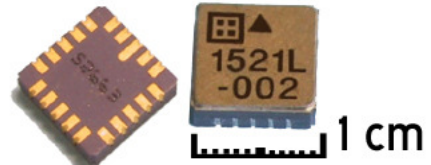




- Low Noise: $5 \mu\text{g}/\sqrt{\text{Hz}}$ typical for 2g Full Scale Version
- High Stability
- -55 to +175°C Operation
- Responds to DC and AC Acceleration
- $\pm 4\text{V}$ Differential Output or 0.5V to 4.5V Single Ended Output
- +5 VDC, 5 mA Power (Typical)
- Integrated Sensor & Amplifier
- Internal Temperature Sensor
- Nitrogen Damped & Hermetically Sealed
- Serialized for Traceability
- Pin Compatible with Models 1210 and 1221
- RoHS Compliant



Available G-Ranges

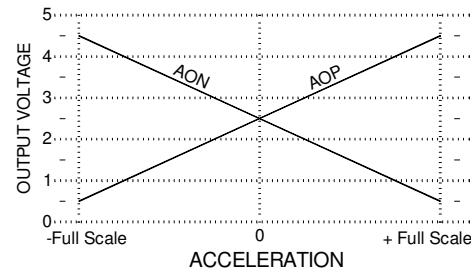
Full Scale Acceleration	20 Pin LCC
$\pm 2 \text{ g}$	1521L-002
$\pm 5 \text{ g}$	1521L-005
$\pm 10 \text{ g}$	1521L-010
$\pm 25 \text{ g}$	1521L-025
$\pm 50 \text{ g}$	1521L-050
$\pm 100 \text{ g}$	1521L-100
$\pm 200 \text{ g}$	1521L-200

DESCRIPTION

The Model 1521 is a low-cost, integrated accelerometer for use in zero to medium frequency instrumentation applications that require extremely low noise. **The 1521 was designed to support the harsh conditions of down hole drilling, and 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 gradients. Each device is marked with a serial number on its bottom surface for traceability. An optional calibration test sheet (1521-TST) is also available which lists the measured bias, scale factor, linearity, operating current and frequency response.

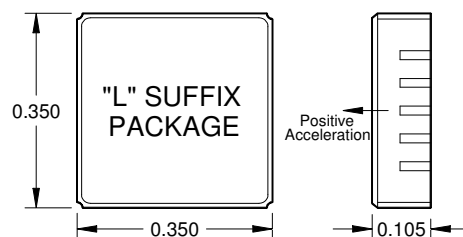
APPLICATIONS

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



OPERATION

The Model 1521 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. 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 nominally +2.5 volts. 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.



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**PERFORMANCE****By Model:** $V_{DD}=V_R=5.0$ VDC, $T_C=25^\circ\text{C}$.

Model Number	Input Range	Frequency Response (Nominal, 3 dB)	Sensitivity (Differential) ¹	Output Noise, Differential (RMS, typical)	Max. Mechanical Shock (0.1 ms)
UNITS	g	Hz	mV/g	$\mu\text{g}/(\text{root Hz})$	g (peak)
1521-002	± 2	0 - 400	2000	5	6000
1521-005	± 5	0 - 600	800	7	
1521-010	± 10	0 - 1000	400	10	
1521-025	± 25	0 - 1500	160	25	
1521-050	± 50	0 - 2000	80	50	
1521-100	± 100	0 - 2500	40	100	
1521-200	± 200	0 - 3000	20	200	

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

All Models: Unless otherwise specified $V_{DD}=V_R=5.0$ VDC, $T_C=25^\circ\text{C}$, Differential Mode.

PARAMETER	MIN	TYP	MAX	UNITS
Cross Axis Sensitivity		2	3	%
Bias Calibration Error ²		0.5	1	% of Span
Bias Temperature Shift ($T_C = -55$ to $+125^\circ\text{C}$) ²		50	100	(ppm of span)/ $^\circ\text{C}$
Scale Factor Calibration Error ^{2,3}		0.5	1	%
Scale Factor Temperature Shift ($T_C = -55$ to $+125^\circ\text{C}$) ²	-200	-100	0	ppm/ $^\circ\text{C}$
Non-Linearity (-90 to +90% of Full Scale) ^{2,3}		0.15	0.5	% 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		5	6	mA
Mass: 'L' package		0.62		grams

Note 2: Tighter tolerances may be available on special order.

