2 Axis Accelerometer Optimized for Single Axis of Rotation Inclination Sensing

MXC624xEU

FEATURES

- 2-axis accelerometer Optimized for Single Axis of Rotation Inclination Sensing
  - ±0.25 Degrees MAX Angle Error
    - -10 C to 60 C
    - ±30 Degrees of Inclination
  - 0.2 % X to Y Sensitivity TC matching
- Programmable anti-vibration filter
  - Attenuation >60dB @ 50Hz
  - No sensor resonance
- 400kHz I2C Interface (1.8V compatible)
- Built-in self-test functionality
- Small 3 x 3 x 1 mm Ceramic LCC-6 package
- Operates from 2.7V to 5.5V Supply
- High-reliability automotive process and package
- RoHS Compliant
- Operates from -40 C to 125 C

APPLICATIONS

- Cell Antenna Pitch and Roll Monitoring
- Inclination Sensing in High Vibration Environments

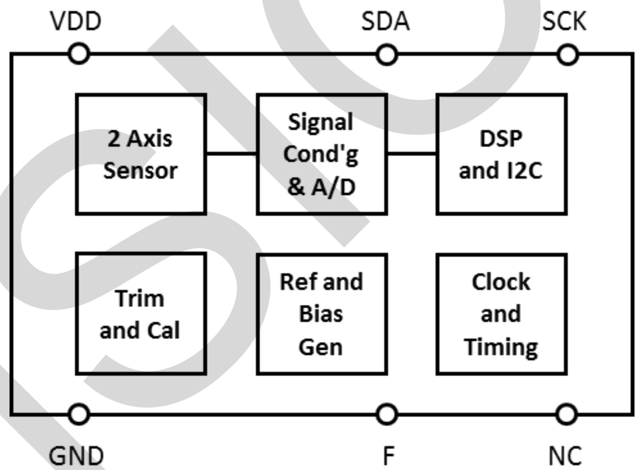


FIGURE 1. BLOCK DIAGRAM

DESCRIPTION

The MXC624xEU is a complete 2 axis accelerometer system optimized for inclination sensing in a single axis of rotation and can achieve better than ±0.25 degrees of accuracy over the temperature range of -10 C to 60 C. Two different I2C addresses are available so both pitch and roll can be monitored on a single I2C bus. Offset (0g bias) and sensitivity for each axis are measured at 3 different temperatures (-10 C, 20 C, 60 C) during which key error correction coefficients are generated and matched to the internal unique device identifier These coefficients are supplied electronically to the end user enabling very high accuracy of inclination sensing over a wide operating temperature range, without the need for additional over temperature calibration. See the "Electronically Supplied Correction Coefficients" section later in this document for more details.

The device includes a programmable internal anti-vibration filter. This filter can provide as much as 45dB attenuation above 25Hz, and 60dB attenuation above 50Hz (see "Response to Vibration" section), making it ideal for high vibration environments.

The MXC624xEU uses MEMSIC's proprietary thermal accelerometer technology. Because the sensing element uses heated gas molecules instead of a mechanical beam structure as the proof mass, the device is extremely repeatable and reliable, with 50,000g shock tolerance, no possibility of "stiction," and virtually no mechanical resonance. This makes the device extremely well suited to harsh or high vibration environments, where other sensors can exhibit false readings due to resonance or other errors.

The MXC624xEU runs from a single 2.7V to 5.5V supply, and is packaged in a small 6-pin, 3 x 3 x 1 mm ceramic LCC-6 package.

The MXC624xEU is not intended for general purpose acceleration measurements. For general purposes acceleration measurements please refer to the MXC6244AU.

©MEMSIC, Inc.
One Technology Drive, Suite 325, Andover, MA01810, USA
Tel: +1 978 738 0900 Fax: +1 978 738 0196
www.memsic.com

SENSOR CHARACTERISTICS

(TA=25C, V_{DD}= 3.3V, Fs=3125Hz, unless otherwise specified. Typical values are specified at 25C)

Parameter	Conditions	Min	Typ	Max	Units
Sensitivity	TA=25C	975	1024	1075	LSB/g
	X/Y Matching over Temperature (-10 to +60 C)		±0.2	±0.4[1,4]	%
	X/Y Matching over Temperature (-40 to +85 C)		±0.3	±0.5[1,4]	%
Zero-g Bias	TA=25C		±5	±30[1]	mg
	Temperature Drift (-40 to +85C)		±0.1	±0.3[1]	mg/C
Sensor Bandwidth	(Note 2)		11		Hz
Input Referred Noise	Total RMS Noise, ODR = 1.5Hz		0.75		mg rms
	Total RMS Noise, ODR = 100Hz		1.5		
Offset shift when self-test is asserted	X-offset (ST[2:0]=111)		+2		g
	Y-offset (ST[2:0]=111)		-2		
Resonance	(Note 3)	Undetectable			Hz

Note 1: Established statistically as the average value ±3 standard deviations from 30 pieces x 3 lot characterization data
Note 2: The sensor has an inherent low pass filter characteristic which is very effective in attenuating out of band vibration.
Note 3: The thermal accelerometer sensors use heated gas molecules, and have no measurable resonance
Note 4: Indicates how closely X and Y axis sensitivities' change over temperature.

