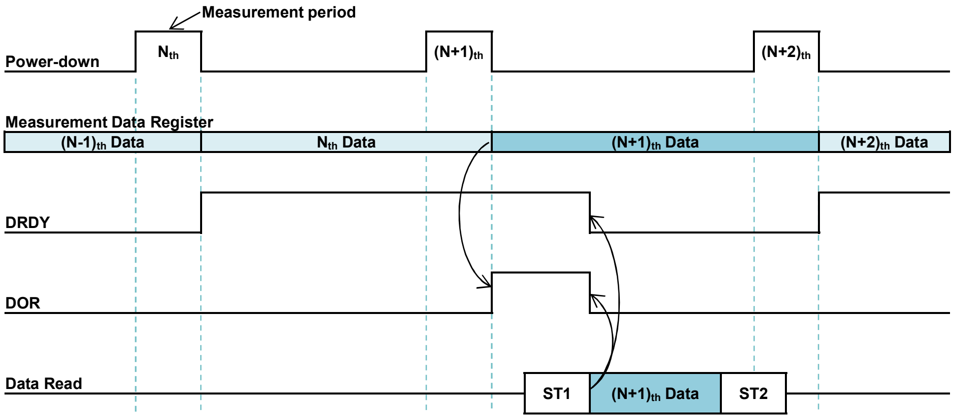


Figure 11: MAGNETOMETER DOR bit and data over-run

However if the data read start right after N_{th} measurement complete but does not manage to finish before $(N+1)_{th}$ measurement end, N_{th} measurement data is protected from being over-run by the $(N+1)_{th}$ data. In such case the DRDY will not be set after the complete of $(N+1)_{th}$ measurement because data registers are protected from being updated. Instead the DOR will be set to indicate the $(N+1)_{th}$ data is skipped, as illustrated in the Figure 12.

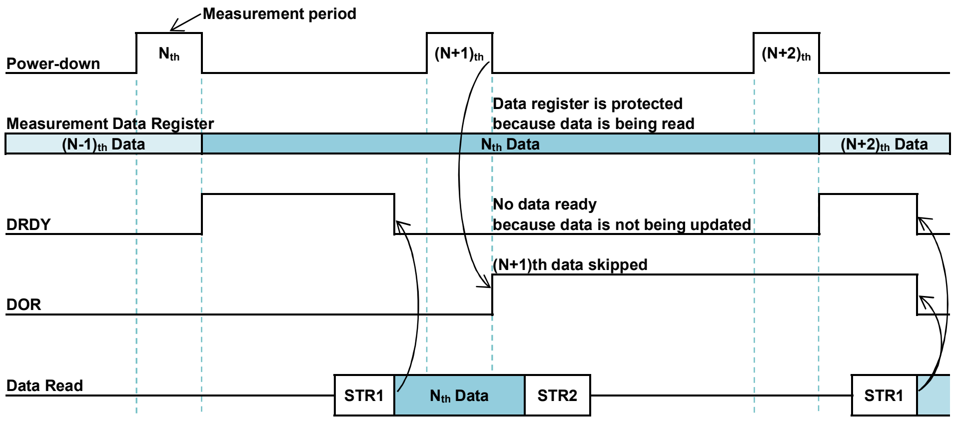


Figure 12: MAGNETOMETER DOR bit and data skip

HSM is the I2C high-speed mode (Hs-mode) bit. Bit set represents I2C is in the high-speed mode. Otherwise I2C is in the standard or fast mode.

Register 11h to 16h: Magnetic Measurement Data Registers

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
11h	HXL	HX[7:0]								R	NA
12h	HXH	HX[15:8]								R	NA
13h	HYL	HY[7:0]								R	NA
14h	HYH	HY[15:8]								R	NA

15h	HZL	HZ[7:0]	R	NA
16h	HZH	HZ[15:8]	R	NA

HX[15:0], HY[15:0] and HZ[15:0] are magnetic measurement data registers of X-/Y-/Z-axis respectively. When measurement period complete, measured data is stored to these magnetic measurement data registers using two's complement format. Measurement range for each axis is from -8190 to +8190.

Measurement Data (each axis)[15:0]		Magnetic Flux Density (uT)
Two's complement (Hex)	**Decimal**	
1FFE	8190	4914 (max)
…	…	…
0001	1	0.6
0000	0	0
FFFF	-1	-0.6
…	…	…
E002	-8190	-4914 (min)

Register 18h: Status Register 2

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
18h	ST2	0	0	0	0	HOFL	0	0	0	R	NA

HOFL is the magnetic sensor overflow bit. Bit set means magnetic sensor overflow occurs. GME605 MAGNETOMETER limits the sum of absolute values of each axis to 4912uT, i.e. $\|X\|+\|Y\|+\|Z\|<4912\text{uT}$. Even the measurement data registers are not saturated, magnetic sensor may overflow. In such case the measurement data is not correct and the HOFL bit will be set. HOFL bit can be cleared by reading ST2 (18h) register, or when next measurement period starts.

Register 31h: Control Register 2

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
31h	CNTL2	0	0	0	MODE[4:0]					R/W	NA

MODE[4:0] set the following operation modes. Other settings are prohibited.

