ANALOG DEVICES

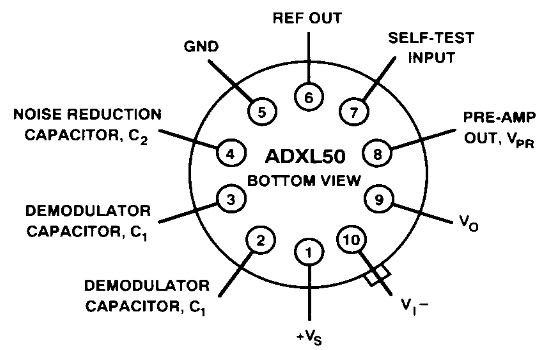
Monolithic Accelerometer with Signal Conditioning

ADXL50*

FEATURES
Full-Scale Measurement Range: ±50 g
Self-Test on Digital Command
Single Supply Operation: +5 V to +24 V
Output Range: 0.25 V to 4.75 V
Accuracy of Span: 8% over −55°C to +125°C
Uncommitted Output Amplifier for Custom Scaling and Zero-g Level Adjustment
Programmable Bandwidth: DC up to 1 kHz
Additional Filtering: 2-Pole with External Passive Components
High Shock Survival: >2000 g Unpowered

APPLICATIONS
Crash Detection for Airbag Deployment and Seatbelt Retraction
Vibration Analysis and Cancellation
Measurement, Characterization and Instrumentation, e.g., Crash Dummies

PIN CONFIGURATIONS
(TO-100 Metal Can)



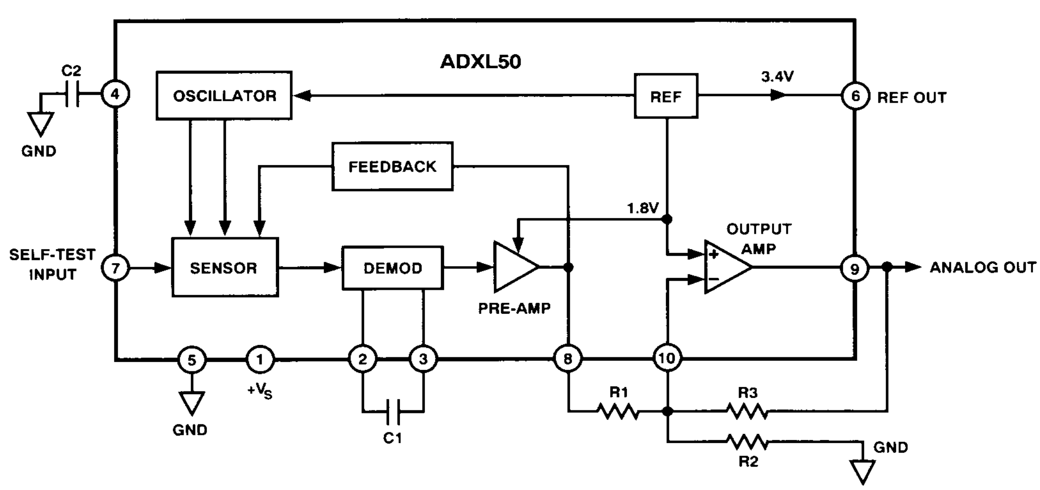
GENERAL DESCRIPTION
The ADXL50 is a monolithic accelerometer which combines a polysilicon micromachined sensor with signal conditioning and signal processing circuitry. It is capable of measuring both positive and negative acceleration in the ±50 g range, offering a bandwidth of dc up to 1 kHz.

The ADXL50 uses a capacitive measurement scheme. The analog output is directly proportional to acceleration, and is fully scaled, referenced and temperature compensated resulting in high accuracy and linearity over the automotive temperature range.

A digitally commandable self-test allows the sensor beam to be electrostatically deflected at any time, producing an output voltage which corresponds to the −50 g output of a healthy sensor beam.

*Patents pending.

FUNCTIONAL BLOCK DIAGRAM



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ADXL50—SPECIFICATIONS (T_A = +25°C and V_S = +5 V, unless otherwise noted.)