ELECTRICAL SPECIFICATIONS

(TA=25C, V_{DD}= 3.3V, Fs=3125Hz, unless otherwise specified. Typical values are specified at 25C)

Parameter	Conditions	Min	Typ	Max	Units
Supply Voltage		2.7		5.5	V
Supply Current	Operating Mode		1.3	3	mA
	Sleep Mode		0.2	1	uA
Operating Temperature		-40		125	°C
A/D Sample Frequency (Fs)	Programmable via I2C	3.1, 6.2, 12.5, 25, 50, 100			kHz
	Angle Detection Disabled	Fs/1024			
Wake Time	(After exiting Sleep mode)		300	500	ms
Power On Time	(After Vdd Rising Edge)		300	500	ms
Power On Reset Threshold		0.8	1.2	1.6	V
VDD Rise Time	(Note 5)			8	ms

Note 5: Maximum allowable power supply rise time from 0.25V to 2.7V (minimum). Slower VDD rise time may cause erroneous data retrieval from OTP memory at power-up

DIGITAL PARAMETERS (Note 6)

(TA=25C, V_{DD}= 5V, unless otherwise specified. Typical values are specified at 25C)

Parameter	Conditions	Min	Typ	Max	Units
Logic Input Low	SDA, SCK Inputs		0	0.3*VIO	V
Logic Input High	SDA, SCK Inputs	0.7*VIO	VIO		V

Note 6: VIO is automatically detected using a peak-hold circuit on the SCK pin. The SCK or SDA voltage should not remain in the LOW state for more than 10ms.

DIGITAL SWITCHING CHARACTERISTICS

(TA=25C, V_{DD}= 5V, unless otherwise specified. Typical values are specified at 25C)

Parameter	Symbol	Min	Typ	Max	Units
Operating Valid Time (Note 7)	t_{OP}	30			ms
SCK Clock Frequency	f_{SCK}	0.1		400	kHz
Rise Time	t_R			0.3	µs
Fall Time	t_F			0.3	µs
SCK Low Time	t_{LOW}	1.3			µs
SCK High Time	t_{HIGH}	0.6			µs
SDA Setup Time	$t_{SU;D}$	0.1			µs
SDA Hold Time	$t_{H;D}$	0		0.9	µs
Start Setup Time	$t_{SU;S}$	0.6			µs
Start Hold Time	$t_{H;S}$	0.6			µs
Stop Setup Time	$t_{SU;P}$	0.6			µs
Bus Free Time	t_{BF}	1.3			µs

Note 7: This is the wait time after VDD applied to communicate successfully over I2C interface.

ABSOLUTE MAXIMUM RATINGS*

Supply Voltage (V_{DD}) ………………………..-0.5 to +7V
Storage Temperature …..……………-40°C to +150°C

*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 LCC-6 PACKAGE

Pin	Name	Description	I/O
1	NC	No Connect – Leave Open	
2	F	Factory Use, connect to ground	
3	VDD	Positive power supply. Connect to 2.7V to 5.5V. Bypass this to ground using a 0.1uF capacitor	P
4	SCK	I2C clock input	I
5	SDA	I2C data pin (input/output)	I/O
6	GND	Connect to power supply ground.	P

RESPONSE TO VIBRATION

The MXC6243/44EU are unique in their vibration attenuation characteristics, due both to its sensor structure, and its signal processing features.

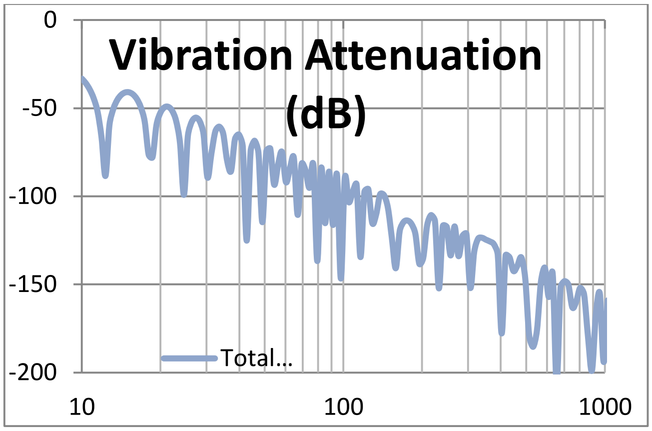
The MXC6243/44EU uses MEMSIC's proprietary thermal MEMS acceleration sensor, which uses heated gas molecules in a sealed cavity as the proof-mass. This technology offers two distinct benefits: (a) The sensor has no detectable resonance, and (b) The sensor has an inherent low-pass frequency response, which provides very effective filtering of unwanted vibration signals prior to the electronic signal path. Additional filtering is provided by a digital second order comb filter, which enables the device to tolerate very high levels of out-of-band vibration with negligible effect on angle calculation accuracy. This digital vibration filter is programmable via the I2C interface. The table below shows the tradeoffs among A/D clock rate (Fs), Output Data Rate (ODR), and the vibration attenuation at selected frequencies.