- MODE[4:0]=00h: Power-down mode
- MODE[4:0]=01h: Single measurement mode
- MODE[4:0]=02h: Continuous measurement mode 1
- MODE[4:0]=04h: Continuous measurement mode 2
- MODE[4:0]=06h: Continuous measurement mode 3
- MODE[4:0]=08h: Continuous measurement mode 4
- MODE[4:0]=10h: Self-test mode

- MODE[4:0]=1Fh: Fuse ROM access mode

Power-down Mode

Set MODE[4:0] to 00h to enter power-down mode. All internal circuits are turned off, but all registers remain accessible and register values are retained. GME605 MAGNETOMETER will automatically enter power-down mode after power-on or by RSTN or SRST reset, as shown in the Figure 9.

Single Measurement Mode

GME301 will make a single measurement once and automatically transit to the power-down mode every time when entering the single measurement mode by setting MODE[4:0]=01h. Measurement data is then stored to the measurement data registers (HX to HZ) and DRDY bit set. The measurement result is available to access anytime before another measurement starts. Depending on the timing, the current result may be over-run by the next measurement, Figure 13, or the next measurement data is skipped, Figure 14.

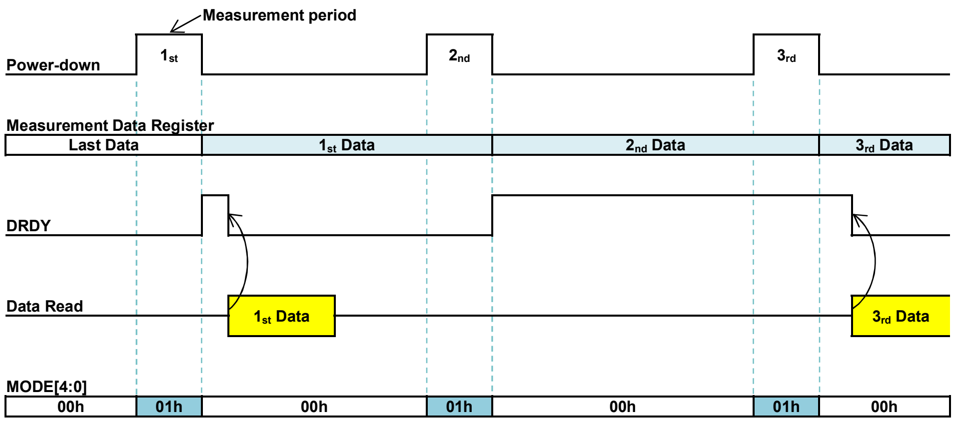


Figure 13: MAGNETOMETER single measurement and data over-run

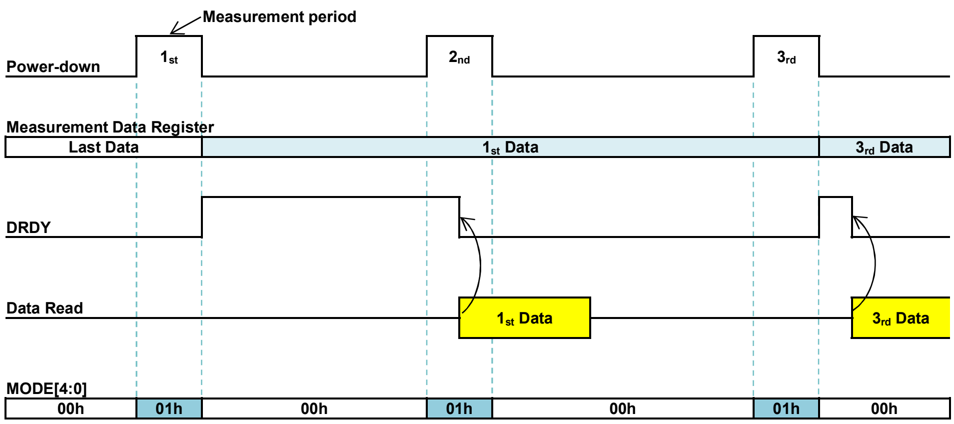


Figure 14: MAGNETOMETER single measurement and data skip

Continuous Measurement Mode

When put into the continuous measurement mode by setting MODE[4:0]=02h/04/06h/08h, GME605 MAGNETOMETER will make periodic data measurement with four ODR options of 10/20/50/100Hz respectively. The measurement data will be stored to the measurement data registers (HX to HZ) after the current measurement is finished, and DRDY bit is set accordingly. All circuit except the OSC is turned off intermittently until next measurement due. DRDY bit can be cleared by reading any of the data registers (HX to TMPS) or ST2 register. The timing of normal continuous mode is illustrated in the Figure 15.

To switch between operation mode, user needs to return to power-down mode by setting MODE[4:0]=00h and then set to another operation mode, as shown in the Figure 9.