Parameter	Test Conditions	Min	Typ	Max	Units
INPUT					
Measurement Range[1]	T_{MIN} to T_{MAX}	−50		+50	g
Transverse Sensitivity	T_{MIN} to T_{MAX}			2	%
PREAMPLIFIER					
Zero-g Output	Applied Acceleration = 0 g	1.75	1.80	1.85	V
Sensitivity			20		mV/g
Full-Scale Output Span	Applied Acceleration = −50 g to +50 g	0.8		2.80	V
Output at Self-Test[2]	Pin 7 = "High"		0.80		V
Voltage Noise[6]	At Bandwidth = 0.3 kHz		±0.33		% FS
	At Bandwidth = 1.0 kHz		±0.6		% FS
UNCOMMITTED AMPLIFIER					
Input Offset Voltage	T_{MIN} to T_{MAX}			±10	mV
Input Bias Current	T_{MIN} to T_{MAX}			10	nA
Open-Loop Gain		100			dB
Output Swing	No Output Load	0.10		V_S−0.1	V
Output Swing	Output Current = 100 µA	0.25		4.75	V
Capacitive Load				1000	pF
ACCURACY					
Initial Accuracy			5		% FS
Overall Accuracy of Span	T_{MIN} to T_{MAX}		8		% FS
LINEARITY					
Overall Linearity	T_{MIN} to T_{MAX}		0.5		% FS
FREQUENCY RESPONSE					
Bandwidth[3]	C_1 = 25 nF (See Figure 1)		1		kHz
Resonant Frequency[4]			22		kHz
REFERENCE					
Output Voltage		3.395	3.400	3.405	V
Output Voltage Drift	T_{MIN} to T_{MAX}			50	ppm/°C
Power Supply Rejection (DC)		60			dB
Output Current				500	µA
POWER SUPPLY					
Operating Voltage[5]		+4.75	+5	+5.25	V
Quiescent Supply Current			10	13	mA
TEMPERATURE					
Operating Range	T_{MIN} to T_{MAX}	−55		+125	°C
PACKAGE	Metal Can		ADXL50H		
	Side Brazed Ceramic		ADXL50D		

NOTES

[1]Positive acceleration, causing the output of the preamplifier to rise, is defined as follows: Header Package: acceleration in the plane of Pins 5 and 10, towards Pin 10. Pin 10 is identified by the metal tab (see "PIN CONFIGURATIONS" diagram). Ceramic Package: acceleration in the plane of the package, towards the end of the package containing the notch.

[2]Applying +5 V to the self-test input has an effect on the acceleration sensing element equivalent to applying an acceleration of −50 g to the ADXL50.

[3]The bandwidth is user-programmable, and set by an external capacitor (C_1 in Figure 1). C_1 = 25 nF sets the −3 dB point at 1 kHz, the maximum recommended measurement frequency. The bandwidth is inversely proportional to C_1.

[4]With the bandwidth set at the recommended maximum (i.e., 1 kHz), the beam resonant frequency produces a peak at 3× below the passband signal level.

[5]The ADXL50 is guaranteed to meet the above specifications operating from a supply of +5 V ± 5%. It will continue to operate, and will suffer no permanent damage, from a supply as high as +24 V (see "Absolute Maximum Ratings").

[6]A noise reduction capacitor, C_N = 16 nF, must be connected from Pin 4 to ground.

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ABSOLUTE MAXIMUM RATINGS*

Acceleration (Any Axis) . . . . 2000 g
$+V_S$ . . . . +24 V
Output Short Circuit Duration . . . . Indefinite
Operating Temperature . . . . −55°C to +125°C
Storage Temperature . . . . −65°C to +150°C

*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.

