MEMSIC Accelerometer Application Note MXR7150VW&MXR7999VW

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AE and R&D Department

Revision History

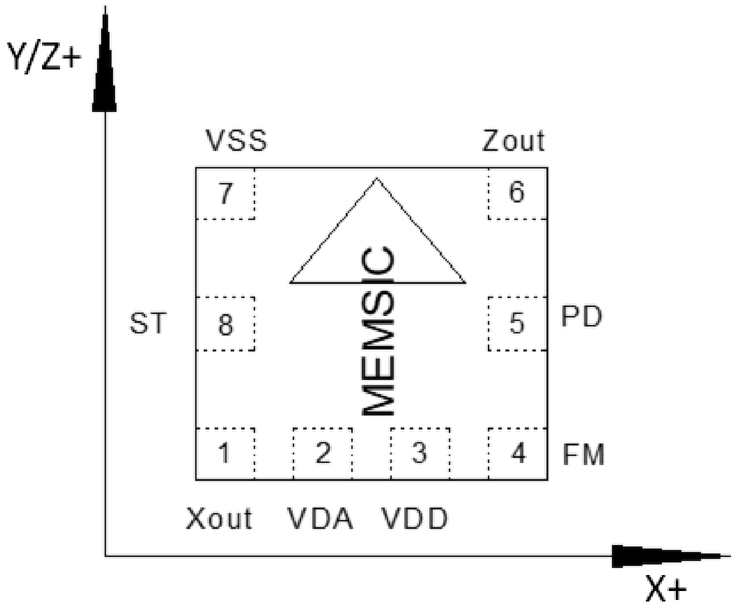
Version	Data	Author	Note
1.0	2020-07-09	AE and R&D Department	Initial release
1.1	2020-09-30	AE Department	Add recommendation for component placement
1.2	2021-07-01	AE Department	Add Tape and Reel Specification
2.0	2022-07-28	AE Department	Correct the polarity of PD at the waveform

Table of Content

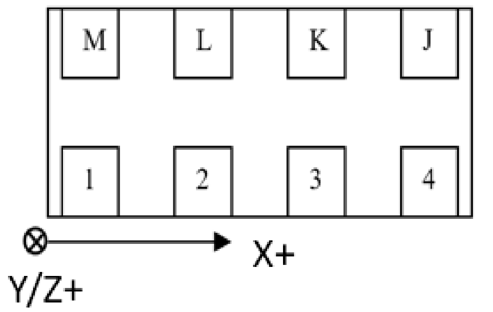
1 Hardware Design

1.1 Pin Description

Pin	Name	Description
1	Xout	X-axis acceleration signal output.
2	VDA	This is the analog power supply. This pin supplies current to the analog circuitry. The DC voltage should be equal to the voltage supplied to the VDD pin.
3	VDD	This is the digital power supply. This pin supplies current to the heater element and digital circuitry. The DC voltage should be between 4. 75V and 5.25V.
4	FM	Ground. Factory use only.
5/J	PD	Power Down.
6/M	Zout	Z-axis acceleration signal output.
7/L	VSS	Ground.
8/K	ST	Self-Test Input. This pin controls the self-test function of the sensor. Bringing STIN high will cause a negative deflection Y/Zout and Xout from initial value.



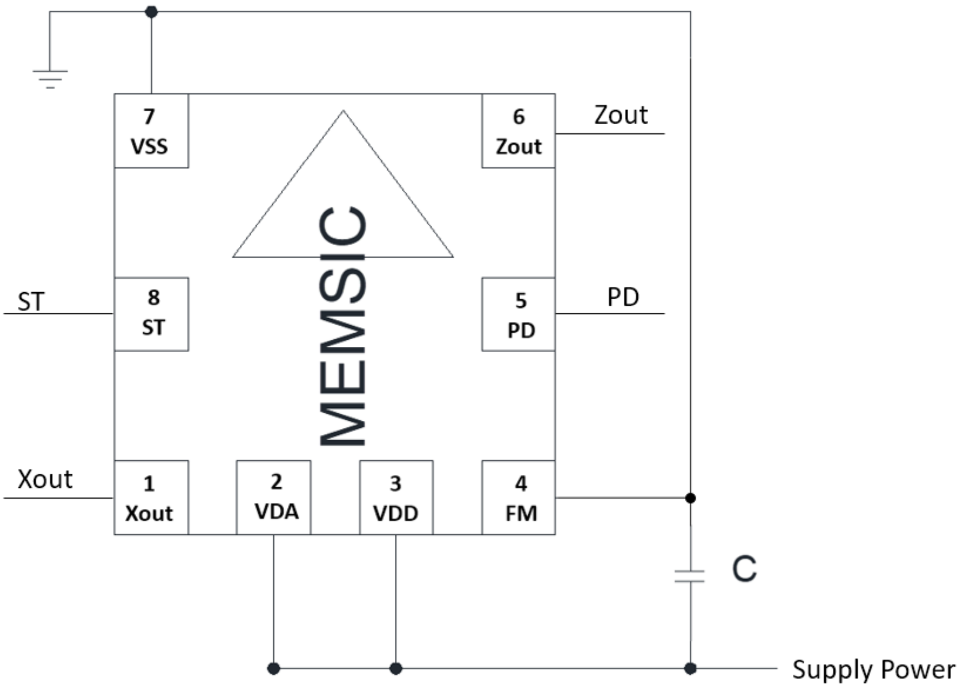
XZ SENSING (TOP VIEW)