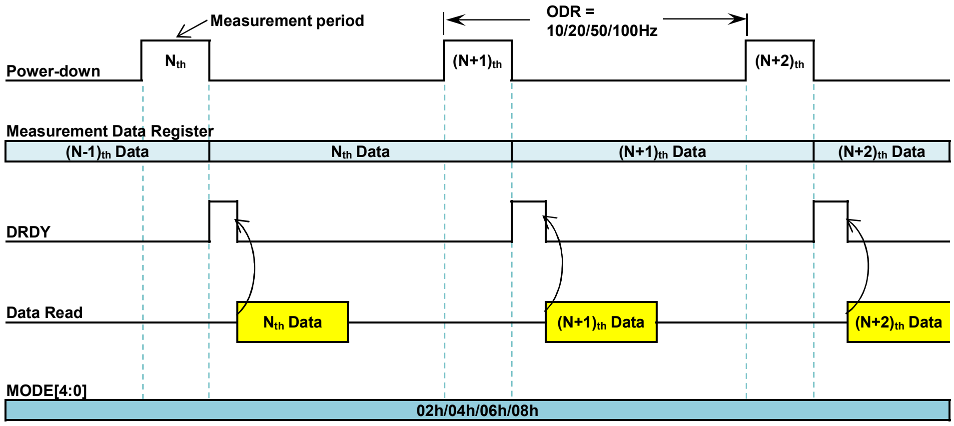


Figure 15: MAGNETOMETER normal continuous measurement mode

Self-test Mode

Self-test mode is used to check if the magnetic sensor is working normally. GME301 will start the self-test sequence when setting MODE[4:0]=10h, and automatically transits to power-down mode when complete. At first the built-in internal magnetic source will generate a magnetic field for measurement. After the measurement process is finished, the measurement data is stored in the measurement data registers (HX to HZ) and set the DRDY bit. User can access the measurement result for judgment with the same procedure as the single measurement mode. When the reading is in the range of the following table, GME605 MAGNETOMETER is working normally.

	HX[15:0]	HY[15:0]	HZ[15:0]
Criteria	-40<HX<40	-40<HY<40	-320<HZ<-80

Fuse ROM Access Mode

GME605 MAGNETOMETER has fuse ROM for storing calibration data. When MODE[4:0] is set to 1Fh, all magnetic coefficient data of fuse ROM is read. After reading fuse ROM is finished, operation mode returns to power-down mode automatically.

Register 32h: Control Register 3

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
32h	CNTL3	0	0	0	0	0	0	0	SRST	R/W	NA

SRST is the soft reset bit. When set, all registers are reset to default values. After reset, SRST bit is cleared automatically.

Register 60h~62h: Magnetic Coefficient Registers

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
60h	ASAX	COEFX[7:0]								R	NA
61h	ASAY	COEFY[7:0]								R	NA
62h	ASAZ	COEFZ[7:0]								R	NA

ASAX, ASAY and ASAZ are magnetic sensor sensitivity coefficient value for X-, Y- and Z-axis respectively. The coefficient is used for the sensitivity adjustment by the following equation:

$$H_{adj} = H \times \left(\frac{ASA}{128} + 1 \right)$$

where

H : the measuremet data read out from the measurement data registers

ASA : the sensitivity adjustment value

H_{adj} : the adjusted measurement data

MAGNETOMETER Digital Interface

MAGNETOMETER I2C Interface General Description

The I2C interface is compliant with standard, fast and high-speed I2C standard. The devices support the 7-bit control functions and SDA and SCL facilitate communication between GME605 MAGNETOMETER and master with clock rates up to 3.4MHz.

The 7-bit device slave address can be selected by the CAD pin as summarized in the below table.

CAD	7-bit Slave Address
1'b0	0x0C
1'b1	0x0D

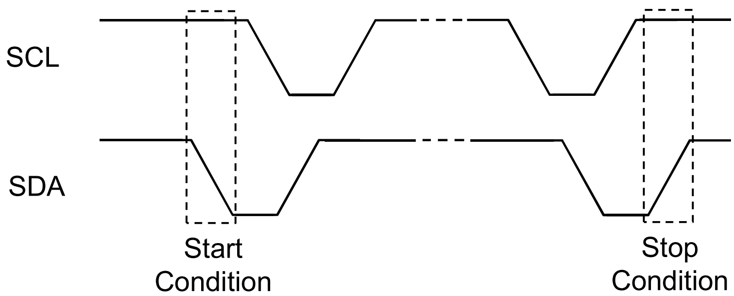
The I2C bus takes master clock through SCL pin and exchanges serial data via SDA. SDA is a bidirectional (input/output) connection. Both are open-drain connection and must be connected externally to VID via a pull-up resistor. The I2C interface supports multiple read and write. When using multiple read/write, the internal I2C address pointer will automatically increase by 1 for the next access.

MAGNETOMETER I2C Access Format: Standard and Fast Mode

One data bit is transferred for each SCL cycle. The SDA must not change level when the SCL is high. The level changes in SDA while SCL is high are reserved control signals. The SDA and SCL remain high when I2C bus is idle.

Data transfer begins by bus master indicating a start condition (ST) of a falling edge on SDA when SCL is high. The master terminates transmission and frees the bus by issuing a STOP condition (SP). Stop condition is a rising edge on SDA while SCL is high. The bus remains active if a repeated START (SR) condition is generated instead of a STOP condition. Figure 16 illustrates the START and STOP condition.