Fs (kHz)	ODR (Hz)	Vibration Attenuation (dB)		
		50Hz	100Hz	300Hz
100	48.8	See Plots Below		
50	24.4			
25	12.2			
12.5	6.1			
6.25	3			
3.125	1.5			

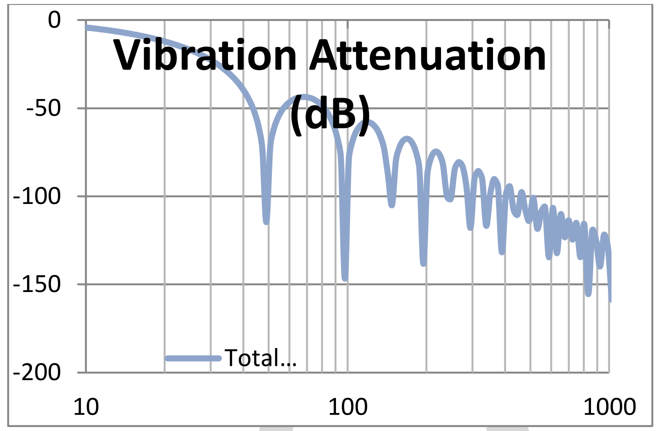
The following plots show the attenuation vs. vibration frequency, swept from 10Hz to 1000Hz, at the 6 different filter clock settings. The combined attenuation A due to the low-pass characteristic of the sensor and the comb filter can be expressed as

$$A = -20 * \log_{10}\left[\frac{1}{\sqrt{1+\frac{f^2}{12^2}}} * \left[\frac{1}{512} * \frac{\sin\left(\pi * 512 * \frac{f}{F_s}\right)}{\sin\left(\pi * \frac{f}{F_s}\right)}\right]^2\right]$$

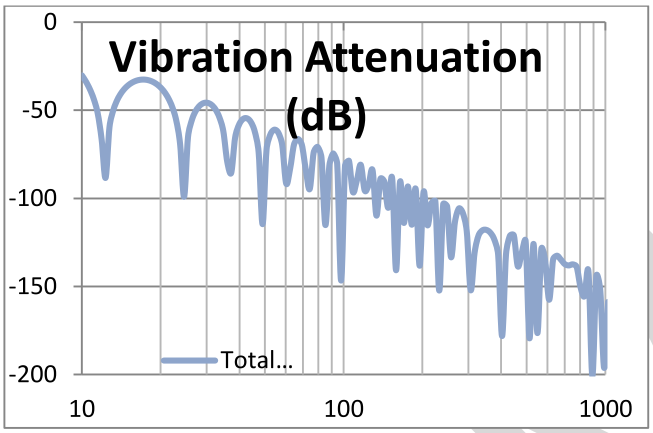
Where A is attenuation in dB, and f is the vibration frequency in Hz.



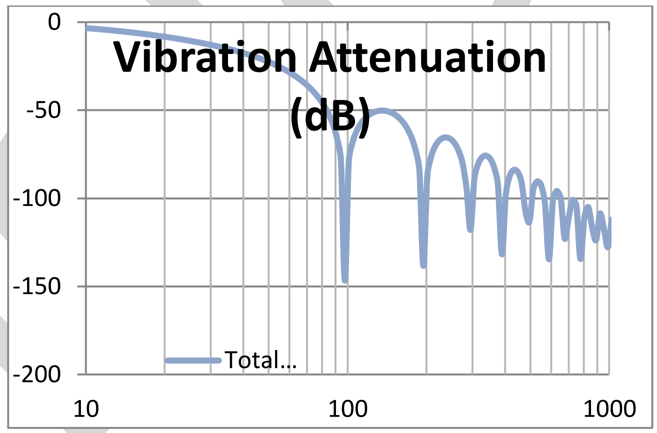
Attenuation vs. Vibration Frequency
Fclk = 3.125kHz



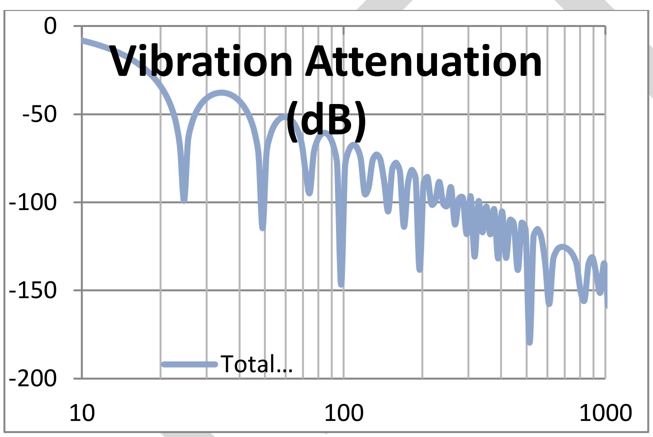
Attenuation vs. Vibration Frequency
Fclk = 25kHz