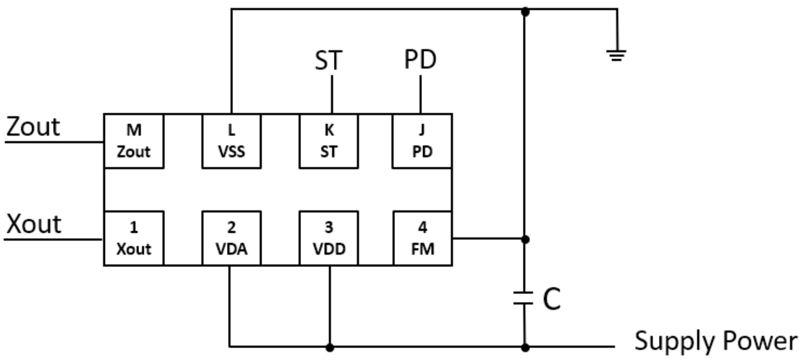
XZ SENSING (BOTTOM VIEW)

Note: The MEMSIC logo's arrow indicates the +Y/Z sensing direction of the device.

1.2 Schematic Design



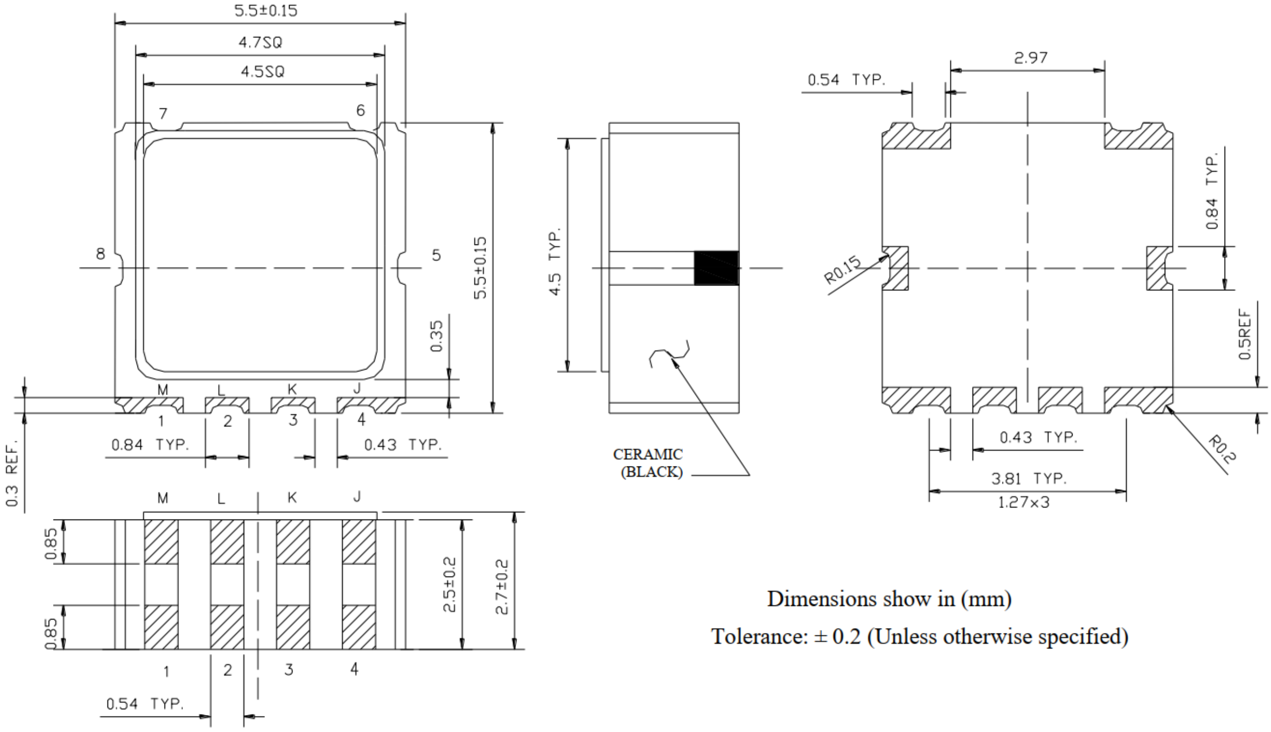
Flat Mount



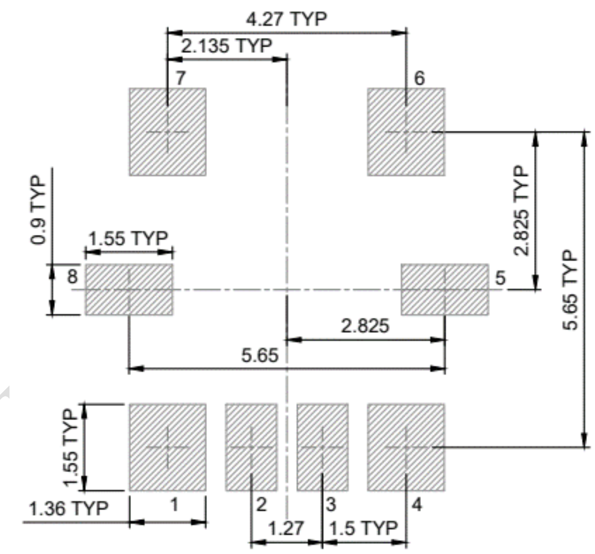