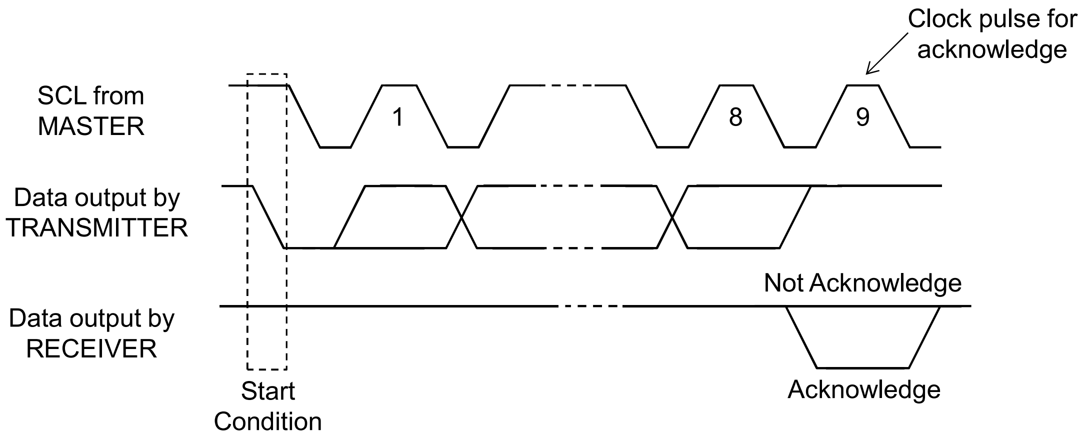
Figure 16: MAGNETOMETER I2C START and STOP condition



After a start condition (ST), the 7-bit slave address + RW bit must be sent by master. If the slave address does not match with GME605 MAGNETOMETER, there is no acknowledge and the following data transfer will not affect GME605 MAGNETOMETER. If the slave address corresponds to GME605 MAGNETOMETER, it will acknowledge by pulling SDA to low and the SDA line should be let free by bus master to enable the data transfer. The master should let the

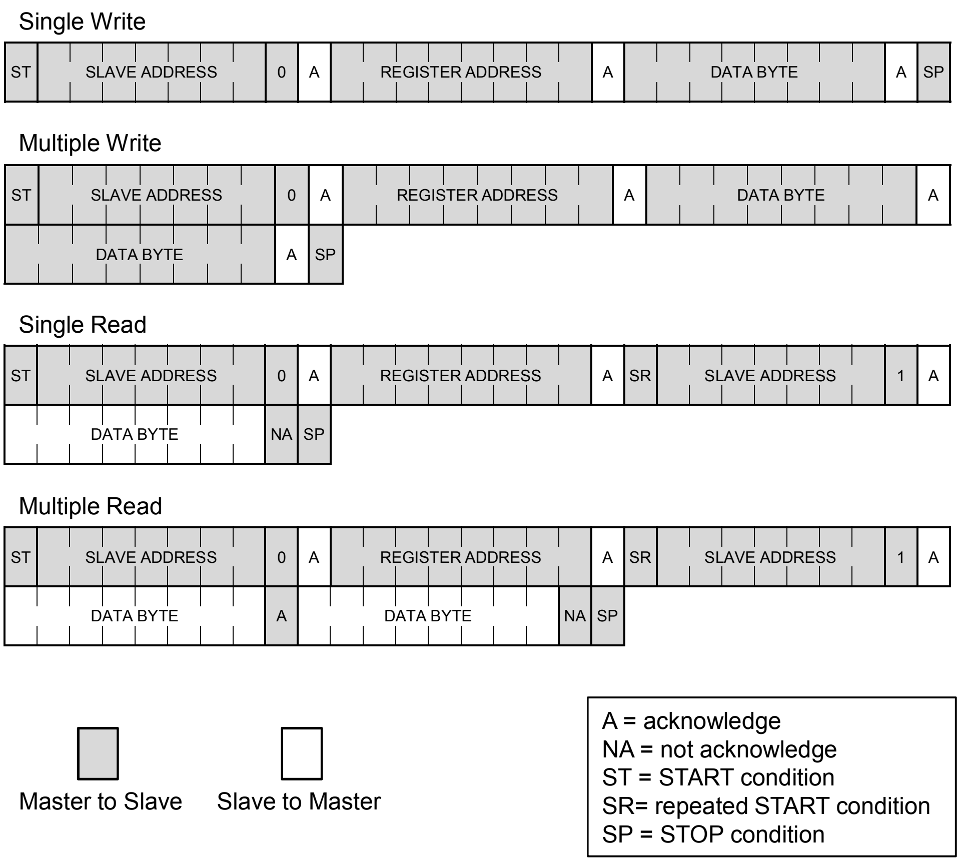
SDA high (no pull down) and generate a high SCL pulse for GME605 MAGNETOMETER acknowledge. Figure 17 illustrates the acknowledge signal sequence.