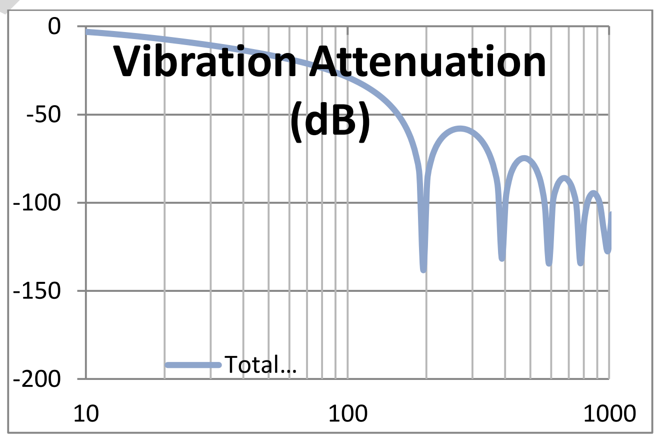
Attenuation vs. Vibration Frequency
Fclk = 6.25kHz



Attenuation vs. Vibration Frequency
Fclk = 50kHz



Attenuation vs. Vibration Frequency
Fclk = 12.5kHz



Attenuation vs. Vibration Frequency
Fclk = 100kHz

I2C INTERFACE DESCRIPTION

Two different I2C addresses are available enabling two devices to be connected on the same I2C bus for measuring pitch and roll as shown in the table to the right.

Part Number	7 Bit Binary Address	Hex
MXC6243EU	0010011b	0x13
MXC6244EU	0010100b	0x14

A slave mode I^{2}C interface, capable of operating in standard or fast mode, is implemented on the MXC624xEU. The interface uses a serial data line (SDA) and a serial clock line (SCL) to achieve bi-directional communication between master and slave devices. A master (typically a microprocessor) initiates all data transfers to and from the device, and generates the SCL clock that synchronizes the data transfer. The SDA pin on the MXC624xEU operates both as an input and an open drain output. Since the MXC624xEU only operates as a slave device, the SCL pin is always an input. There are external pull-up resistors on the I^{2}C bus lines. Devices that drive the I^{2}C bus lines do so through open-drain n-channel driver transistors, creating a wired NOR type arrangement.

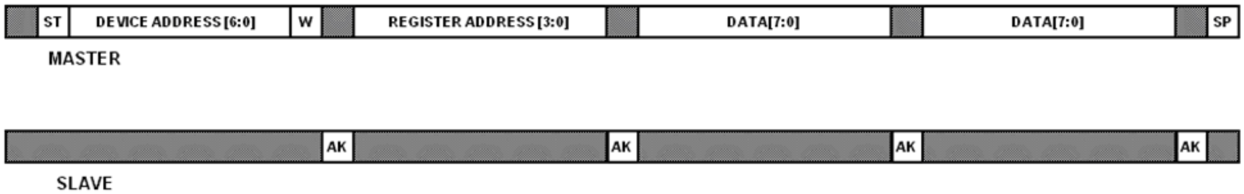
Data on SDA is only allowed to change when SCL is low. A high to low transition on SDA when SCL is high is indicative of a START condition, whereas a low to high transition on SDA when SCL is high is indicative of a STOP condition**.** When the interface is not busy, both SCL and SDA are high. A data transmission is initiated by the master pulling SDA low while SCL is high, generating a START condition. The data transmission occurs serially in 8 bit bytes, with the MSB transmitted first. During each byte of transmitted data, the master will generate 9 clock pulses. The first 8 clock pulses are used to clock the data, the 9th clock pulse is for the acknowledge bit. After the 8 bits of data are clocked in, the transmitting device releases SDA, and the receiving device pulls it down so that it is stable low during the entire 9th clock pulse. By doing this, the receiving device "acknowledges" that it has received the transmitted byte. If the slave receiver does not generate an acknowledge, then the master device can generate a STOP condition and abort the transfer. If the master is the receiver in a data transfer, then it must signal the end of data to the slave by not generating an acknowledge on the last byte that was clocked out of the slave. The slave must release SDA to allow the master to generate a STOP or repeated START condition.

The master initiates a data transfer by generating a START condition. After a data transmission is complete, the master may terminate the data transfer by generating a STOP condition. The bus is considered to be free again a certain time after the STOP condition. Alternatively, the master can keep the bus busy by generating a repeated START condition instead of a STOP condition. This repeated START condition is functionally identical to a START condition that follows a STOP. Each device that sits on the I^{2}C bus has a unique 7-bit address.

The first byte transmitted by the master following a START is used to address the slave device. The first 7 bits contain the address of the slave device, and the 8th bit is the R/W* bit (read = 1, write = 0; the asterisk indicates active low, and is used instead of a bar). If the transmitted address matches up to that of the MXC624xEU, then the MXC624xEU will acknowledge receipt of the address, and prepare to receive or send data.

If the master is writing to the MXC624xEU, then the next byte that the MXC624xEU receives, following the address byte, is loaded into the address counter internal to the MXC624xEU. The contents of the address counter indicate which register on the MXC624xEU is being accessed. If the master now wants to write data to the MXC624xEU, it just continues to send 8-bit bytes. Each byte of data is latched into the register on the MXC624xEU that the address counter points to. The address counter is incremented after the transmission of each byte.