Vertical Mount

Note: C = 1.0uF

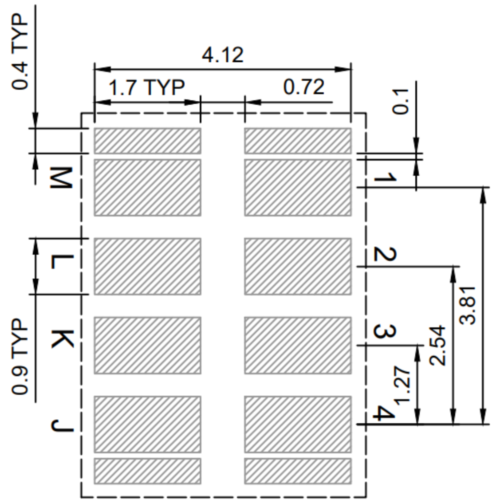
1.3 Mechanical Package Outline Dimensions



1.4 Land Pattern



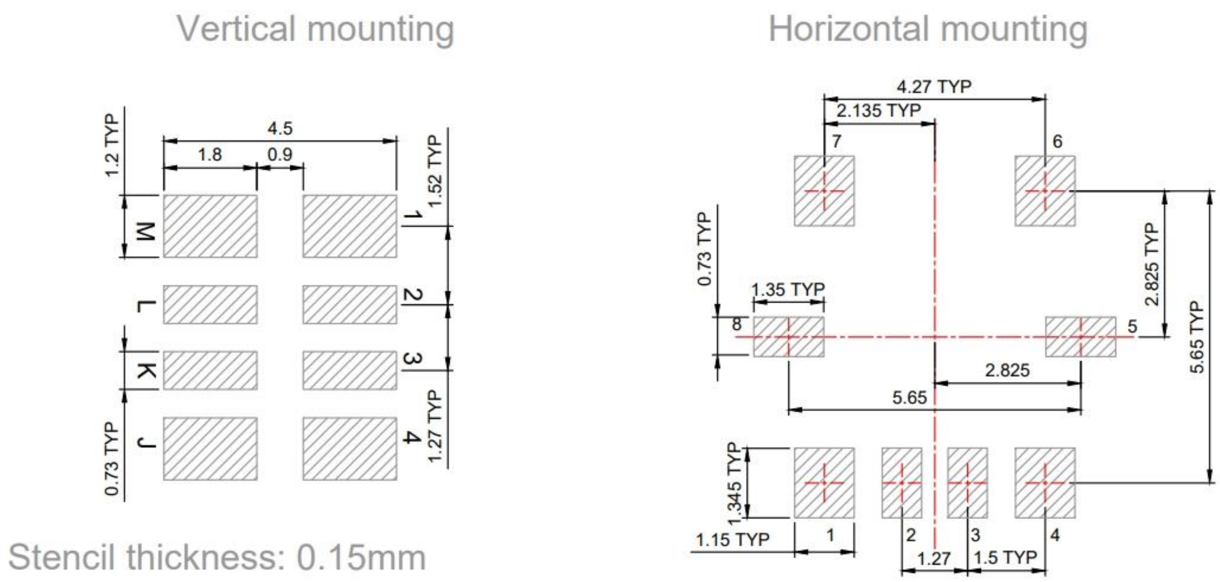
Flat Mount



Vertical Mount

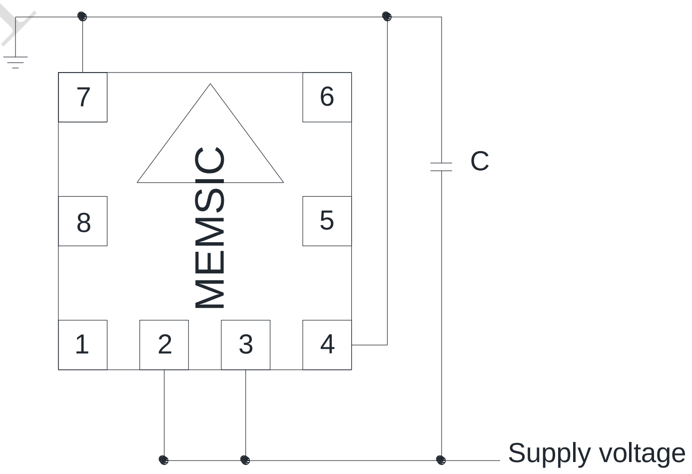
Note: Dimensions show in (mm).

