



Low Cost Dual-Axis Accelerometer with Rationmetric Outputs

Automotive Grade

MXR7150VW

FEATURES

- Dual axis accelerometer fabricated on a single CMOS IC
- Monolithic design with mixed mode signal processing
- Zero-g temperature stability better than $\pm 100\text{mg}$ from -40C to 125C
- Sensitivity temperature compensation better than $\pm 5\%$ from -40C to 125C
- $\pm 13.3\text{g}$ dynamic range, 150mV/g sensitivity
- 29Hz bandwidth
- On Demand Self Test
- $>50,000\text{ g}$ shock survival rating
- 4.90V to 5.25V single supply operation
- Small surface mount package, $5.5\text{mm} \times 5.5\text{mm} \times 2.7\text{mm}$
- XZ mounting
- RoHS compliant

AUTOMOTIVE APPLICATIONS

- Suspension (Mid range G sensor)
- Roll Over Detection

GENERAL DESCRIPTION

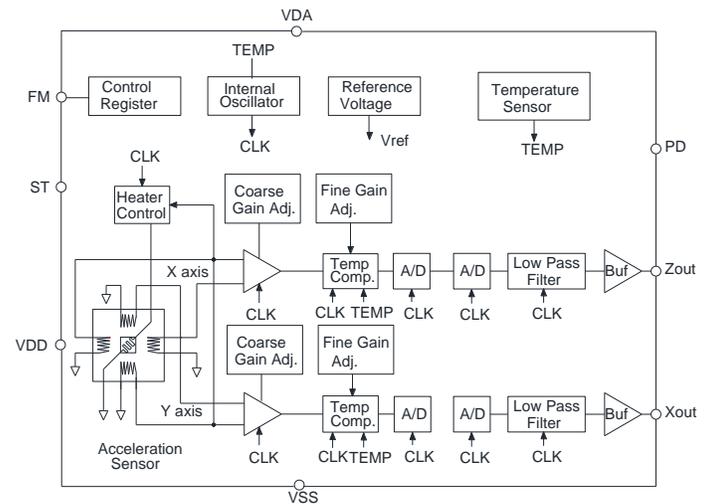
The MXR7150VW is a low cost, dual axis accelerometer built on a standard, submicron CMOS process. It measures acceleration with a full-scale range of -13.3g to $+13.3\text{g}$ and a sensitivity of 150mV/g .

The MXR7150VW provides a g-proportional rationmetric analog output above/ below the zero-g point at 50% of the supply voltage.

The typical noise floor is $2\text{ mg} / \sqrt{\text{Hz}}$, allowing signals below 1mg to be resolved at 1Hz bandwidth. The inherent 3dB roll off of the device is 29Hz providing immunity to and attenuation of higher frequency vibrations present in automotive applications.

The MXR7150VW is packaged in a hermetically sealed LCC surface mount package ($5.5\text{ mm} \times 5.5\text{ mm} \times 2.7\text{ mm}$ height), and the package can be used for XZ sensing, its operation temperature is -40C to $+125\text{C}$.

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MXR7150VW FUNCTIONAL BLOCK DIAGRAM

It can measure both dynamic acceleration (e.g., vibration) and static acceleration (e.g., gravity).

The design is based on heat convection and requires no solid proof mass. This eliminates stiction, particle, and inherent resonant frequency problems associated with competitive devices and provides shock survivability to greater than $50,000\text{g}$, leading to significantly lower failure rates and lower loss due to handling during assembly and at customer field application.

Due to the standard CMOS structure of the MXR7150VW, additional circuitry can easily be incorporated into custom versions for high volume applications. Contact MEMSIC's local office for more information.