Figure 17: MAGNETOMETER acknowledge signal sequence



A write to GME605 MAGNETOMETER includes transmission of a START condition, the slave address with R/W bit=1'b0, one byte of data to specify the register address to write, subsequent one or more bytes of data, and finally a STOP condition. "Single Write" and "Multiple Write" in Figure 18 illustrates the frame format of single and multiple write to GME605 MAGNETOMETER respectively.

Figure 18: MAGNETOMETER I2C access format: standard and fast mode



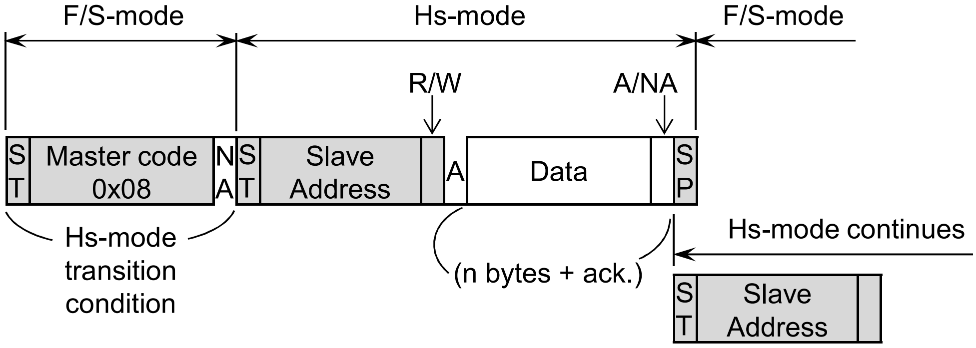
A read from GME605 MAGNETOMETER starts with transmission of a START condition, the slave address with R/W bit=1'b0, and one byte of data to specify the register address to read. A repeated START condition and the slave address with R/W bit=1'b1 are transmitted subsequently. The slave address with R/W bit=1'b1 initiates a read operation. GME605 MAGNETOMETER acknowledge receipt of the read operation command by pulling SDA low during the 9^{th} SCL clock and begin transmitting the contents starting from the specified register address. The master must acknowledge all correctly received bytes except the last byte. The final byte must be followed by a not acknowledge from the master and the STOP condition. "Single Read" and "Multiple Read" in Figure 18 illustrates the frame format for reading single or multiple byte from GME605 MAGNETOMETER.

MAGNETOMETER I2C Access Format: High-Speed Mode

GME605 MAGNETOMETER supports the I2C high-speed mode (Hs-mode). Hs-mode can only be initiated after the Hs-mode transition condition is met. The Hs-code transition condition is communicated under Fast/Standard-mode beginning with START (ST) condition, then the 8-bit master code and finally not-acknowledge (NA) bit, as shown in the Figure 19.

After the master sends master code to GME605 MAGNETOMETER, GME605 MAGNETOMETER responses with not-acknowledge (NA) and switch over to circuit ready for Hs-mode communication. From next START (ST) condition GME605 MAGNETOMETER can start communicating at the Hs-mode. The STOP (SP) condition will make GME605 MAGNETOMETER end the Hs-mode and switch back to Fast/Standard-mode.

Figure 19: MAGNETOMETER data transfer format in Hs-mode



MAGNETOMETER I2C Specifications

Table 13: MAGNETOMETER I2C Timing Specification: Standard Mode

Parameter	Symbol	Minimum	Typical	Maximum	Unit
SCL clock frequency	f_{SCL}	—	—	100	kHz
Clock low period	t_{LOW}	4.7	—	—	µs
Clock high period	t_{HIGH}	4	—	—	µs
Start hold time	$t_{HD.STA}$	4	—	—	µs
Start setup time	$t_{SU.STA}$	4.7	—	—	µs
Data-in hold time	$t_{HD.DAT}$	0	—	—	µs
Data-in setup time	$t_{SU.DAT}$	250	—	—	ns
Stop setup time	$t_{SU.STO}$	4	—	—	µs
Rise time	t_r	—	—	1	µs
Fall time	t_f	—	—	0.3	µs

Table 14: MAGNETOMETER I2C Timing Specification: Fast Mode

Parameter	Symbol	Minimum	Typical	Maximum	Unit
SCL clock frequency	f_{SCL}	—	—	400	kHz
Clock low period	t_{LOW}	1.3	—	—	µs
Clock high period	t_{HIGH}	0.6	—	—	µs
Bus free to new start	t_{BUF}	1.3	—	—	µs
Start hold time	$t_{HD.STA}$	0.6	—	—	µs
Start setup time	$t_{SU.STA}$	0.6	—	—	µs
Data-in hold time	$t_{HD.DAT}$	0	—	—	µs
Data-in setup time	$t_{SU.DAT}$	100	—	—	ns
Stop setup time	$t_{SU.STO}$	0.6	—	—	µs
Rise time	t_r	—	—	0.3	µs
Fall time	t_f	—	—	0.3	µs
Spike width	t_{SP}	—	—	50	µs