1.5 Stencil Design



- It is recommended to use a stencil of thickness between 0.12mm~0.18mm. Stencil thickness should consider all devices on the PCB. It is suggested to select relatively thicker stencil to ensure adequate solder volume.
- Stencil opening ratio is suggested between 0.8~1.4. 1:1 is a regular opening ratio. To increase the solder volume, a larger opening ratio is recommended.

1.6 PCB Layout and Fabrication Suggestions



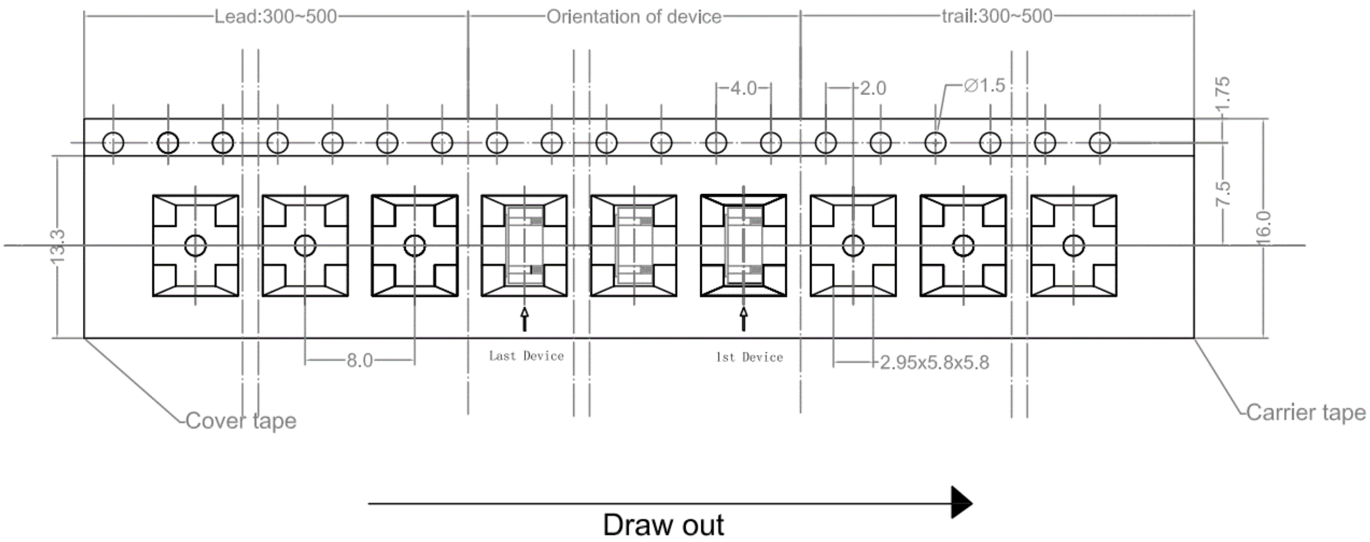
- The bypass capacitance should be placed near the VDD and VSS pins to ensure low noise performance and accurate outputs.
- Robust low inductance ground and supply wiring should be used.
- Care should be taken (like isolated rings and planes, signal route out perpendicular to the external thermal gradient) to ensure there is "thermal symmetry" on the PCB immediately surrounding the MEMSIC device and that there is no significant heat source nearby. This will minimize any errors in the measurement of acceleration.