If the master wants to read data from the MXC624xEU, it first needs to write the address of the register it wants to begin reading data from to the MXC624xEU address counter. It does this by generating a START, followed by the address byte containing the MXC624xEU address, with R/W* = 0. The next transmitted byte is then loaded into the MXC624xEU address counter. Then, the master repeats the START condition and re-transmits the MXC624xEU address, but this time with the R/W* bit set to 1. During the next transmission period, a byte of data from the MXC624xEU register that is addressed by the contents of the address counter will be transmitted from the MXC624xEU the master. As in the case of the master writing to the MXC624xEU, the contents of the address counter will be incremented after the transmission of each byte. The protocol for multiple byte reads and writes between a master and a slave device is depicted in FIGURE 2.



MULTIPLE BYTE WRITE

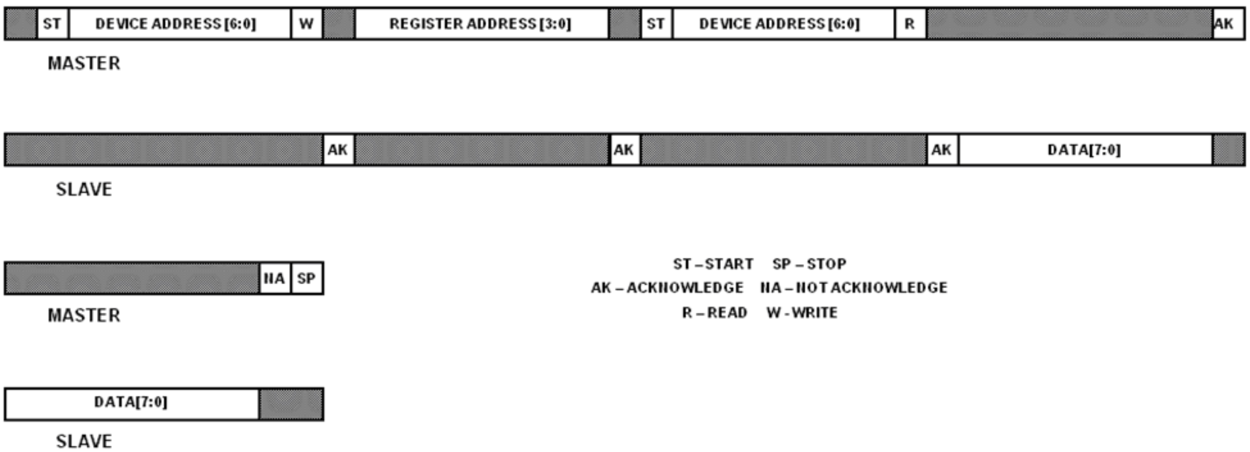


FIGURE 2: Multiple byte read.

MXC624xEU I2C interface allows I2C interface voltage VIO to be lower than the supply voltage VDD. VIO can be as low as 1.8V. In order to achieve reliable operation, avoid the situation when both SCL and SDA pins are low for longer than 10ms. I2C interface voltage VIO should not be greater than VDD.

I2C REGISTER DEFINITION

The MXC6244 has 10 user-accessible registers which are identified and summarized in the table below.

Address	Name	Definition	Access
x00	XOUT0	Lower 8 bits of X acceleration output	read
x01	XOUT1	Higher bits of 14-bit X output	read
x02	YOUT0	Lower 8 bits of Y acceleration output	read
x03	YOUT1	Higher bits of 14-bit Y output	read
x06	STATUS	Status	read
x07	PD/ST	Several control signals	write
x08	Factory 8	Factory use only	read
x09	Factory 9	Factory use only	read
x0A	CLK_CONT	Controls ADC clock and ODR	write
x10 – x17	Identifier	Concatenated Contents Identify Dev	read

User Register Summary

Following is a more detailed description of the contents and function of each Register.

Register 0x00: XOUT0 – Lower 8 bits of x-axis acceleration output (read only)

D7	D6	D5	D4	D3	D2	D1	D0
XOUT[7]	XOUT[6]	XOUT[5]	XOUT[4]	XOUT[3]	XOUT[2]	XOUT[1]	XOUT[0]

Register 0x01: XOUT1 – Upper 6 bits of x-axis acceleration output (read only)

D7	D6	D5	D4	D3	D2	D1	D0
0	0	XOUT[13]	XOUT[12]	XOUT[11]	XOUT[10]	XOUT[9]	XOUT[8]

The number of bits in XOUT is fixed at 14 bits. Output is presented in 2's complement format. Bits 6 and 7 of register $01 are always zeroes.

Register 0x02: YOUT0 – Lower 8 bits of y-axis acceleration output (read only)

D7	D6	D5	D4	D3	D2	D1	D0
YOUT[7]	YOUT[6]	YOUT[5]	YOUT[4]	YOUT[3]	YOUT[2]	YOUT[1]	YOUT[0]

Register 0x03: YOUT1 – Upper 6 bits of y-axis acceleration output (read only)

D7	D6	D5	D4	D3	D2	D1	D0
0	0	YOUT[13]	YOUT[12]	YOUT[11]	YOUT[10]	YOUT[9]	YOUT[8]

The number of bits in YOUT is fixed at 14 bits. Output is presented in 2's complement format. Bits 6 and 7 of register $03 are always zeroes.

