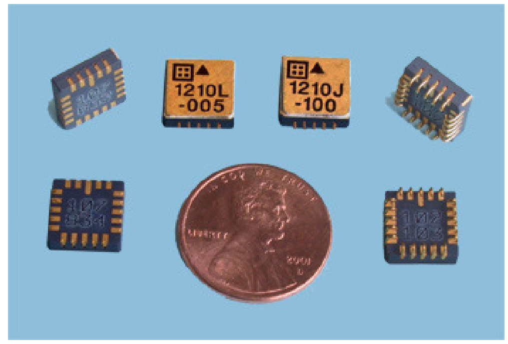
SILICON DESIGNS, INC

Model 1210
Analog Accelerometer

- Capacitive Micromachined
- Nitrogen Damped & Hermetically Sealed
- ±4V Differential Output or 0.5V to 4.5V Single Ended Output
- Fully Calibrated
- Responds to DC and AC Acceleration
- -55 to +125°C Operation
- +5 VDC, 7 mA Power (typical)
- Non Standard g Ranges Available
- Integrated Sensor & Amplifier
- LCC or J-Lead Surface Mount Package
- Serialized for Traceability
- Pin Compatible with Model 1221
- RoHS Compliant



Available G-Ranges

Full Scale Acceleration	20 pin LCC	20 pin JLCC
± 5 g	1210L-005	1210J-005
± 10 g	1210L-010	1210J-010
± 25 g	1210L-025	1210J-025
± 50 g	1210L-050	1210J-050
±100 g	1210L-100	1210J-100
±200 g *	1210L-200	1210J-200
±400 g *	1210L-400	1210J-400
* Recommended for Down Hole Drilling		

DESCRIPTION

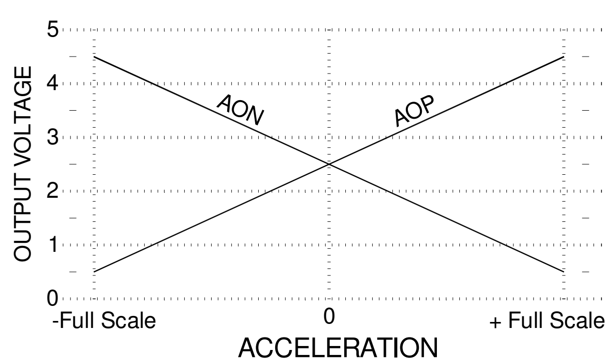
The Model 1210 is a low-cost, integrated accelerometer for use in zero to medium frequency instrumentation applications. Each miniature, hermetically sealed package combines a micro-machined capacitive sense element and a custom integrated circuit that includes a sense amplifier and differential output stage. It is relatively insensitive to temperature changes and gradients. Each device is marked with a serial number on its bottom surface for traceability. An optional calibration test sheet (1210-TST) is also available which lists the measured bias, scale factor, linearity, operating current and frequency response.

OPERATION

The Model 1210 produces two analog output voltages, which vary with acceleration as shown in the figure below. The outputs can be used either in differential or single ended mode referenced to +2.5 volts. Two reference voltages, +5.0 and +2.5 volts (nominal), are required; the output scale factor is ratiometric to the +5 volt reference voltage, and both outputs at zero acceleration are equal to the +2.5 volt reference. The sensitive axis is perpendicular to the bottom of the package, with positive acceleration defined as a force pushing on the bottom of the package.

COMMERCIAL
- Automotive
  - Air Bags
  - Active Suspension
  - Adaptive Brakes
  - Security Systems
- Shipping Recorders
- Appliances

INDUSTRIAL
- Vibration Monitoring
- Vibration Analysis
- Machine Control
- Modal Analysis
- Robotics
- Crash Testing
- Instrumentation



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

PERFORMANCE

By Model: V_{DD}=V_R=5.0 VDC, T_C=25°C.