MAXIMUM RATINGS *

Case Operating Temperature ⁵	-55 to +175 $^\circ\text{C}$
Storage Temperature	-55 to +125 $^\circ\text{C}$
Acceleration Over-range	1000g for 0.1 ms
Voltage on V_{DD} to GND	-0.5V to 6.5V
Voltage on Any Pin (except DV) to GND ³	-0.5V to $V_{DD}+0.5\text{V}$
Voltage on DV to GND ⁴	$\pm 15\text{V}$
Power Dissipation	50 mW

Note 3: 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 4: The application of DV voltages higher than required to bring the output to positive full scale may cause device damage.

Note 5: Limited exposure at 175 $^\circ\text{C}$ recommended for maximum lifespan.

*** NOTICE:** Stresses greater than those listed above may cause permanent damage to the device. These are maximum 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.

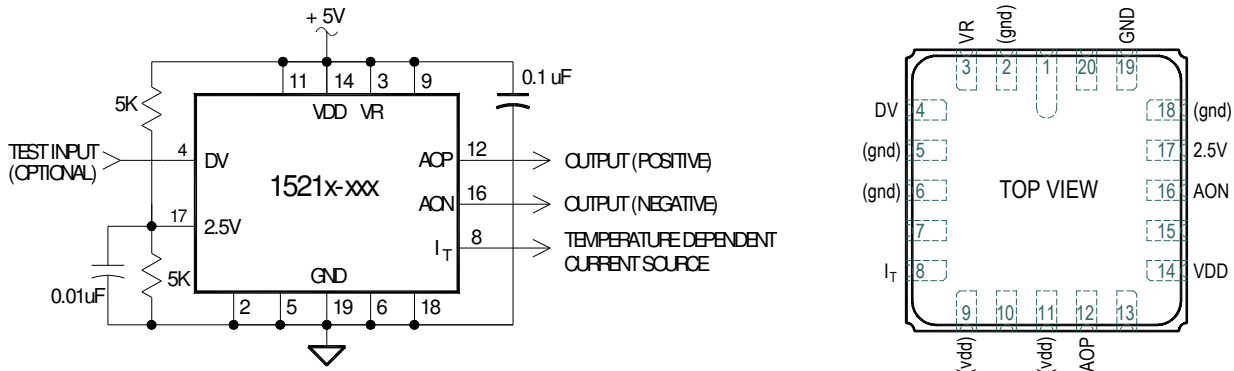
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SIGNAL DESCRIPTIONS

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

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.

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

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ESD and LATCH-UP CONSIDERATIONS: The model 1521 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 1521 into (or remove it from) a powered socket.

INTERNAL TEMPERATURE SENSING

The model 1521 accelerometer contains a temperature dependent current source that is output on pin 8. This signal is useful for measuring the internal temperature of the accelerometer so that any previously characterized bias and scale factor temperature dependence, for a particular accelerometer, can be corrected. The nominal output current at 25°C is ≈500 (±200) μA and the nominal sensitivity is 1.5 (±0.5) μA/°C. Fluctuations in V_{DD} & V_R have little effect 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.

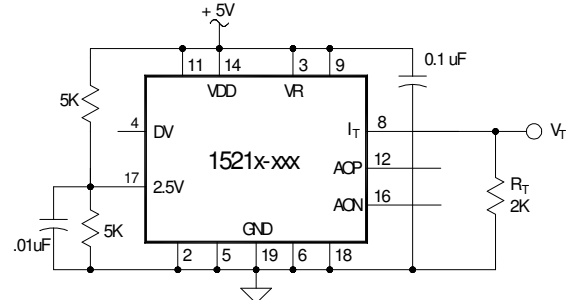


FIGURE 1

With a single resistor R_T = 2K between I_T (pin 8) and GND, as shown in Figure 1, the output voltage V_T will vary between +0.76 and +1.3 volts from -55 to +125°C, which equates to a sensitivity of ≈+3 mV/°C.

$$V_T \approx R_T [(500\mu A) + [(1.5\mu A)(T - 25)]]$$

$$\frac{\Delta V_T}{\Delta T} = R_T (1.5\mu A)$$

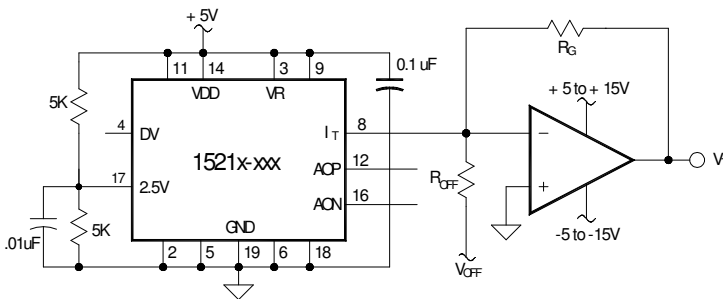


FIGURE 2

If a greater voltage change versus temperature or lower signal source impedance is needed, the circuit in Figure 2 can be used. With offset voltage V_{OFF} = -5V, gain resistor R_G = 15.0K and offset resistor R_{OFF} = 7.32K, the output voltage V_T will vary between +4.5 and +0.5 Volts from -55 to +125°C, which equates to a sensitivity of ≈ -29 mV/°C.