Register 0x06: STATUS –status register (read only)

D7	D6	D5	D4	D3	D2	D1	D0
X	CRC_OK	FAIL	TILT	X	X	X	X

FAIL is an indication whether one of the two built-in self-test checks has failed. See section Internal Fault Detection for description of the internal self-test checks. The OTP failure (CRC check failed) is not indicated by this bit, only checks (b), and (c), defined in the Internal Fault Detection section are indicated by this bit. FAIL bit being high does not necessarily mean the device is bad, just that it is reading unexpected acceleration values.

CRC_OK is an indicator that OTP memory has loaded correctly and passed the CRC check. It transitions high approximately 10ms after power-up. If this bit stays low it is an indication of OTP memory failure. The part should not be trusted in such condition. It is recommended to read this bit 50ms after power-up to make sure it is high.

Register 0x07: Power Down and Self-Test – (write only)

D7	D6	D5	D4	D3	D2	D1	D0
PD	X	SelfTest	X	X	X	Dis_Fail_I2C	1

PD = 1 powers down the MXC624xEU to a non-functional low power state with a maximum current drain of 1 uA.

SelfTest = 1 enables on-demand self-test. When enabled, one of the four heaters in the sensor dissipates only a fraction of the power dissipated by the other 3 heaters which will cause a change in the output of X and Y by a known amount. This can be used to ensure the sensor is working properly.

Writing both PD=1 and SelfTest = 1 will cause the Software Reset, similar to power-up. MXC624xEU will clear all registers and perform its startup routine, including OTP CRC check.

Dis_Fail_I2C = 1 disables checking of the two self-test checks (b) and (c), defined in the Internal Fault Detection section

Register 0x08: FACTORY 8 - is a factory register. It should be written to 0x0F after every power-up or Software Reset. Failure to do so will cause on-demand Self-Test to not work properly and may cause unpredictable behavior.

D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	1	1	1	1

Register 0x0A: CLK_CONT – controls the ADC clock frequency Fs and associated low pass filter response and ODR. (write only)

D7	D6	D5	D4	D3	D2	D1	D0
x	x	x	CKADC[2]	CKADC[1]	CKADC[0]	0	1

D0 should be written to 1 so that unused angle detection circuits are disabled.

D1 should be written to 0 so that angle detection anti-dithering circuits are disabled.

CKADC<2:0> allows the user to adjust clock frequency of the A/D converter. This setting also affects the transfer function of the digital filter following the ADC. The user is advised to optimize this setting to pick the best combination of ODR and vibration immunity (see “RESPONSE TO VIBRATION” section)

CKADC<2:0>	ADC Clock Freq (kHz)	ODR (Hz)
000	3.125	3
001	6.25	6
010	12.5	12.5
011	25	25
100	50	50
101	100	100
110	100	100
111	100	100

ELECTRONICALLY SUPPLIED CORRECTION COEFFICIENTS

Each device is measured at 3 different temperatures and correction coefficients are generated and matched with a unique device identifier in an electronic file. The coefficients are supplied electronically upon request coincident with the shipment of the devices. The coefficients can be used along with a customer supplied temperature sensor to increase the accuracy of the solution. The coefficients need to be matched to each specific device using the unique device identifier. A description of the coefficients and there intended purposed follows.

X_Offset: This is the measured 0g output on the X axis at 25 C. It can be subtracted from X axis values measured in the end user application to remove device X axis 0g trimming error. Units are Counts

Y_Offset: This is the measured 0g output on the Y axis at 25 C. It can be subtracted from Y axis values measured in the end user application to remove device Y axis 0g trimming error. Units are Counts.

X_TC: Slope of the best fit linear regression line of the X axis offset measured at the 3 temperatures (-10, 25, 60 C). It can be used with a temperature sensor to reduce error associated with X axis 0g bias change with temperature. Units are Counts/C

Y_TC: Slope of the best fit linear regression line of the Y axis offset measured at the 3 temperatures (-10, 25, 60 C). It can be used with a temperature sensor to reduce error associated with Y axis 0g bias change with temperature. Units are Counts/C

Y_SF_ADJ: Y sensitivity scale factor adjustment term used to normalize the Y axis sensitivity to the X axis at 25 C. After removing offset error from the Y axis measurement, multiply the remaining Y axis value with this coefficient to normalize the Y axis sensitivity to the X axis.