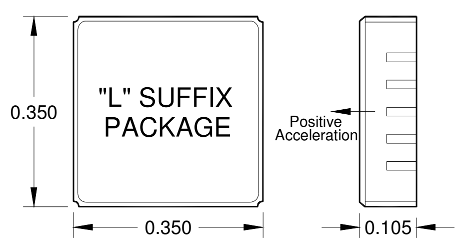
Model Number	Input Range	Frequency Response (Nominal, 3 dB)	Sensitivity (Differential) [1]	Output Noise, Differential (RMS, typical)	Max. Mechanical Shock (0.1 ms)
	g	Hz	mV/g	µg/(root Hz)	g
1210-005	±5	0 - 400	800	32	2000
1210-010	±10	0 - 600	400	63	5000
1210-025	±25	0 - 1000	160	158	
1210-050	±50	0 - 1500	80	316	
1210-100	±100	0 - 2000	40	632	
1210-200	±200	0 - 2500	20	1265	
1210-400	±400	0 - 3500	10	2530	

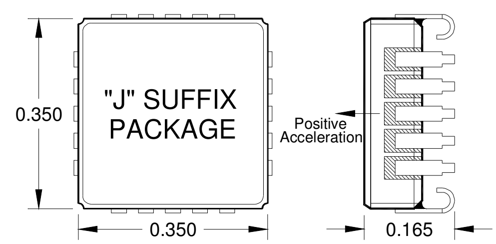
Note 1: Single ended sensitivity is half of values shown.

All Models: Unless otherwise specified V_{DD}=V_R=5.0 VDC, T_C=25°C, Differential Mode.

PARAMETER		MIN	TYP	MAX	UNITS
Cross Axis Sensitivity			2	3	%
Bias Calibration Error[2]	-005		2	4	% of Span
	-010 thru -400		1	2	
Bias Temperature Shift (T_C= -55 to +125°C)[2]	-005		100	300	(ppm of span)/°C
	-010 thru 200		50	200	
Scale Factor Calibration Error[2,3]			1	2	%
Scale Factor Temperature Shift (T_C= -55 to +125°C) [2]			+300		ppm/°C
Non-Linearity (-90 to +90% of Full Scale) [2,3]	-005 thru -025		0.5	1.0	% of span
	-050, -100		0.5	1.25	
	-200		0.7	1.5	
	-400		1.0	2.0	
Power Supply Rejection Ratio			25		dB
Output Impedance			90		Ohms
Operating Voltage		4.75	5.0	5.25	Volts
Operating Current (I_{DD}+I_{VR}) [2]			7	10	mA
Mass: 'L' package (add 0.06 grams for 'J' package)			0.62		grams

Note 2: Tighter tolerances available on special order. Note 3: 100g and greater versions are tested from -65 to +65g.





SIGNAL DESCRIPTIONS

V_{DD} and GND (power): Pins (8,9,11,14) and (2,5,6,18,19) respectively. Power (+5 Volts DC) and ground.

AOP and AON (output): Pins 12 and 16 respectively. Analog output voltages proportional to acceleration. The AOP voltage increases (AON decreases) with positive acceleration; at zero acceleration both outputs are nominally equal to the +2.5 volt reference. The device experiences positive (+1g) acceleration with its lid facing up in the earth's gravitational field. Either output can be used individually or the two outputs can be used differentially but differential mode is recommended for both lowest noise and highest accuracy operation. Voltages can be measured ratiometrically to VR for good accuracy without requiring a precision reference voltage. (See plot.)

DV (input): Pin 4. Deflection Voltage. Normally left open. A test input that applies an electrostatic force to the sense

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE element, simulating a positive acceleration. The nominal voltage at this pin is ½ V_{DD}. DV voltages higher than required to bring the output to positive full scale may cause device damage.

VR (input): Pin 3. Voltage Reference. Tie directly to V_{DD} for ratiometric measurements or to a +5V reference for better absolute accuracy. A 0.1µF bypass capacitor is recommended at this pin.