1.7 Tape and Reel Specification

MXR7xxxVW Vertical mount

Tape Reel Packing

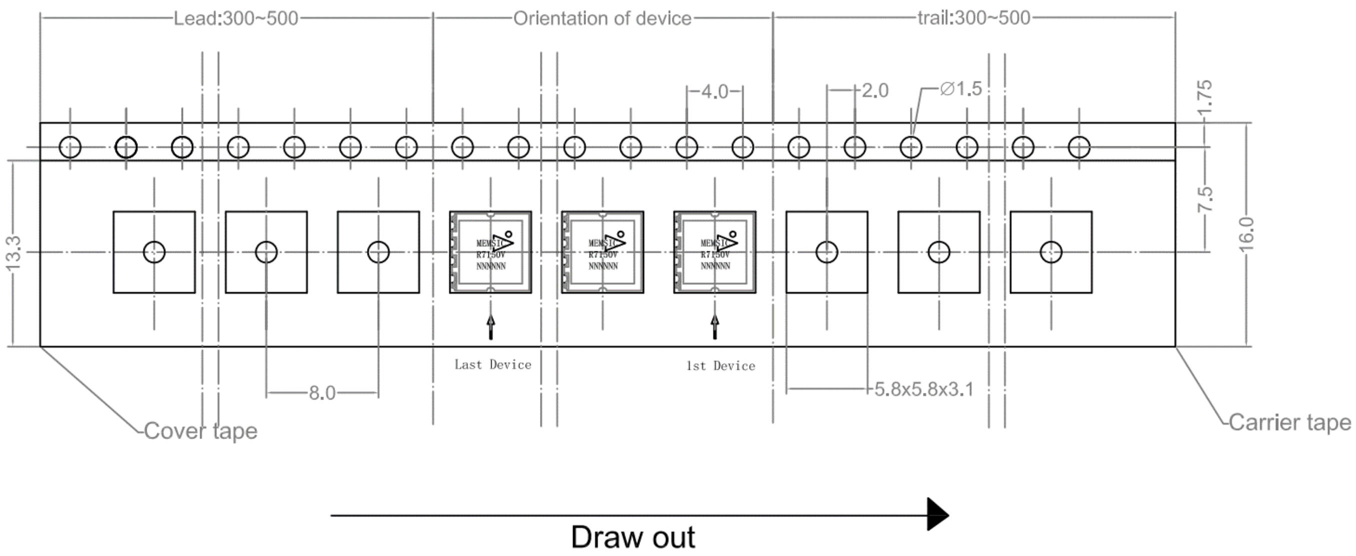
Unit:mm



MXR7xxxVW-P Flat mount

Tape Reel Packing

Unit:mm



1.8 Solder Paste

The 4# or 5# solder paste is recommended, the 5# solder paste is the best.

1.9 Component Placement

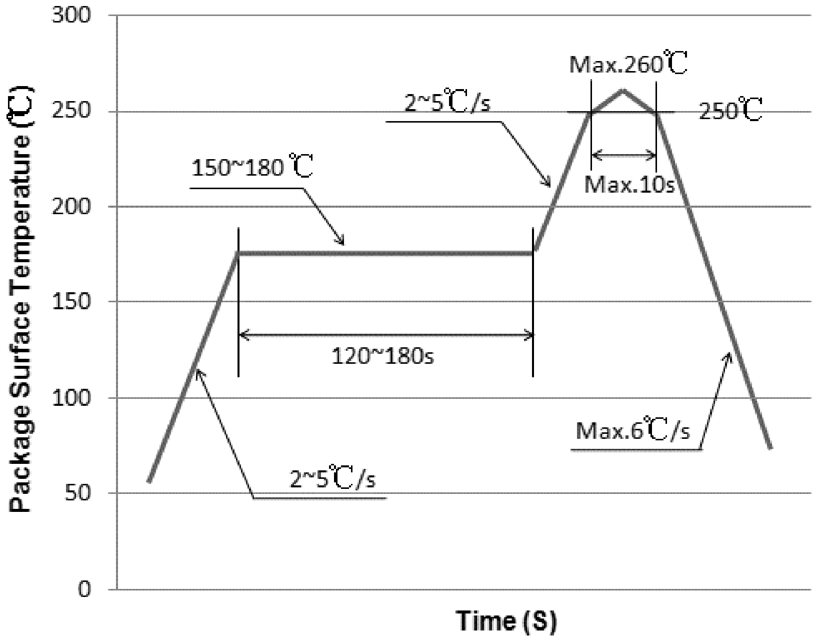
- To avoid sensor damage caused by excessive forces during the SMT, do not use the nozzle made of hard materials such as alloy and ceramic, rubber nozzle is recommended.
- The distance between SMT picker nozzle to device surface suggest to maintain at 0~0.1mm is better even just touch the surface, but don't over.
- Z height distance control methods are recommended over the force control.

Rubber Nozzle

1.10 SMT Reflow

- Reflow is limited by 2 times. Second reflow should be applied after device has cooled down to room temperature (25℃).
- Recommended reflow profile for Pb free process is shown in Figure 6. The time duration of peak temperature (260℃) should be limited to 10 seconds.

Recommended solder reflow profile is as below.



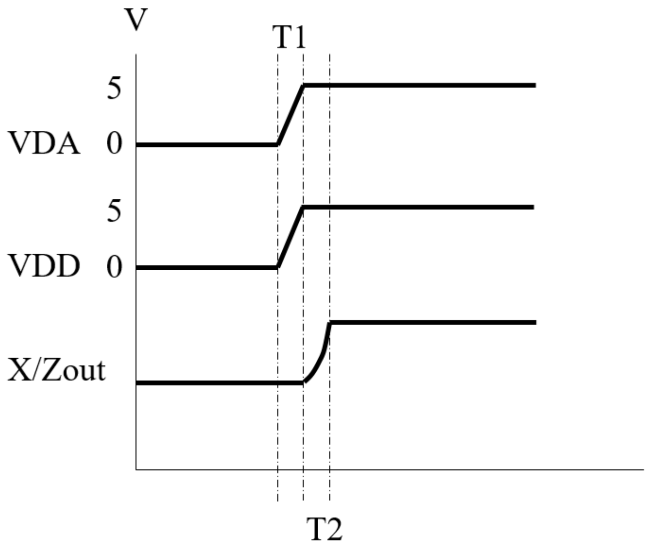
1.11 Manual Soldering

It is not recommended to use hand-soldering processes. If a hand-soldering process must be applied. Suggestions are as below.

- When de-soldering a defective part off the PCB, the temperature must be controlled to avoid the damage on the peripheral devices. Clean the solder remains and solder mask on the soldering pad.
- Apply solder paste to the pads with proper volume to avoid bridging.
- Position the device on the solder pad accurately.
- When soldering a device manually with a heat gun, the temperature on the device should not exceed 260℃ and the soldering time should be limited to 10 seconds.