Figure 20: MAGNETOMETER I2C Timing Diagram: Standard and Fast Mode

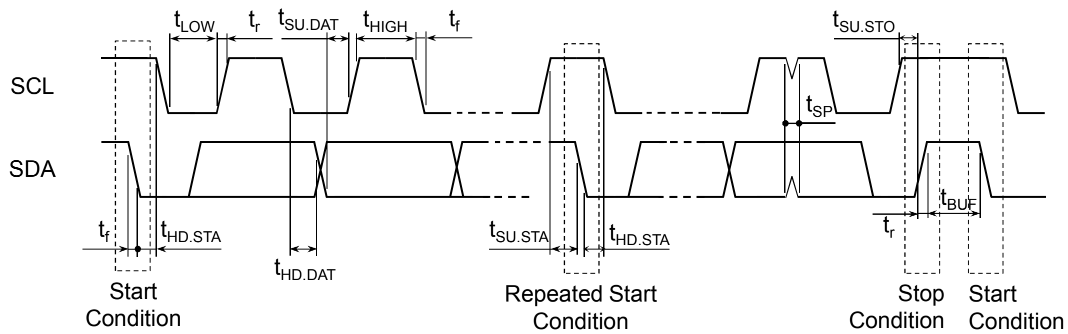
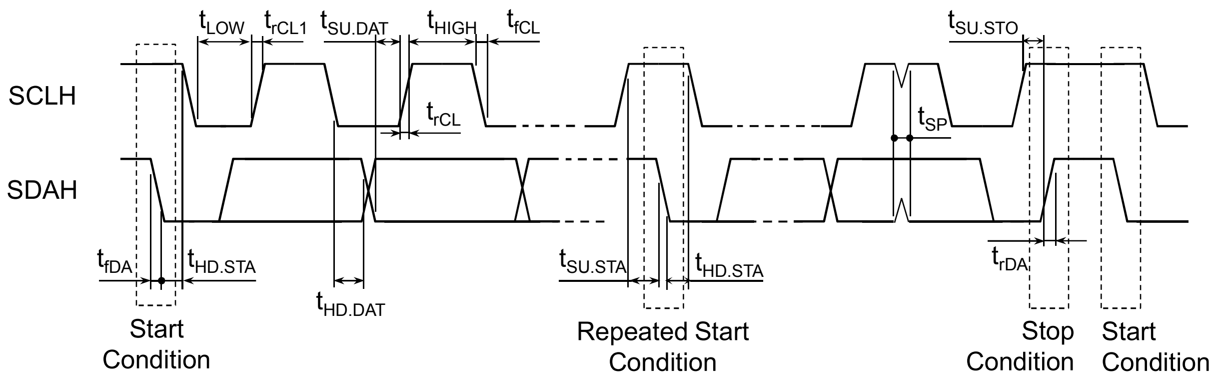


Table 15: MAGNETOMETER I2C Timing Specification: Fast Mode

Parameter	Symbol	Minimum	Typical	Maximum	Unit
SCLH clock frequency	f_{SCLH}	—	—	3.4	MHz
Clock low period	t_{LOW}	220	—	—	ns
Clock high period	t_{HIGH}	110	—	—	ns
Start hold time	$t_{HD.STA}$	160	—	—	ns
Start setup time	$t_{SU.STA}$	160	—	—	ns
Data-in hold time	$t_{HD.DAT}$	0	—	—	ns
Data-in setup time	$t_{SU.DAT}$	10	—	—	ns
Stop setup time	$t_{SU.STO}$	160	—	—	ns
Rise time of SCLH	t_{rCL}	10	—	40	ns
Rise time of SCLH after a repeated START condition and acknowledge bit	t_{rCL1}	10	—	80	ns
Rise time of SDAH	t_{rDA}	10	—	80	ns
Fall time of SCLH	t_{fCL}	—	—	40	ns
Fall time of SDAH	t_{fDA}	—	—	80	ns
Spike width	t_{SP}	—	—	10	ns