2.5 Volt (input): Pin 17. Voltage Reference. Tie to a resistive voltage divider from +5 volts or to a +2.5 volt reference voltage.

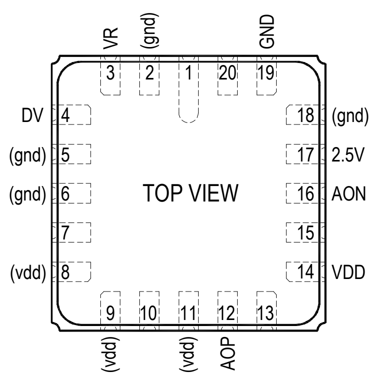
ABSOLUTE MAXIMUM RATINGS *

Case Operating Temperature	-55 to +125°C
Storage Temperature	-55 to +125°C
Acceleration Over-range	2000g for 0.1 ms
Voltage on V_{DD} to GND	-0.5V to 6.5V
Voltage on Any Pin (except DV) to GND [4]	-0.5V to V_{DD}+0.5V
Voltage on DV to GND [5]	±15V
Power Dissipation	50 mW

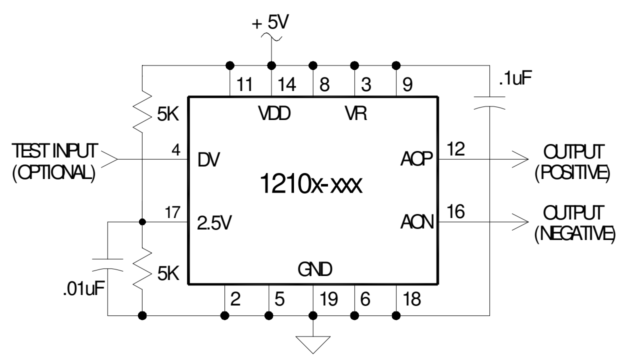
Note 4: Voltages on pins other than DV, GND or V_{DD} may exceed 0.5 volt above or below the supply voltages provided the current is limited to 1 mA.

Note 5: The application of DV voltages higher than required to bring the output to positive full scale may cause device damage.

***NOTICE:** Stresses greater than those listed above may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at or above these conditions is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*



PIN OUT (LCC & JLCC Packages)



RECOMMENDED CONNECTIONS

The 2.5V reference input (pin 17) may be driven from either a precision voltage source or by the capacitively bypassed resistive divider shown above.

DEFLECTION VOLTAGE (DV) TEST INPUT: This test input applies an electrostatic force to the sense element, simulating a positive acceleration. It has a nominal input impedance of 32 kΩ and a nominal open circuit voltage of **½ V_{DD}**. For best accuracy during normal operation, this input should be left unconnected or connected to a voltage source equal to ½ of the **V_{DD}** supply. The change in differential output voltage (**AOP** - **AON**) is proportional to the square of the difference between the voltage applied to the **DV** input (**V_{DV}**) and **½ V_{DD}**. Only positive shifts in the output voltage may be generated by applying voltage to the **DV** input. When voltage is applied to the **DV** input, it should be applied gradually. The application of **DV** voltages greater than required to bring the output to positive full scale may cause device damage. The proportionality constant (***k***) varies for each device and is not characterized.

$$\Delta(AOP - AON) \approx k\left(V_{DV} - \frac{1}{2}V_{DD}\right)^2$$

ESD and LATCH-UP CONSIDERATIONS: The model 1210 accelerometer is a CMOS device subject to damage from