2 Device Operation

2.1 Power-On Timing



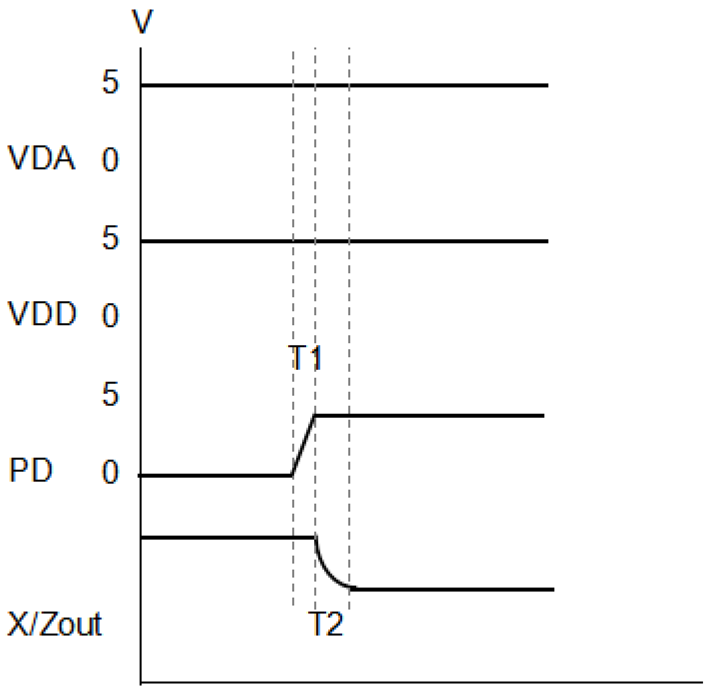
Item	Typ	Max	Unit
T1		10	ms
T2	100	250	ms

Turn on (Cold Start) Timing

T1 is the power supply rising time, which should be less than 10ms.
T2 is the sensor turn on (cold start) time. Should delay 250ms (Max) before reading the output after VDD and VDA is valid.

Note: Applying power to VDA pin must not be later than applying power to VDD. According to the recommended schematic design, VDA and VDD should be connected to the same power supply.

2.2 Power-Down Operation



Item	Typ	Max	Unit
T1		10	ms
T2	50	150	ms

Power Down Timing

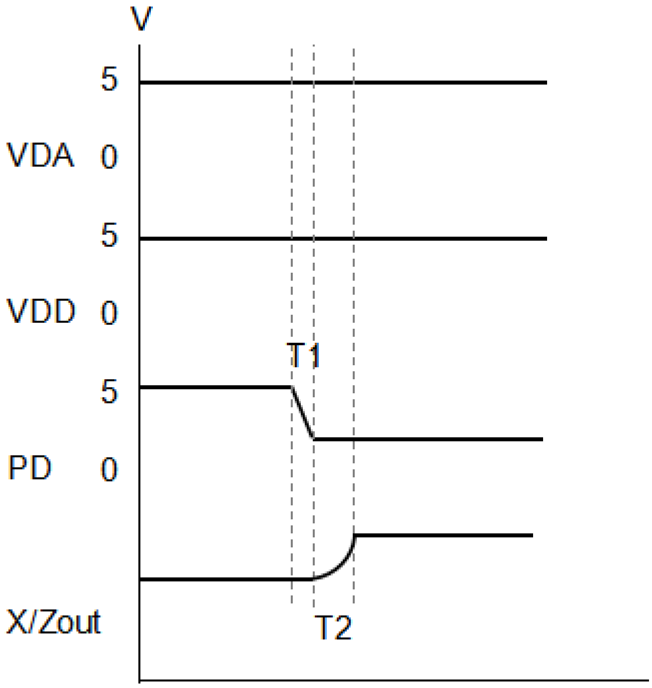
T1 is the PD signal falling time, which should be less than 10ms.

Pull PD pin low to let the MXR7150/7999VW go to power down mode. The power down current is as below.

Item	Typ	Max	Unit
Power Down Current @5.0V	5	10	uA

Power Down Current

2.3 Power-On Operation



Item	Typ	Max	Unit
T1		10	ms
T2	50	150	ms

Power On (Hot Start) Timing

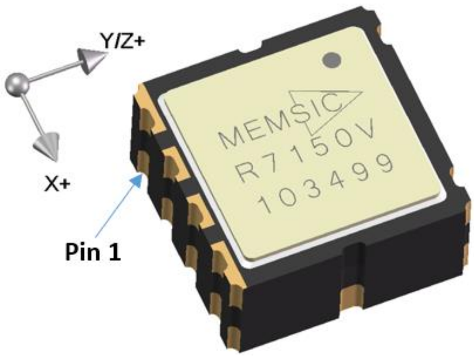
T1 is the PD signal rising time, which should be less than 10ms.
T2 is the sensor turn on (hot start) time. Should delay 150ms (Max) before reading the output after PD pin signal is high. The supply current of normal working mode is as below.