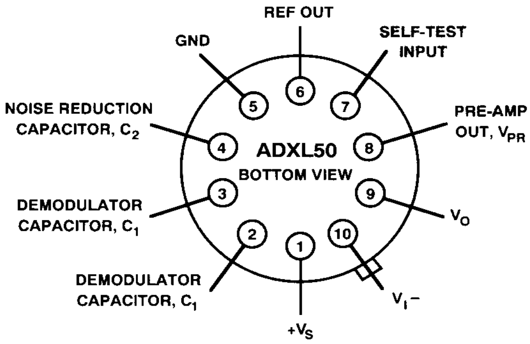
PIN DESIGNATIONS

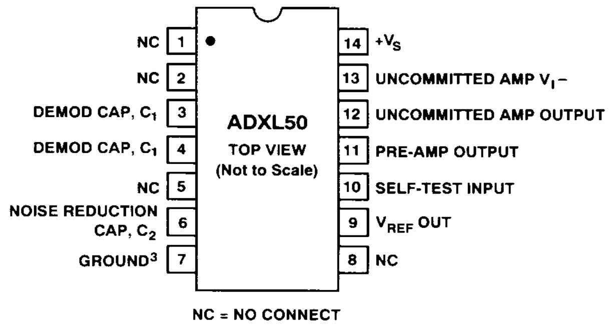
10-Pin Metal Can

Pin	Function
1	$+V_S$
2	Demod Cap, C_1
3	Demod Cap, C_1
4	Noise Reduction Cap, C_2
5	Ground[1]
6	V_{REF} Out
7	Self-Test Input
8	Pre-Amp Output
9	Uncommitted Amp Output
10	Uncommitted Amp V_I-

14-Pin Ceramic

Pin	Function
1	NC[2]
2	NC
3	Demod Cap, C_1
4	Demod Cap, C_1
5	NC
6	Noise Reduction Cap, C_2
7	Ground[3]
8	NC
9	V_{REF} Out
10	Self-Test Input
11	Pre-Amp Output
12	Uncommitted Amp Output
13	Uncommitted Amp Vi−
14	$+V_S$





NOTES
[1]The case of the metal can package is connected to Pin 5, Ground.
[2]"NC" designates that the pin is unconnected internally.
[3]The lid of the side brazed ceramic package is connected to Pin 7, Ground.

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ADXL50 PRODUCT DESCRIPTION

The ADXL50's novel architecture merges surface micromachined polysilicon with BiMOS circuitry and laser wafer-trimmed thin-film resistors. The sensor is a differential capacitor so it is inherently stable over temperature. Analog's expertise in signal conditioning, along with the large portfolio of proven BiMOS circuits, allow the ADXL50 to be fully scaled, referenced and temperature compensated. No external active components are required to interface directly to an ADC.

For additional flexibility, the ADXL50 has an uncommitted output amplifier for user programming of the output zero-g level, scaling, and filtering. The output span of the ADXL50's preamp is 1.8 V ±1.0 V at ±50 g. The uncommitted output amplifier allows the user to adjust the zero-g level and output span (up to 0.25 V to 4.75 V) by adding external resistors. External capacitors may be added to the resistor network for 1 or 2 poles of filtering.

The ADXL50 can be powered from a standard +5 V supply and is robust enough to survive harsh automotive conditions and shocks of more than 2000 g unpowered. The structure of the ADXL50 is intrinsically more stable over temperature than piezoelectric or piezoresistive techniques.

SELF TEST FEATURE

The ADXL50 employs on-chip test circuits for a self-test at any time. The tight mechanical spacings on the sensor allow electrostatic manipulation of the beam structure with a +5 V supply. With a digital input to begin the ADXL50's self-test, the beam is deflected in a controlled manner resulting in an output which is within 5% of the specified negative full-scale output.

APPLICATIONS

AMPLIFYING AND OFFSET SHIFTING THE PREAMP SIGNAL

The unconditioned output of the ADXL50's preamplifier is 1.8 V at 0 g acceleration with a span of ±1.0 V for ±50 g input, i.e., 20 mV/g. An uncommitted output amplifier has been included on the chip to enhance the user's ability to offset the 0 g level and to amplify and filter the signal. In Figure 1, it can be seen that access is provided to the inverting input and the output of this amplifier via Pins 10 and 9, respectively, while the noninverting input is connected internally to +1.8 V, which is derived from the on-chip 3.4 V reference.