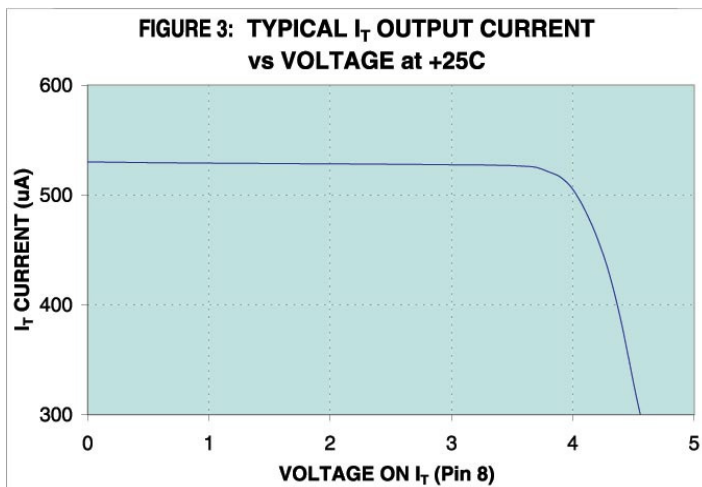
$$R_{OFF} = \frac{-V_{OFF}}{\left(\frac{V_T}{R_G}\right) + (500\mu A) + [(1.5\mu A)(T - 25)]}$$

$$V_T \approx -R_G \left[\frac{V_{OFF}}{R_{OFF}} + (500\mu A) + [(1.5\mu A)(T - 25)] \right]$$

$$R_G = \frac{-\Delta V_T}{(1.5\mu A)(\Delta T)}$$

$$\frac{\Delta V}{\Delta T} = -R_G (1.5\mu A)$$

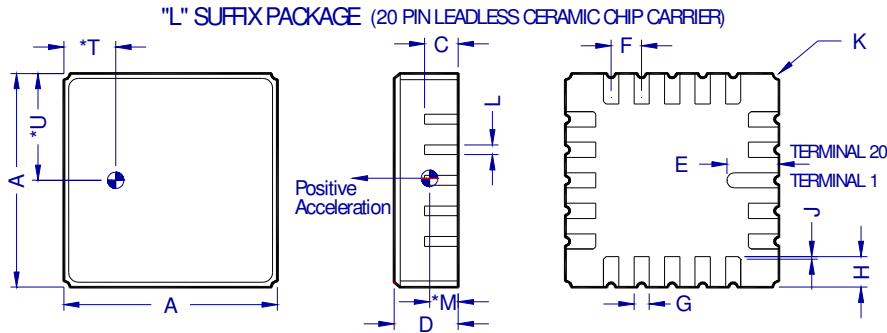
Figure 3 shows the voltage compliance of the temperature dependent current source (I_T) at room temperature. The voltage at pin 8 must be kept in the 0 to +3V range in order to achieve proper temperature readings.



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PACKAGE DIMENSIONS



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.342	0.358	8.69	9.09
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 RTYP		0.25 RTYP	
L	0.016 TYP		0.41 TYP	
* M	0.048 TYP		1.23 TYP	
* T	0.085 TYP		2.16 TYP	
* U	0.175 TYP		4.45 TYP	

- NOTES:
1. CONTROLLING DIMENSION: INCH.
 2. LID IS ELECTRICALLY TIED TO TERMINAL 19 (GND).
 3. * DIMENSIONS 'M', 'T' & 'U' LOCATE ACCELERATION SENSING ELEMENT'S CENTER OF MASS.
 4. TERMINALS ARE PLATED WITH 60 MICRO-INCHES MIN GOLD OVER 80 MICRO-INCHES MIN NICKEL.
 5. PACKAGE: 90% MINIMUM ALUMINA (BLACK), LID: SOLDER SEALED KOVAR.

SOLDERING RECOMMENDATIONS:

RoHS Compliance: The model 1521 does not contain elemental lead and is RoHS compliant.

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.

LCC 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.

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