Item	Typ	Max	Unit
Supply Current @5.0V	3.5	6.0	mA

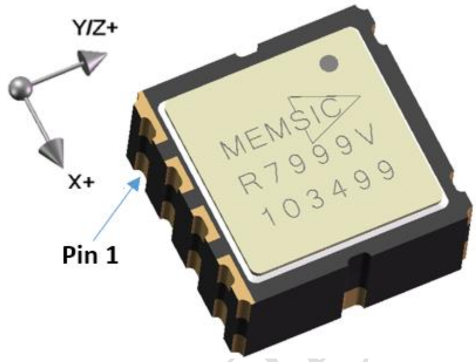
Normal Mode Supply Current

2.4 Analog Output

The direction of sensing axis is as below.

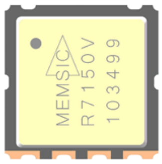
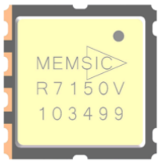
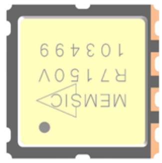
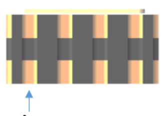
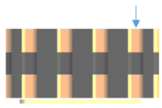


MXR7150VW Sensing Axis Reference

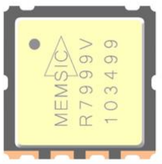
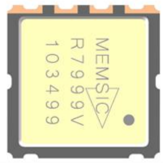
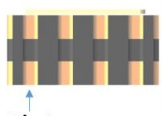
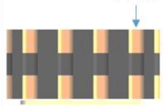


MXR7999VW Sensing Axis Reference

The following table lists all corresponding output signals on X and Y/Z while the sensor is at rest or at uniform motion in a gravity field.

Sensor Orientation (Gravity Vector ↓)					 Pin 1	 Pin 1
Output Signal X	2.50V	2.35V	2.50V	2.65V	2.50V	2.50V
Output Signal Y/Z	2.65V	2.50V	2.35V	2.50V	2.50V	2.50V

MXR7150VW Analog Output

Sensor Orientation (Gravity Vector ↓)					 Pin 1	 Pin 1
Output Signal X	2.50V	1.50V	2.50V	3.50V	2.50V	2.50V
Output Signal Y/Z	3.50V	2.50V	1.50V	2.50V	2.50V	2.50V

MXR7999VW Analog Output

Note: VDA=VDD=5.0V.

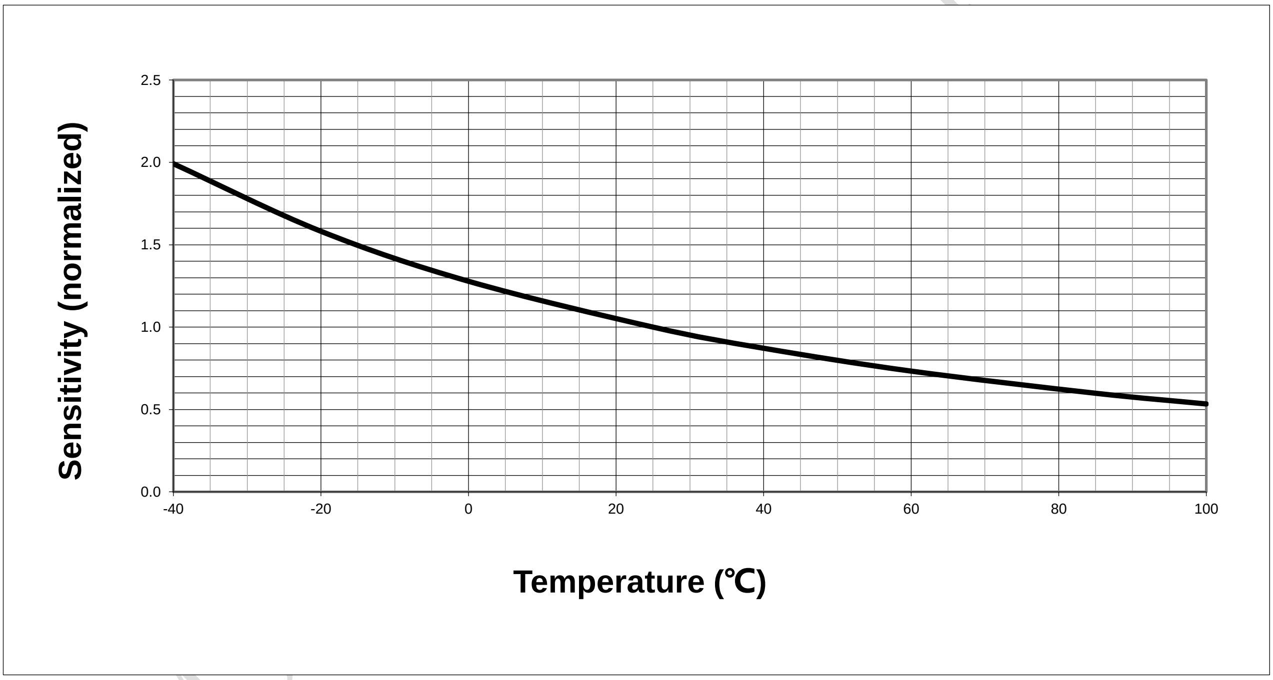
2.5 Self-Test

2.5.1 Self-Test Principle

The gas law governs the change in sensitivity over temperature. All thermal accelerometers display the same sensitivity change with temperature. The sensitivity change depends on variations in heat transfer that are governed by the laws of physics. Manufacturing variations do not influence the sensitivity change, so there are no unit-to-unit differences in sensitivity change. The sensitivity change is governed by the following equation (and shown in below figure in ℃):