UNIQUE DEVICE IDENTIFIER

Each device has a unique identifier that can be used to match electronically supplied correction coefficients to an individual device. The unique device identifier is generated by reading register 0x10 through 0x17 and concatenating the contents. Below is an example:

Register Contents

0x10	0x11	0x12	0x13	0x14	0x15	0x16	0x17
129	134	28	24	240	128	40	72

Device Identifier = 12913428242401284072

SENSITIVITY TEMPERATURE COMPENSATION

The best 0g bias stability over temperature is obtained when the internal sensitivity compensation is disabled. A beneficial characteristic of MEMSIC thermal accelerometers is sensitivity temperature dependence is common to both axes. When calculating inclination as the Arc-tangent (X/Y), the change in sensitivity on each axis cancel each other when the ratio is taken. Sensitivity variation with temperature can be ignored when used in this manner.

USING MXC624xEU TO MEASURE INCLINATION

The MXC624xEU needs to be mounted vertically in the plane that will be rotated around a vector normal to the plane as shown in Figure 3.

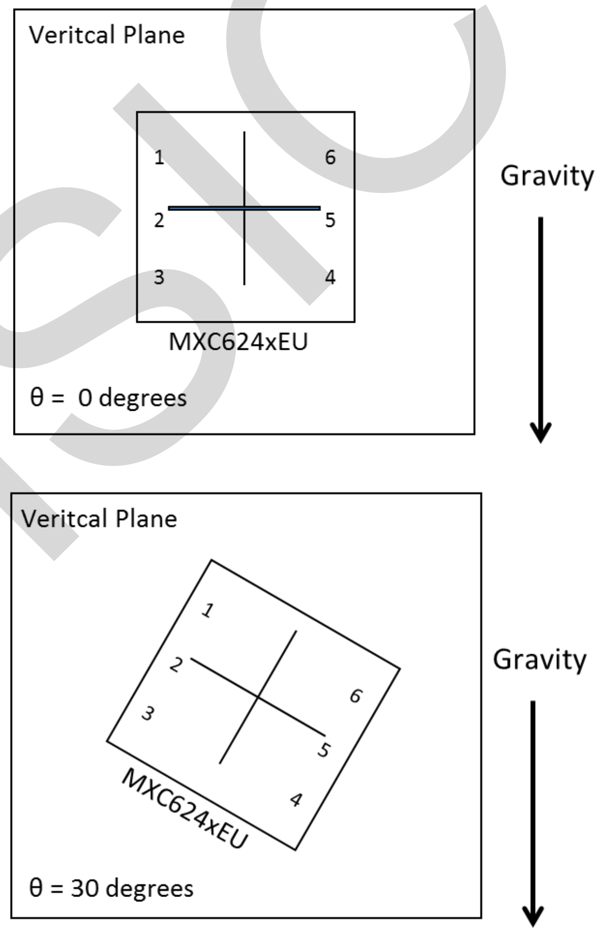


FIGURE 3: Illustration of using a MXC624xEU to measure inclination.

As the device is rotated in the vertical plane the acceleration measured on the X axis will change as the sine of the rotation angle (θ) and the Y axis will change as the cosine of the rotation angle. From geometry we know that:

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

Rotation angle is calculated as ATAN(X/Y).

To obtain more accurate results the correction coefficients supplied electronically with the device can be used along with a temperature sensor (not supplied by MEMSIC). The formula to calculate the inclination is now:

$$\theta = tan^{-1}\frac{X_{Corrected}}{Y_{Corrected}}$$

$$X_{Corrected} = X_{Measured} - (\,X\_Offset + (temp - 25) * X\_TC)$$

$$Y_{Corrected} = (Y_{Measured} - (\,Y\_Offset + (temp - 25) * Y\_TC)) * Y\_SF\_ADJ$$

Using this approach inclination accuracy or < 0.25 degrees can be achieved over the temperature range of -10 C to 60C over an inclination range of ±30 degrees.

INTERNAL FAULT DETECTION

The MXC624XEU has a variety of internal fault detection circuit features, which can be enabled or disabled via the I2C interface.

On power up (within 10ms of a valid supply voltage appearing on the VDD pin), the internal circuitry checks for the following conditions:

(a) Valid non-volatile memory contents. On power up a CRC algorithm checks if any of the bits have changed from their factory programmed values. If this check is completed successfully the CRC_OK bit is set in the Status register.

In addition to the above test done at power up, the following monitoring is performed on a continuous basis:

(b) If at any time either the X or Y output exceeds 2g continuously for more than approximately 4 seconds the FAIL flag will be set in the I2C Status register and remains Set for as long as the condition persists, or the part is reset by via the I2C interface.

(c) If at any time both the X and the Y outputs fall below 0.375g (which is an indication of either a free fall event, excessive off-axis tilt, or a leak in the gas cavity), for more than approximately 4 seconds the FAIL flag will be set in the I@C Status register for as long as the condition persists, or the part is reset via the I2C interface.

The user may choose to disable checks (b) and (c) by setting I2C bit Dis_Fail in the PD/ST register.

Finally, there is an additional "Signal Path Self-Test" which is available on demand. This self-test mode is initiated via the I2C interface (See the section titled "Initiating On-Demand Signal Path Self-Test". If the self-test bit is enabled, the power is reduced to one of the heater elements, inducing a deliberate offset in both the X and Y axes of the sensor structure. This offset can be seen on the X and Y digital outputs (via I2C interface), serving as a reliable measure of proper sensor and circuit operation.