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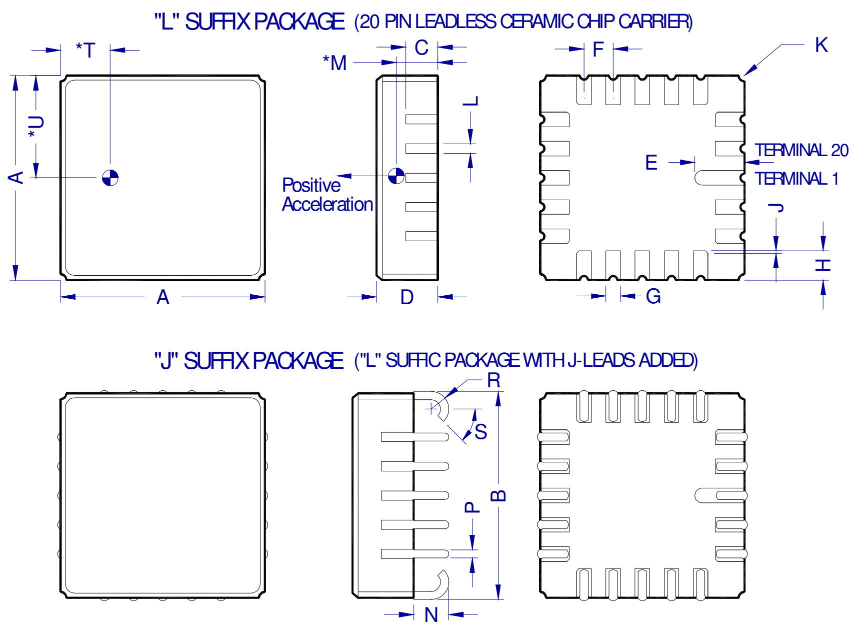
large electrostatic discharges. Diode protection is provided on the inputs and outputs but care should be exercised during handling to assure that the device is placed only on a grounded conductive surface. Individuals and tools should be grounded before coming in contact with the device. Do not insert the model 1210 into (or remove it from) a powered socket.

BIAS STABILITY CONSIDERATIONS: Bias temperature hysteresis can be minimized by temperature cycling your model 1210 accelerometer after it has been soldered to your circuit board. If possible, the assembled device should be exposed to ten cycles from -40 to +85 °C minimum (-55 to +125 °C recommended). The orientation to the Earth's gravitational field during temperature cycling should preferably be in the same orientation as it will be in the final application. The accelerometer does not need to have power applied during this temperature cycling.

PACKAGE DIMENSIONS

Notes: 1. * Dimensions 'm', 't' & 'u' locate acceleration sensing element's center of mass.
2. Lid is electrically tied to terminal 19 (GND).
3. Controlling dimension: inch.
4. Terminals are plated with 60 micro-inches min gold over 80 micro-inches min nickel. (This plating specification does not apply to the metallized pin-1 identifier mark on the bottom of the j-lead version of the package).
5. Package: 90% minimum alumina (black), lid: solder sealed kovar.

Dim	Inches		Millimeters	
	Min	Max	Min	Max
A	0.342	0.358	8.69	9.09
B	0.346	0.378	8.79	9.60
C	0.055 TYP		1.40 TYP	
D	0.095	0.115	2.41	2.92
E	0.085 TYP		2.16 TYP	
F	0.050 BSC		1.27 BSC	
G	0.025 TYP		0.64 TYP	
H	0.050 TYP		1.27 TYP	
J	0.004 x 45°		0.10 x 45°	
K	0.010 R TYP		0.25 R TYP	
L	0.016 TYP		0.41 TYP	
* M	0.048 TYP		1.23 TYP	
N	0.050	0.070	1.27	1.78
P	0.017 TYP		0.43 TYP	
R	0.023 R TYP		0.58 R TYP	
* T	0.085 TYP		2.16 TYP	
* U	0.175 TYP		4.45 TYP	



SOLDERING RECOMMENDATIONS:

RoHS Compliance: The model 1210 does not contain elemental lead and is RoHS compliant.

<u>*WARNING*</u>: If no-lead solder is to be used to attach the device, we do not recommend the use of reflow soldering methods such as vapor phase, solder wave or hot plate. These methods impart too much heat for too long of a period of time and may cause excessive bias shifts. For no-lead soldering, we only recommend the manual "Solder Iron Attach" method (listed on the next page of this data sheet). We also do not recommend the use of ultrasonic bath cleaners because these models contain internal gold wires that are thermo sonically bonded.