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MXR7150VW SPECIFICATIONS (Measurements @ 25°C, Acceleration = 0 g unless otherwise noted; V_{DD} = V_{DA} =5.0V unless otherwise specified)

Parameter	Conditions	MXR7150VW			Units
		Min	Typ	Max	
SENSOR INPUT					
Measurement Range ¹	Each Axis	13.3			g
Non linearity	Best fit straight line		3.0		% of FS
Alignment Error			±0.5		degrees
Transverse Sensitivity			±0.5		%
SENSITIVITY					
Sensitivity, Analog Outputs at pins Xout and Yout ^{1,2}	Each Axis				
Change over Temperature	@5.0V supply Δ from 25°C, -40°C to +125°C	140	150	160	mV/g
				±5	%
Offset BIAS LEVEL					
Offset	Each Axis	-0.53	0	+0.53	g
Voltage		2.42	2.50	2.58	V
Offset over Temperature	Δ from 25°C, -40°C to +125°C based on 150mV/g			±400	mg
NOISE PERFORMANCE					
Noise Density, rms			30		mg/√Hz
FREQUENCY RESPONSE					
3dB Bandwidth		26	29	32	Hz
SELF TEST					
Delta Output changes at Xout, Yout			2		g
Xout and Yout OUTPUTS					
Normal Output Range (Guaranteed symmetric clipping)		0.5		4.5	V
Turn-On Time	@5.0V Supply		150		mS
POWER SUPPLY					
Operating Voltage Range		4.90	5.10	5.25	V
Supply Current ³	@ 5.0V		3.5	6.0	mA
TEMPERATURE RANGE					
Operating Range		-40		+125	°C
PRESSURE RANGE					
Operating Range		40		300	KPa.

Note:

¹ Guaranteed by measurement of initial offset and sensitivity at room temperature.

² The device operates over a 4.9V to 5.25V supply range. The output zero g reference voltage scales 50% of the supply voltage. Sensitivity has a linear scale over the supply range of 4.9 to 5.25 volts according to the ratio (V_{dd}/5.0 volts) x (150mV/g).

Recommended to filter with a minimum of 200Hz low pass filter.

³ Note that the accelerometer has a constant heater power control circuit thereby requiring higher supply current at lower operating voltage.

ABSOLUTE MAXIMUM RATINGS*

Supply Voltage (V_{DD}, V_{DA})¹-0.5 to +7.0V
 Storage Temperature-55°C to +150°C
 Storage Pressure.....1,378 kPa
 Acceleration (any axis, Un-powered for 0.5 msec)..50,000 g
 Acceleration (any axis, Powered for 0.5 msec)... 10,000 g
 Output Short Circuit Duration, any pin to common.....Indefinite

*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 device reliability.

¹ Exposure for up to 60 minutes to absolute maximum ratings for supply voltages will not affect device reliability.

Ordering Guide

Model	Package Style
MXR7150VW	LCC-8 SMD*

* Parts are shipped in tape and reel packaging.

Pin Description: LCC Package

Pin	Name	Description
1	Xout	X-Channel Ratiometric Output
2	VDA	Analog Supply
3	VDD	Digital Supply, V _{DA} and V _{DD} must be the same voltage
4	FM	Ground. Connect to VSS
5/J	PD	PD
6/M	Zout	Z-Channel Ratiometric Output
7/L	VSS	Ground
8/K	ST	Self -Test Input

Caution

ESD (electrostatic discharge) sensitive device.

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

Small circle indicates pin one (7).

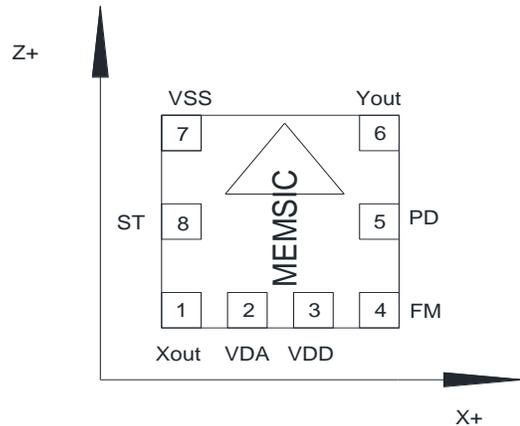
ESD Compliance:

The MXR7150VW sensor is in compliance with the following ESD standards:

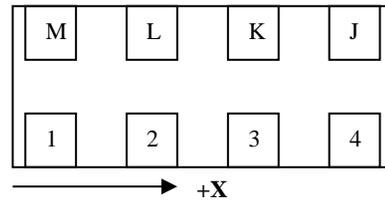
HBM class H2 per AEC-Q100-002 Rev. E

MM class M2 per AEC-Q100-003 Rev. E

XZ Sensing (Top View):



XZ Sensing (Bottom View):



THEORY OF OPERATION

The MEMSIC device is a complete dual-axis acceleration measurement system fabricated on a monolithic CMOS IC process. The device operation is based on heat transfer by natural convection and operates like other accelerometers having a proof mass except it is a gas in the MEMSIC sensor.