Figure 21: MAGNETOMETER I2C Timing Diagram: High-speed Mode



Package

Outline Dimension

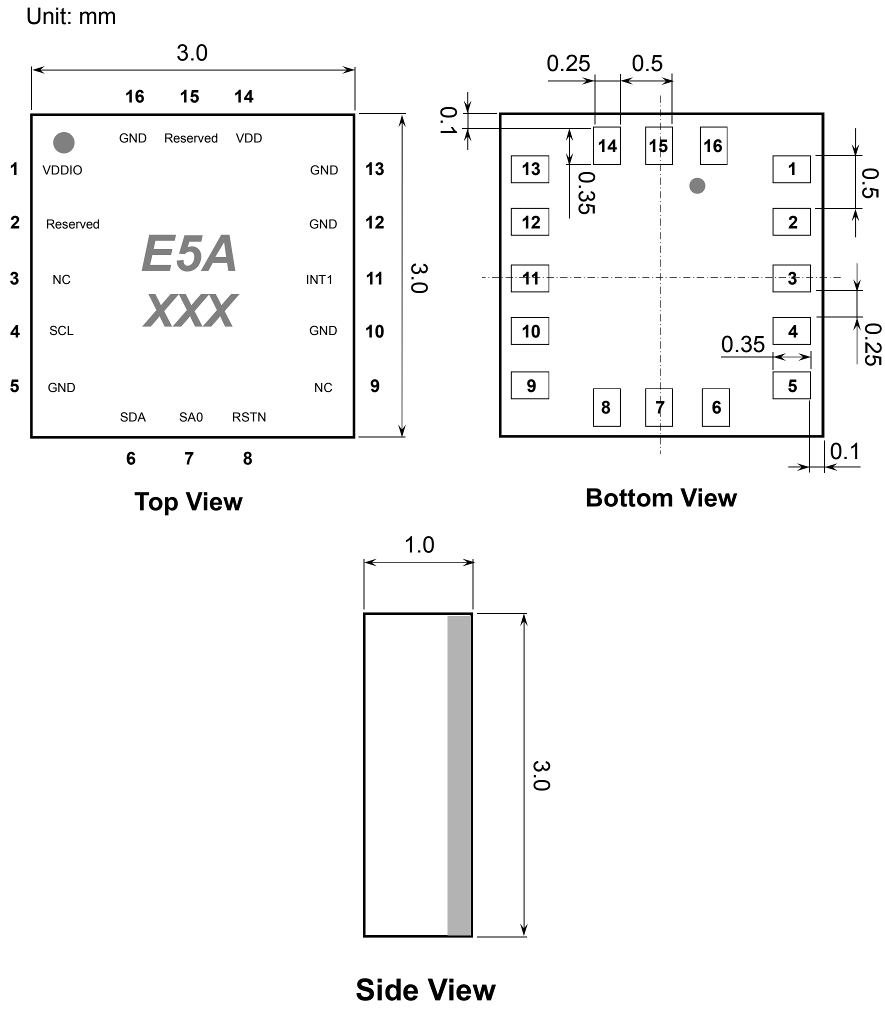


Figure 22: Package Outline Dimension

Axes Orientation

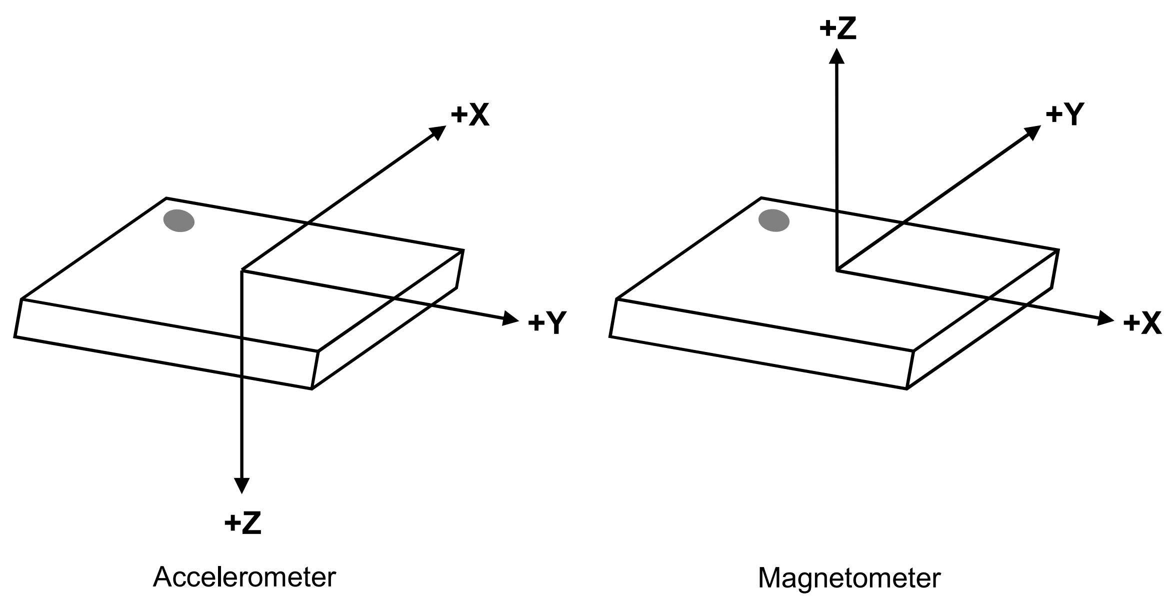


Figure 23: GME605 Axes Orientation

RoHS Compliance

GMEMS LGA sensors are compliant with Restrictions on Hazardous Substances (RoHS), having halide-free molding compound (green) and lead-free terminations. Reflow profiles applicable to those processes can be used successfully for soldering the devices.

Surface Mounting Information

The e-Compass is a delicate device that is sensitive to the mechanical and thermal stress. Proper PCB board design and well-executed soldering processes are crucial to ensure consistent performance. A recommended land pad layout can be found in the below Figure.