Reflow of Sn62 or Sn63 type solder using a hotplate is the preferred method for assembling the model 1210 surface mount accelerometer to your Printed circuit board. Hand soldering using a fine tipped soldering iron is possible but difficult without a steady hand and some form of visual magnification due to the small size of the connections. When using the hand solder iron method, it's best to purchase the J-Leaded version (1210J) for easier visual inspection of the finished solder joints.

Pre-Tinning of Accelerometer Leads is Recommended: To prevent gold migration embrittlement of the solder joints, it is best to pre-tin the accelerometer leads. We recommend tinning one lead at a time, to prevent excessive heating of the accelerometer, using a fine-tipped solder iron and solder wire. The solder bath method of pre-tinning is not recommended due to the high degree of heat the interior of the device gets subjected to which may cause permanent shifts in the bias and/or scale factor.

Hotplate Attach Method using Solder Paste or Solder Wire: Apply solder to the circuit board's pads using Sn62 or Sn63 solder paste or pre-tin the pads using solder and a fine tipped soldering iron. If pre-tinning with an iron, apply flux to the tinned pads prior to placing the components. Place the accelerometer in its proper position onto the pasted or tinned pads then place the entire assembly onto a hotplate that has been pre-heated to 250°C. Leave on hotplate only long enough for the solder to flow on all pads **(DO NOT OVERHEAT!)**

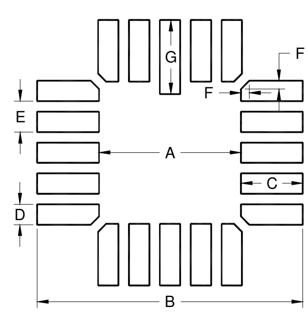
Solder Iron Attach Method using Solder Paste: Apply solder paste to the circuit board's pads where the accelerometer will be attached. Place the accelerometer in its proper position onto the pasted pads. Press gently on the top of the accelerometer with an appropriate tool to keep it from moving and heat one of the corner pads, then an opposite corner pad with the soldering iron. Make sure the accelerometer is positioned so all 20 of its connections are centered on the board's pads. Once the two opposite corner pads are soldered, the part is secure to the board and you can work your way around soldering the remaining 18 connections. Allow the accelerometer to cool in between soldering each pin to prevent overheating.

Solder Iron Attach Method using Solder Wire: Solder pre-tin two opposite corner pads on the circuit board where the accelerometer will be attached. Place the accelerometer in its proper position onto the board. Press gently on the top of the accelerometer and heat one of the corner pads that were tinned and the part will drop down through the solder and seat on the board. Do the same at the opposite corner pad that was tinned. Make sure the accelerometer is positioned so all 20 of its connections are centered on the board's pads. Once the two opposite corner pads are soldered, the part is secure to the board and you can work your way around soldering the remaining 18 connections. Allow the accelerometer to cool in between soldering each pin to prevent overheating.

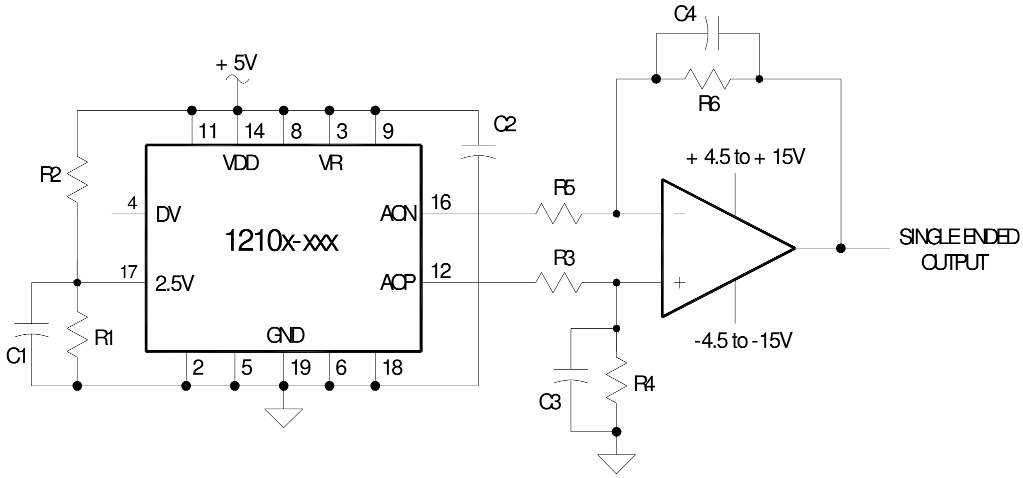
LCC & JLCC Solder Contact Plating Information: The plating composition and thickness for the solder pads and castellations on the "L" suffix (LCC) package are 60 to 225 micro-inches thick of gold (Au) over 80 to 350 micro-inches thick of nickel (Ni) over a minimum of 5 micro-inches thick of moly-manganese or tungsten refractory material. The leads for the "J" suffix (JLCC) package are made of an Iron-Nickel sealing alloy and have the same gold over nickel plating thicknesses as for the LCC pads.

Recommended Solder Pad Pattern: The recommended solder pad size and shape for both the LCC and J-LCC packages is shown in the diagram and table below. These dimensions are recommendations only and may or may not be optimum for your particular soldering process.

DIM	inch	mm
A	.230	5.84
B	.430	10.92
C	.100	2.54
D	.033	0.84
E	.050	1.27
F	.013	0.33
G	.120	3.05



OPTIONAL: Adding a Single Ended Output



R1 = R2 = 5.00K ±0.5% for precision 2.50V ref.	R3, R4, R5 & R6 = 20kΩ to 50kΩ R3 = R5 to within 0.1% for common mode rejection R4 = R6 to within 0.1% for common mode rejection R4 / R3 ratio accurate to within 0.1% for gain control R6 / R5 ratio accurate to within 0.1% for gain control
C1 = C2 (See below for value calculation)	

The 1210 accelerometer will work without any modification in single ended mode. However, to achieve the highest resolution and lowest noise performance from your model 1221 accelerometer module, it should be connected to your voltage measurement instrument in a differential configuration using both the **AOP and AON** output signals. If your measurement instrument lacks differential input capability or you desire to use a differential input capable instrument in single ended mode, then the circuit above can be used to preserve the low noise performance of the model 1221 while using a single ended type connection.

This circuit converts the ± 4 Volt differential output of the model 1210 accelerometer, centered at +2.5 Volts, to a single ended output centered about ground (0.0 Volts). It provides the advantage of low common mode noise by preventing the ground current of the model 1210 from causing an error in the voltage reading.

The op-amp should be located as close as possible to your voltage monitoring equipment so that the majority of the signal path is differential. Any noise present along the differential path will affect both wires to the same degree and the op-amp will reject this noise because it is a common mode signal. The op-amp type is not critical; a µA741 or ¼ of a LM124 can be used. Both plus and minus supplies are needed for the op-amp to accommodate the positive and negative swings of the single ended output signal.

For this design, always set $R_4 = R_6$, $R_3 = R_5$ and $C_3 = C_4$. The gain of the circuit is then determined by the ratio R_4/R_3. When $R_4 = R_3 = R_6 = R_5$, the gain equals 1 and the output swing will be ± 4 Volts single ended with respect to ground. To obtain a ± 5 Volt single ended output, set $R_4/R_3 = R_6/R_5 = 5/4 = 1.25$. The single ended output of the op-amp will be centered at ground if R_4 and C_3 are tied to ground; using some other fixed voltage for this reference will shift the output. The value of the optional capacitors C_3 and C_4 ($C_3 = C_4$) can be selected to roll off the frequency response to the frequency range of interest. The cutoff frequency f_0 (-3 dB frequency) for this single order low pass filter is given by:

$$f_0 = \frac{1}{2\pi R_4 C_3}$$