A single heat source, centered in the silicon chip is suspended across a cavity. Equally spaced aluminum/polysilicon thermopiles (groups of thermocouples) are located equidistantly on all four sides of the heat source (dual axis). Under zero acceleration, a temperature gradient is symmetrical about the heat source, so that the temperature is the same at all four thermopiles, causing them to output the same voltage.

Acceleration in any direction will disturb the temperature profile, due to free convection heat transfer, causing it to be asymmetrical. The temperature, and hence voltage output of the four thermopiles will then be different. The differential voltage at the thermopile outputs is directly proportional to the acceleration. There are two identical acceleration signal paths on the MXR7150VW, one to measure acceleration in the x-axis and one to measure acceleration in the y/z-axis. For more details visit the MEMSIC website at www.MEMSIC.com for a picture/graphic description of the free convection heat transfer principle.

PIN DESCRIPTIONS

X_{OUT} – (pin 1) X-axis acceleration signal output.

V_{DA} – (pin 2) 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 V_{DD} pin.

V_{DD} - (pin 3) This is the digital power supply for the MXR7150VW. This pin supplies current to the heater element and digital circuitry. The DC voltage should be between 4.5V and 5.25V.

FM – (pin 4) Ground. Connect to VSS.

PD/SCK – (pin 5) TBD.

Z_{OUT} – (pin 6) Y-axis acceleration signal output.

VSS – (pin 7) This is the ground pin for the MXR7150VW

ST_{IN}–(pin 8) Self –Test Input

This pin controls the self-test function of the sensor. Bringing ST_{IN} high will cause a negative deflection Z_{out} and X_{out} from initial value.

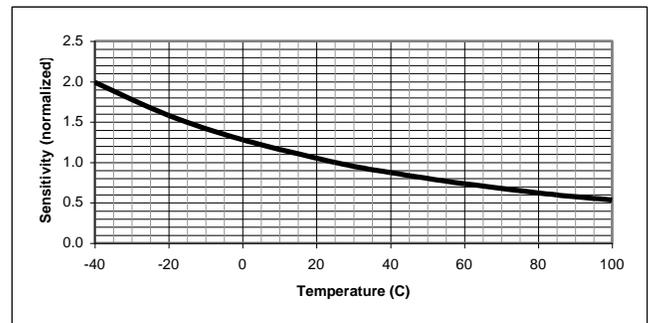
SELF-TEST DESCRIPTION

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 Figure 1 in °C):

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

where S_i is the sensitivity at any initial temperature T_i, and S_f is the sensitivity at any other final temperature T_f with the temperature values in °C, k is the ratio between uncompensated sensitivity and compensated sensitivity at 25°C.



Thermal Accelerometer Sensitivity

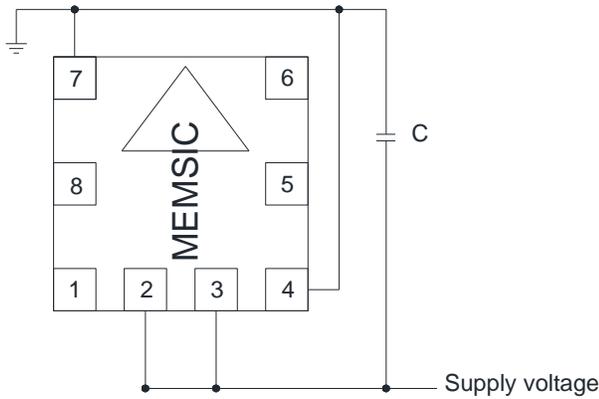
Note1: When the temperature compensation is disabled and self-test is enabled. Self-test follows different gas law from sensitivity temperature dependence. It changes much smaller than sensitivity; this is why the temperature compensation is not done on self-test conditions.

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.

PCB LAYOUT AND FABRICATION SUGGESTIONS

Reference figure and the notes below for recommendations on connecting a power source to the MEMSIC device and PCB fabrication.



PCB Layout

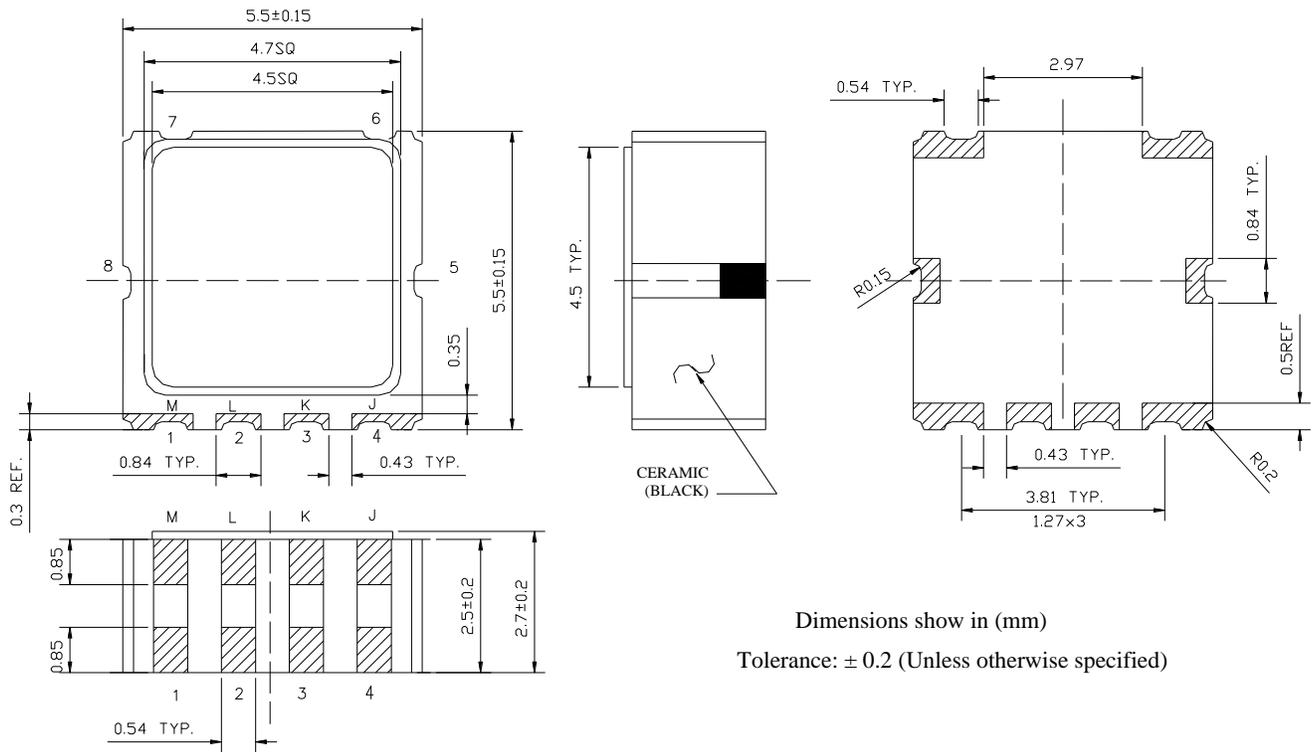
Notes:

1. $C = 1.0\mu\text{F}$
2. The bypass capacitance should be placed near the VDD and VSS pins to ensure low noise performance and accurate outputs. The predominant transient currents on the MXR7150VW are supplied to the heater element in

the thermal sensor through the VDD and VSS pins. The nominal heater resistance is about 500ohm, and nominal heater power is about 7.5 mW. With VDD=5.0V, peak current in the heater element is approximately 10 mA. An internal switching regulator ensures that heater power remains essentially constant with temperature and supply voltage variations. This regulator uses Pulse Width Modulation (PWM) and operates at a fundamental frequency of 1.6 MHz. At VDD=5V, the PWM regulator duty cycle is nominally 15-20%. The bypass capacitor should be able to deliver the required charge during each regulator switching period to ensure low supply noise.

3. Robust low inductance ground and supply wiring should be used.
4. 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.

MECHANICAL PACKAGE OUTLINE DIMENSIONS



Dimensions show in (mm)
Tolerance: ± 0.2 (Unless otherwise specified)