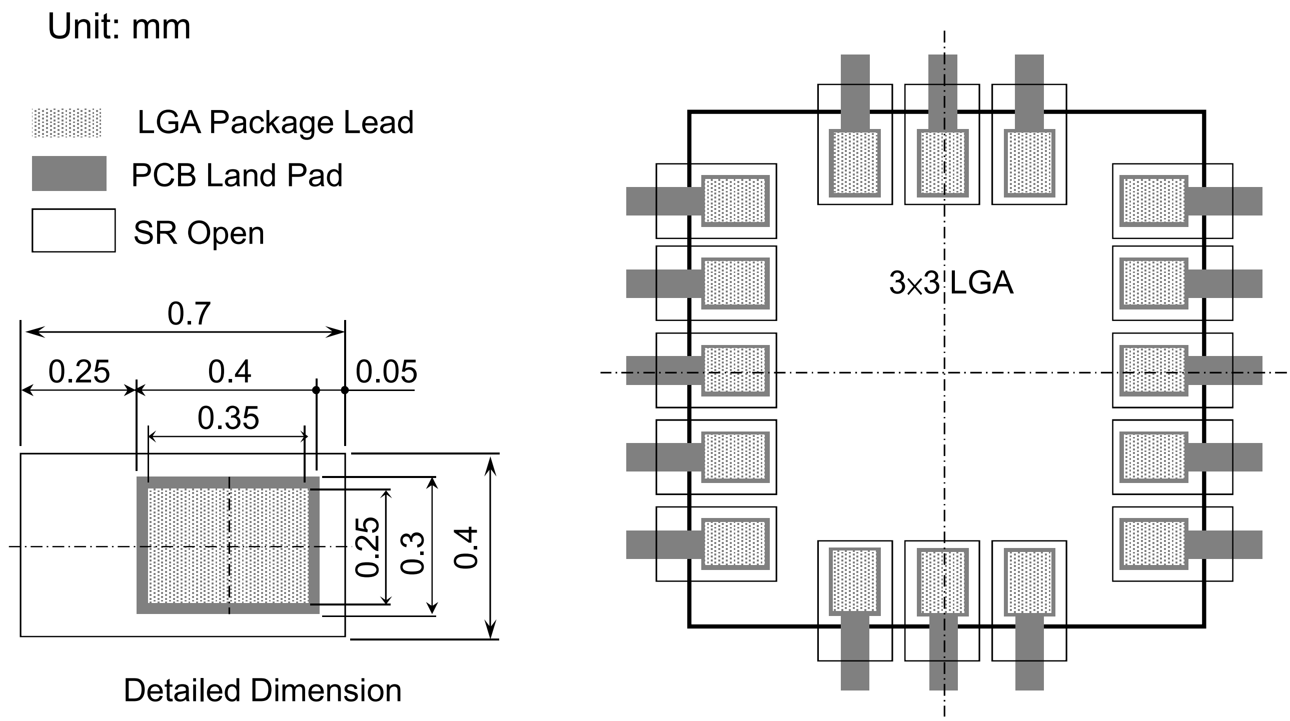


Figure 24: Layout Recommendation for PCB Land Pad

Moisture Sensitivity Level

GME605 package MSL rating is Level 3.

Tape Specification

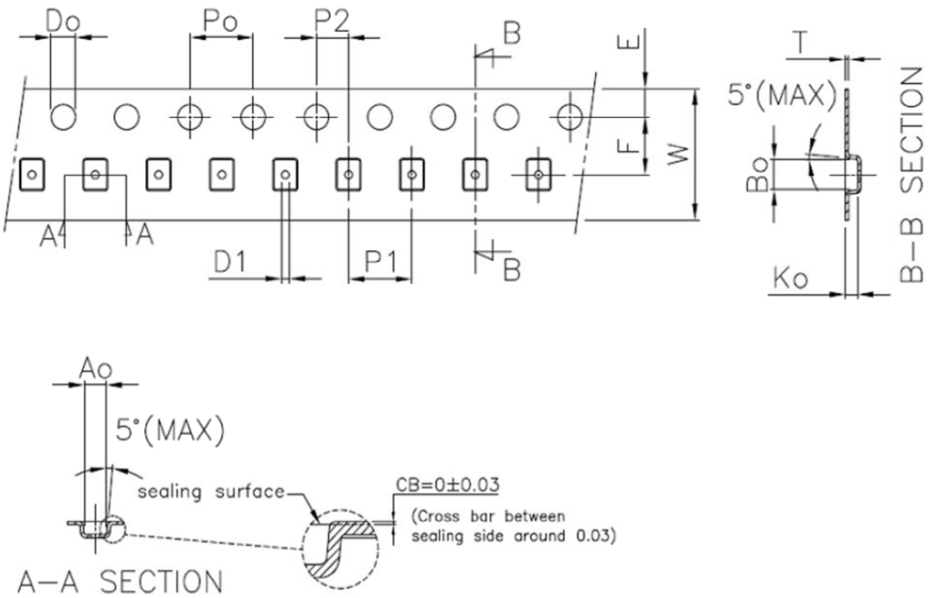


Figure 25: Tape Outline Drawing

Table 16: Tape Dimension

Symbol	Dimension (mm)
A_0	3.3±0.1
B_0	3.3±0.1
K_0	1.25±0.1
P_0	4.0±0.1
P_1	8.0±0.1
P_2	2.0±0.05
T	0.3±0.05
E	1.75±0.1
F	5.5±0.05
D_0	1.5+ 0.1/-0
D_1	1.5
W	12.0±0.3

Document History and Modification

Revision No.	Description	Date
V1.0	First formal release	2016/3/3