$$S_i \text{ x } T_i^{2.8} = k \text{ x } S_f \text{ x } T_f^{2.8}$$

where Si is the sensitivity at any initial temperature Ti, and Sf is the sensitivity at any other final temperature Tf with the temperature values in ℃, k is the ratio between uncompensated sensitivity and compensated sensitivity at 25 ℃.



Thermal Accelerometer Sensitivity

Note1: When the temperature compensation is disabled and self-test is enabled. Self-test follows different gas law from sensitivity temperature dependence. It changes much smaller than sensitivity, this is why the temperature compensation is not done on self-test conditions.

Note2: Initial offset monitoring is a much better and reliable method to ensure sensor integrity, since it is ultra sensitive to sensor structure defect and damage. As long as initial offset is within specification the sensor is functioning correctly.

The sensor structure for the Thermal technology is guaranteed to fall outside the specified initial zero g offset parameters if the sensor is damaged or thermopile is failing. In most cases this will result in either signal path saturation or in the Hardware Error (HE) status bit being set.

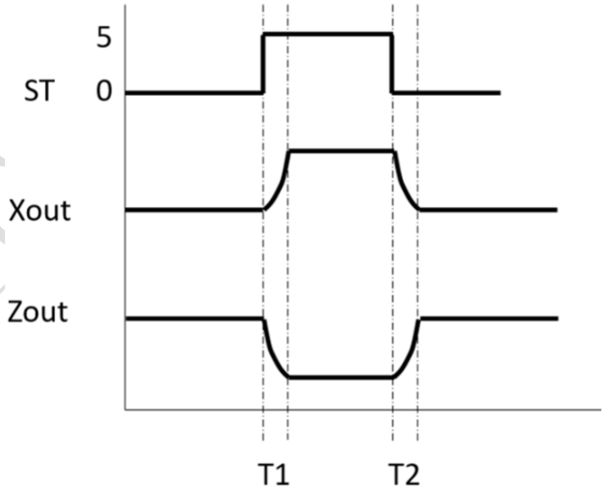
2.5.2 Self-Test Procedure

The recommended method for verifying ST amplitude is as follows:
Step 1. Read acceleration output on the desired axis -- call this Out1.
Step 2. Pull ST pin high, which disables TC and activates ST.
Step 3. Read acceleration output on the same axis(s) -- call this Out2.
Step 4. Subtract (Out2—Out1). This is the ST signal amplitude.
Step 5. Set ST low, returning the accelerometer to normal mode.

For MXR7150VW, if the difference of (Out2—Out1) at Xout is within 2~4g (difference of analog signal is within 0.3V~0.6V), and the difference of (Out2—Out1) at Zout is within -2~-4g (difference of analog signal is within -0.3V~-0.6V), then pass the self-test.

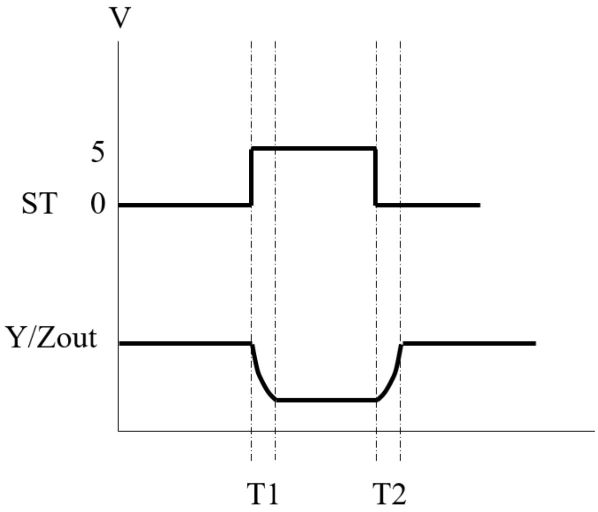
For MXR7999VW, if the difference of (Out2—Out1) at Xout and Zout is within 0.3~0.7g (difference of analog signal is within 0.3V~0.7V), then pass the self-test.

Using the above method, the presence of a real constant acceleration stimulus does not affect the ST amplitude, provided that the acceleration plus self-test signal is not so large that the signal path is saturated.



Item	Typ	Max	Unit
T1	50	150	ms
T2	50	150	ms

MXR7150VW Self-Test Operation Timing



Item	Typ	Max	Unit
T1	50	150	ms
T2	50	150	ms

MXR7999VW Self-Test Operation Timing