SELF-TEST DETAILED DESCRIPTION-INITIATING ON-DEMAND SIGNAL PATH SELF-TEST

As described in the earlier section titled "INTERNAL FAULT DETECTION," there are 3 different types of fault-detection features built into the MXC624XEU. The first type is done automatically whenever power is first applied, the second type are done continuously in the background during normal operation, and the third type is performed on-demand by a command issued over the I2C interface. This section describes this third type in more detail.

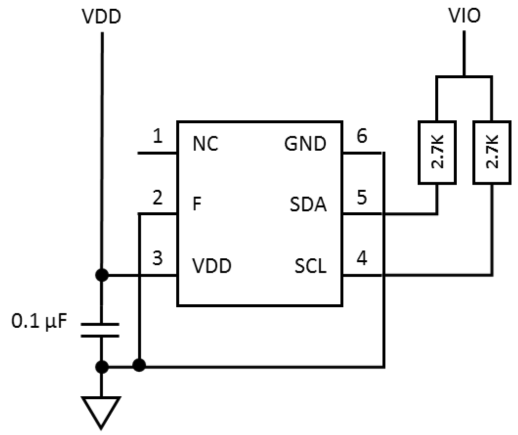
The basic principle of the on-demand self-test is to reduce power to one of the four internal heater elements, inducing a gross offset error, equivalent to approximately +2g on the X channel, and -2g on the Y channel. These offsets can be read via the X and Y I2C registers (see the following section "I2C REGISTER DEFINITION" for a complete description). In this way, the sensor and the signal processing electronics can be checked for functionality. In addition, these offsets should cause the INT output to change state for any programmed angle threshold.

An on-demand self-test is executed by the following 4-step procedure:

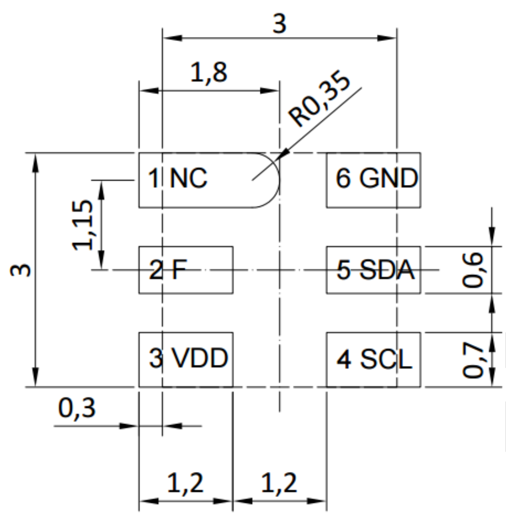
- *Step 1:* Read the X and Y acceleration values (call them OUTX1 and OUTY1).
- *Step 2:* Enable Self-Test (Set the control bit ST=1),
- *Step 3:* Wait 2x the time associated with the selected ODR, then read the X and Y acceleration values (call them OUTX2 and OUTY2)
- *Step 4:* Subtract OUTX1 from OUTX2 and OUTY1 from OUTY2. These values are the X and Y self-test amplitudes. A dramatic shift (>50mg or so) in either the X or Y self-test amplitudes over time indicates a fault in the sensor or signal processing electronics

Using the above method, the presence of a real constant acceleration stimulus does not affect the ST amplitude, provided that (a) the acceleration plus self-test signal is not so large that the signal path is saturated, and (b) the external acceleration does not change dramatically over the self-test period.

CIRCUIT SCHEMATIC



LANDING PATTERN (Unit: mm)



END of LIFE DISPOSAL

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

REFLOW PROFILE

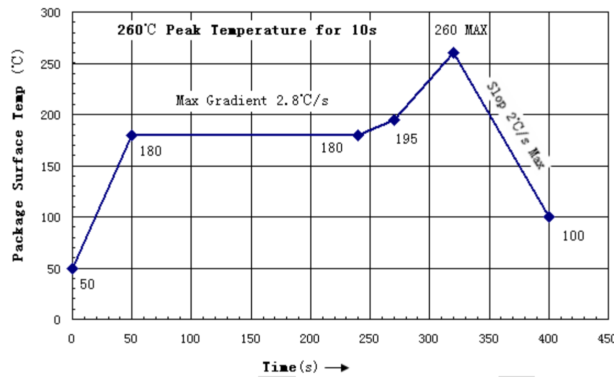


FIGURE 4.

Notes:

- Reflow is limited to two cycles.
- If a second reflow cycle is implemented, it should be applied only after device has cooled down to 25℃ (room temperature)
- Figure 4 is the reflow profile for Pb free process
- The peak temperature on the sensor surface must be limited to under 260℃ for 10 seconds. Follow solder paste supplier's recommendations for the best SMT quality.
- When soldering manually or repairing via soldering iron for the accelerometer, the time must be limited to less than 10 seconds and the temperature must not exceed 275℃. If a heat gun is used, the time must be limited to less than 10seconds and the temperature must not exceed 270℃
- Avoid bending the PCB after sensor assembly

MARKING ILLUSTRATION AND PACKAGE DRAWING: