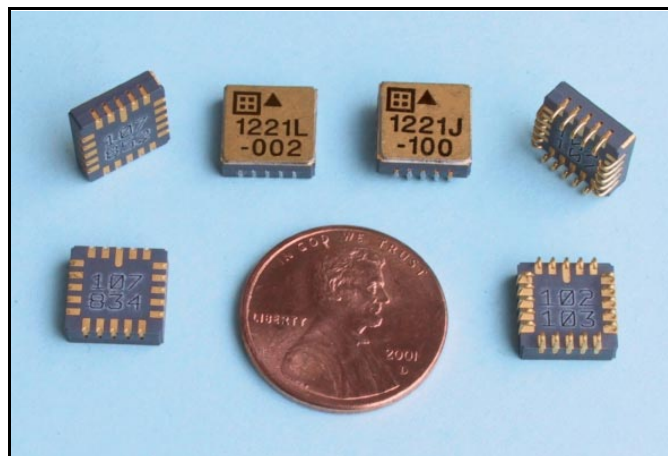


● SENSOR TYPE:

Capacitive Micromachined
Nitrogen Damped
Hermetically Sealed

- **Low Noise:** $2 \mu\text{g}/\sqrt{\text{Hz}}$ typical for 2g Full Scale Version
- Internal Temperature Sensing
- $\pm 4\text{V}$ Differential Output or 0.5V to 4.5V Single Ended Output
- Fully Calibrated
- Responds to DC & AC Acceleration
- -55 to +85 °C Operation
- +5 VDC, 10 mA Power (typical)
- Non-Standard g Ranges Available
- Integrated Sensor & Amplifier
- LCC or J-Lead Surface Mount Package
- Serialized for Traceability



ORDERING INFORMATION

Full Scale Acceleration	Hermetic Packages	
	20 pin LCC	20 pin JLCC
$\pm 2 \text{ g}$	1221L-002	1221J-002
$\pm 5 \text{ g}$	1221L-005	1221J-005
$\pm 10 \text{ g}$	1221L-010	1221J-010
$\pm 25 \text{ g}$	1221L-025	1221J-025
$\pm 50 \text{ g}$	1221L-050	1221J-050
$\pm 100 \text{ g}$	1221L-100	1221J-100
$\pm 200 \text{ g}$	1221L-200	1221J-200

DESCRIPTION

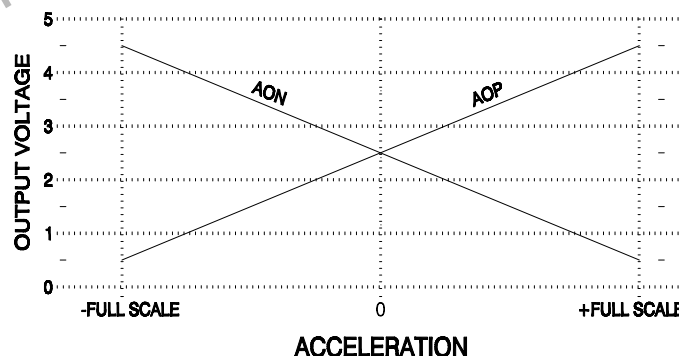
The Model 1221 is a low-cost, integrated accelerometer for use in zero to medium frequency instrumentation applications that require extremely low noise. **The 2g version is ideally suited for seismic applications.** Each miniature, hermetically sealed package combines a micro-machined capacitive sense element and a custom integrated circuit that includes a sense amplifier and differential output stage. It is relatively insensitive to temperature changes and thermal gradients. Each device is marked with a serial number on its bottom surface for traceability.

OPERATION

The Model 1221 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.

APPLICATIONS

- Seismic Monitoring
- Earthquake Detection
- Security Systems
- Machine Control
- Modal Analysis
- Instrumentation
- Appliances
- Robotics
- Crash Testing
- Vibration Monitoring
- Vibration Analysis
- Vehicle Dynamics



Model 1221 Low Noise Analog Accelerometer

SIGNAL DESCRIPTIONS

VDD and GND (power): Pins (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 ratio-metrically to VR for good accuracy without requiring a precision reference voltage. (See plot.)

DV (input): Pin 4. Deflection Voltage. A test input that applies an electrostatic force to the sense element, simulating a positive acceleration. The nominal voltage at this pin is $\frac{1}{2} V_{DD}$. 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 +5 volt power for ratiometric measurements or a +5 volt reference voltage for better absolute accuracy. A 0.1 μ F 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.

I_T (output): Pin 8. Temperature dependent current source. (May be tied to V_{DD}; see full description on page 5).

PERFORMANCE - by Model: Unless otherwise specified V_{DD}=5.0VDC, T_C=25°C, Differential Mode.

Model Number	1221x-002	1221x-005	1221x-010	1221x-025	1221x-050	1221x-100	1221x-200	Units
Input Range	±2	±5	±10	±25	±50	±100	±200	g
Frequency Response (Nominal, 3 dB)	0 - 400	0 - 600	0 - 1000	0 - 1500	0 - 2000	0 - 2500	0 - 3500	Hz
Sensitivity (Differential) ¹	2000	800	400	160	80	40	20	mV/g
Output Noise (RMS, typical)	2	5	10	25	50	100	200	μg/(root Hz)
Max. Mechanical Shock (0.1 ms)	2000							g

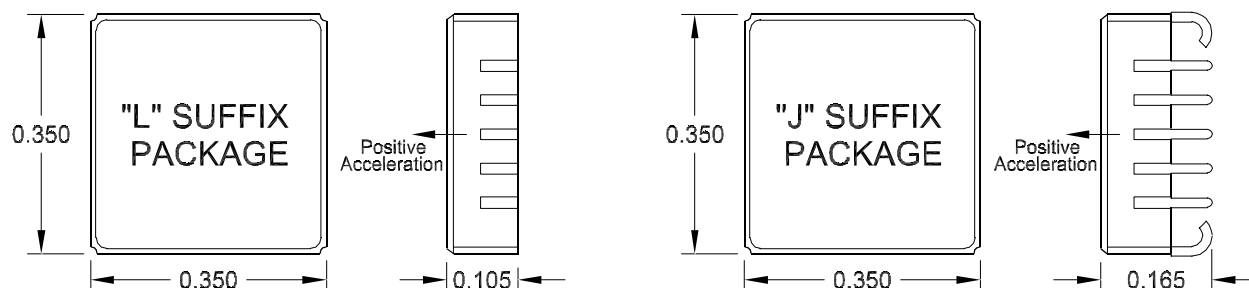
Note 1: Single ended sensitivity is half of values shown.

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

PARAMETER		MIN	TYP	MAX	UNITS
Cross Axis Sensitivity			2	3	%
Bias Calibration Error ²	-002		2	4	% of span
	-005 thru -200		1	2	
Bias Temperature Shift (T _C = -55 to +85°C) ²	-002		100	300	(ppm of span)/°C
	-005 thru -200		50	200	
Scale Factor Calibration Error ^{2,3}			1	2	%
Scale Factor Temperature Shift (T _C = -55 to +85°C) ²			+300		ppm/°C
Non-Linearity (-90 to +90% of Full Scale) ^{2,3}			0.5	1.0	% of span
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			10	14	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



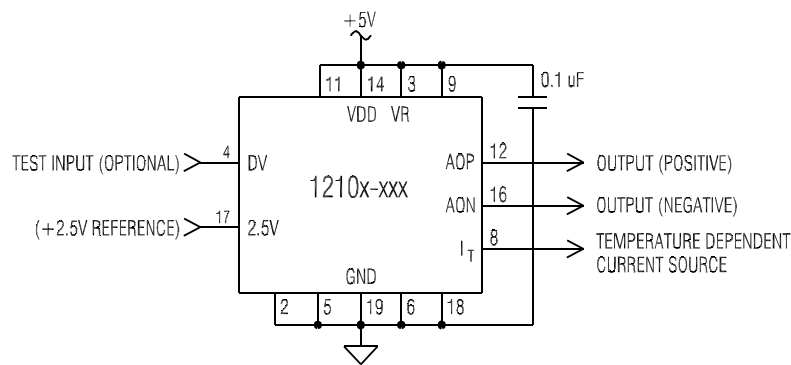
ABSOLUTE MAXIMUM RATINGS *

Case Operating Temperature	-55 to +85°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

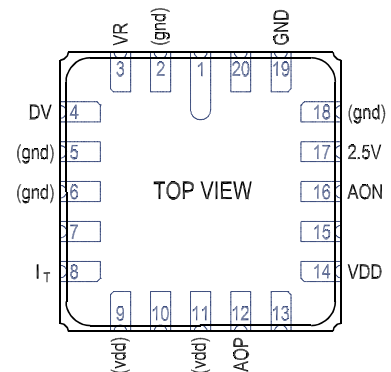
Note 4: Voltages on pins other than DV, GND or V_{DD} may exceed 0.5 volt above or below the supply voltages provided the current is limited to 1 mA..

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.



RECOMMENDED CONNECTIONS



PINOUT
(LCC & JLCC PACKAGES)

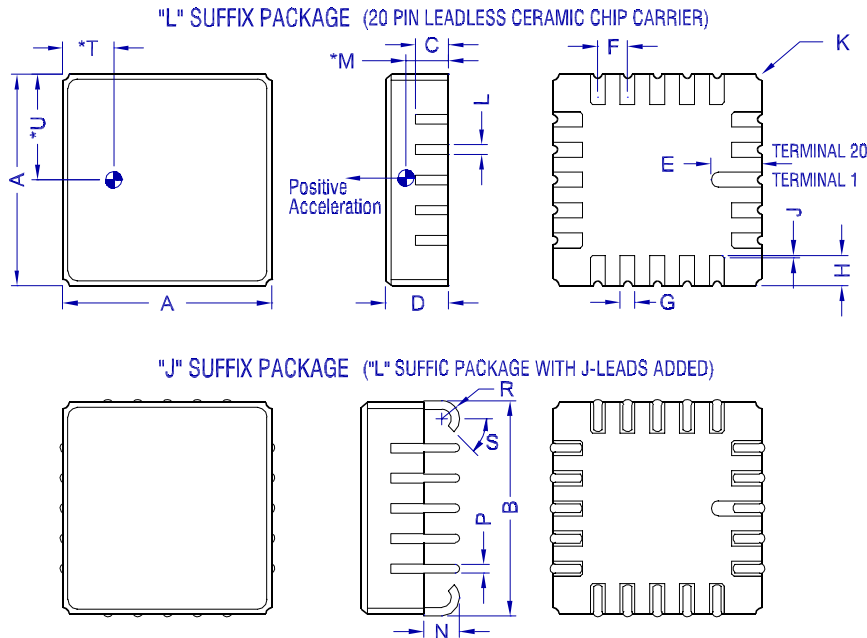
The 2.5V reference input may be driven from either a precision voltage source or a 5kΩ/5kΩ resistive divider from a precision 5V supply. If a resistive divider is used, a 0.01μF bypass capacitor should be connected between the 2.5V input and GND.

DEFLECTION VOLTAGE (DV) TEST INPUT: Left unconnected, the DV input has a nominal voltage of $\frac{1}{2} V_{DD}$. For best accuracy during normal operation, this input should be left unconnected or connected to a voltage source equal to $\frac{1}{2}$ 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 $\frac{1}{2} V_{DD}$. Only positive shifts in the output voltage may be generated by applying voltage to the DV input. 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.

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

ESD and LATCH-UP CONSIDERATIONS: The model 1221 accelerometer is a CMOS device subject to damage from 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 1221 into (or remove it from) a powered socket.

PACKAGE DIMENSIONS



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	0.050	0.060	1.27	1.52
D	0.095	0.115	2.41	2.92
E	0.075	0.095	1.91	2.41
F	0.050 BSC		1.27 BSC	
G	0.022	0.028	0.56	0.71
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	.050	.070	1.27	1.78
P	0.014 TYP		0.36 TYP	
R	0.03 R TYP		0.76 R TYP	
S	45° MINIMUM			
* T	0.085 TYP		2.16 TYP	
* U	0.175 TYP		4.45 TYP	

- 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 PLATED 60 MICRO-INCHES MIN GOLD OVER 80 MICRO-INCHES MIN NICKEL.
 5. PACKAGE: 90% MINIMUM ALUMINA (BLACK), LID: SOLDER SEALED KOVAR.

INTERNAL TEMPERATURE SENSING

The model 1221 accelerometer contains a temperature dependent current source that is output at pin 8. This signal is useful for measuring the internal temperature of the accelerometer so that any previously characterized bias and scale factor dependence for a particular accelerometer can be corrected. The nominal output current at 25°C is around 500 milliamps and the nominal sensitivity is 1.5 $\mu\text{A}/^\circ\text{C}$. It is up to the user to characterize each device's exact output current versus temperature over the range it is to be used. Fluctuations in V_{DD} & V_R have little affect on the temperature reading. A reduction of 0.10 V to both V_{DD} & V_R will reduce the current about 1 μA which corresponds to less than a 1°C change in reading.

A single 2K resistor between I_T (pin 8) and GND, as shown in Figure 1, will yield a 25°C voltage of around 1V and the voltage will vary between about 0.8V and 1.22V from -55 to +85°C providing a sensitivity of around 3 mV/°C.

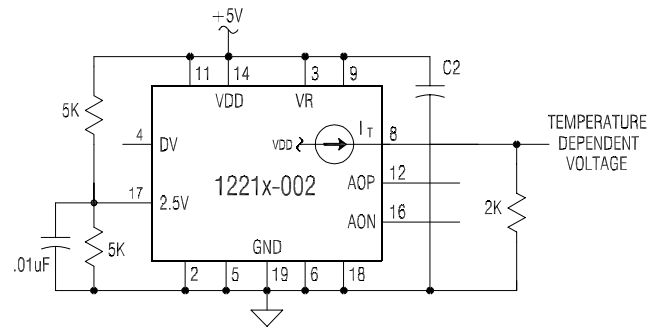


FIGURE 1

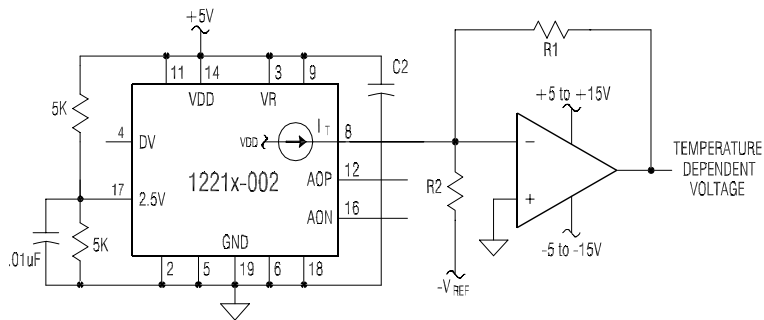


FIGURE 2

If a greater voltage change versus temperature or lower signal source impedance is needed, the circuit in Figure 2 can be used. For $R1=20\text{K}$, the circuit will provide about a 4V swing over the -55 to +85°C temperature range. With $R2$ equal to the -Ref voltage divided by 835 μA (or about 6K if $-V_{REF} = -5\text{V}$), the output will swing between 0.5V and +4.5V (just like the AOP and AON outputs do).

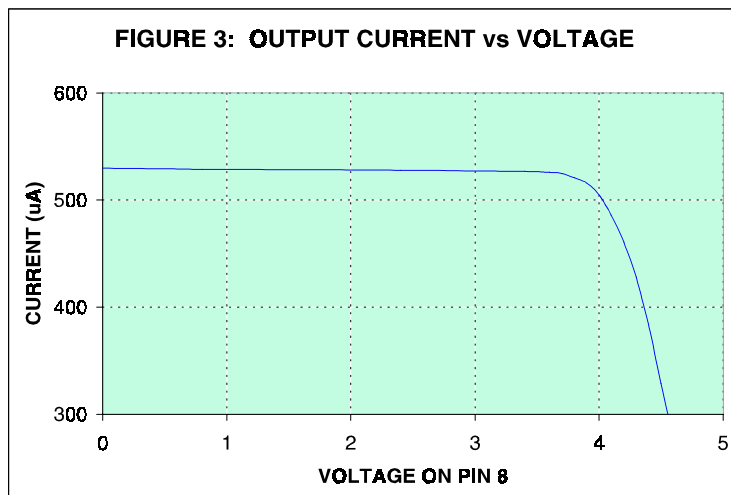


Figure 3 shows the voltage compliance of the temperature dependent current source at room temperature. The voltage at pin 8 must be kept in the 0 to +3V range in order to achieve proper temperature readings.

SOLDERING RECOMMENDATIONS:

Reflow using a hotplate is the preferred method for assembling the model 1221 surface mount accelerometer to your Printed circuit board. Sn62 or Sn63 type solder is recommended. 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 (1221J) 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. 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 scale factor. Instead, we recommend tinning one lead at a time, to prevent excessive heating of the accelerometer, using a fine-tipped solder iron and solder wire.

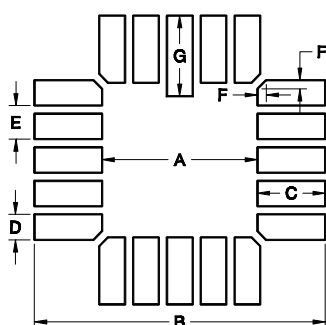
Hotplate Attach Method using Solder Paste or Solder Wire: Apply solder to the circuit board's pads using Sn62 or Sn63 solder paste or pre-tin the pads using solder and a fine tipped soldering iron. If pre-tinning with an iron, apply flux to the tinned pads prior to placing the components. Place the accelerometer in its proper position onto the pasted or tinned pads then place the entire assembly onto a hotplate that has been pre-heated to between 190 and 200°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 was 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.

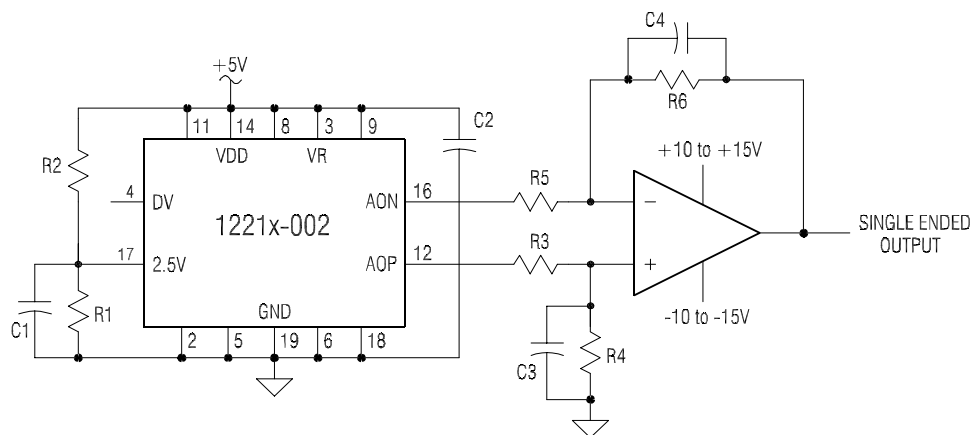
LCC & JLCC Solder Contact Plating Information: The plating composition and thickness for the solder pads and castellations on the "L" suffix (LCC) package are 100 to 225 micro-inches thick of gold (Au) over 80 to 350 micro-inches thick of nickel (Ni) over a minimum of 5 micro-inches thick of moly-manganese or tungsten refractory material. The leads for the "J" suffix (JLCC) package are made of CDA102 copper (Cu) 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	.038	0.97
E	.050	1.27
F	.013	0.33
G	.120	3.05

ADDING A SINGLE ENDED OUTPUT TO THE MODEL 1221 DIFFERENTIAL OUTPUT ACCELEROMETER



$R1 = R2 = 5.00K \pm 0.5\%$ for precision 2.50V ref.

$C1 = C2 = 0.01 \mu F$ ceramic

$R3, R4, R5 \text{ \& } R6 = 20k\Omega \text{ to } 50k\Omega$

$R3 = R5$ 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

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 1221 accelerometer, centered at +2.5 Volts, to a single ended output centered about ground (0.0 VDC). It provides the advantage of low common mode noise by preventing the ground current of the model 1221 from causing an error in the voltage reading.

The op-amp should be located as close as possible to your voltage monitoring equipment. The majority of the length of the signal path can therefore be differential along which noise will affect the wire run as a common mode signal and thus be rejected. The op-amp type is not critical; a $\mu A741$ or $\frac{1}{4}$ 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.

The gain of the op-amp is determined by the ratio $R4/R3$ (where $R4=R6$ and $R3=R5$). If $R3$ through $R6$ are all the same value, 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 $R4/R3 = R6/R5 = 5/4 = 1.25$. The single ended output of the op-amp will be centered at ground if $R4$ and $C3$ are tied to ground; using some other fixed voltage for this reference can shift the output. The value of the optional capacitors $C3$ and $C4$ ($C3=C4$) can be selected to roll off the frequency response to the frequency range of interest.