The scaling factor in the configuration shown is given by $-R_3/R_1$ (since the amplifier is in inverter mode) and the offset is provided by R_2. Therefore, if the span desired is ±2.25 V for the ±50 g input, then R_3/R_1 should be chosen such that

$$\frac{R_3}{R_1} = \frac{V_O\ span}{V_{PR}\ span} = \frac{2.25}{1.0} \quad (1)$$

where V_{PR} span is the output from the preamplifier and V_O span is the uncommitted amplifier's output, giving

$$R_3 = 2.25 \times R_1 \quad (2)$$

R_2 can then be found from the following equation, derived from standard amplifier theory:

$$R_2 = \frac{1.8 \times R_3}{V_{oO} - 1.8} \quad (3)$$

where V_{oO} is the desired 0 g output level.

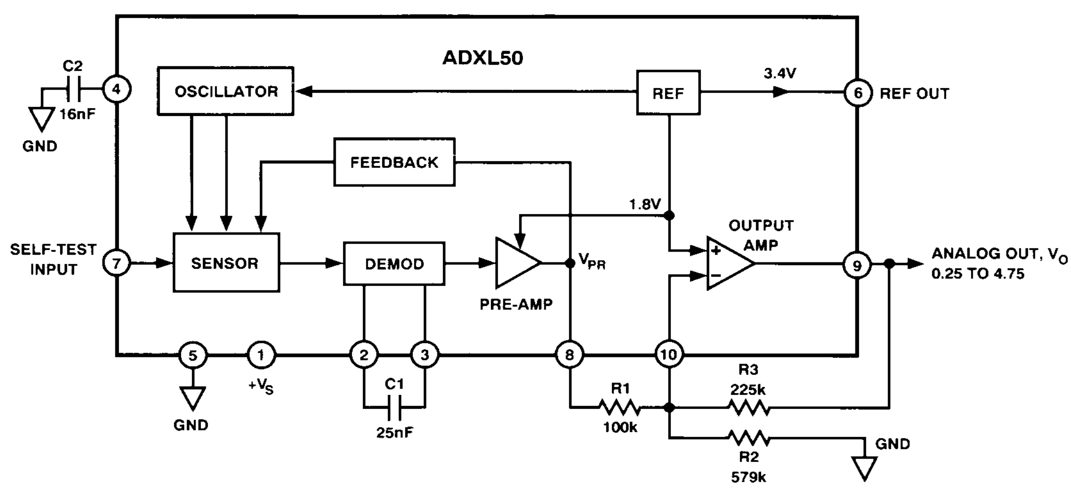

Figure 1. Connections to Be Made to the ADXL50 to Provide an Analog Signal of 0.25 V to 4.75 V, with a Bandwidth of 1 kHz

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To provide an output span of ±2.25 V, with a 0 g output of +2.5 V, then R_1 could be set at 100 kΩ. From Equation 2, R_3 = 225 kΩ, and using Equation 3, R_2 = 579 kΩ.

A general transfer function for the circuit, given by the resistor configuration shown, is:

$$V_O = (1.8 - V_{PR})\frac{R_3}{R_1} + 1.8\left(1 + \frac{R_3}{R_2}\right)$$

which for the resistor values given reduces to:

$$V_O = (1.8 - V_{PR})\,2.25 + 2.50$$

FILTERING THE PREAMP SIGNAL

The uncommitted output amplifier can also be used to filter the signal, if more filtering is required than the 1 pole inherently provided at 1 kHz by the 25 nF demodulation capacitor. The circuit shown in Figure 2, which gives a gain of 3.94, provides an extra 3 poles of filtering at 200 Hz, without using any external active components.

ADXL FAMILY

Analog Devices' ADXL family of accelerometers provides a fully conditioned analog output voltage proportional to acceleration. The family is expected to include accelerometers with measurement ranges from ±2 g up to ±500 g. There are products planned with dual axis and redundant sensing.

The product features of the ADXL series make them ideal for automotive applications such as crash detection/airbag deployment, antilock brake systems, active suspension, and vibration analysis and suppression.

REDUNDANCY

Multiple sensors on the same IC are possible with the ADXL50's architecture due to the small size of the sensor itself and the high density of the BiMOS circuitry. Monolithic dual axis accelerometers can be made by placing the sensors orthogonally on the die. Some sharing of the support circuitry will provide even greater economic value.

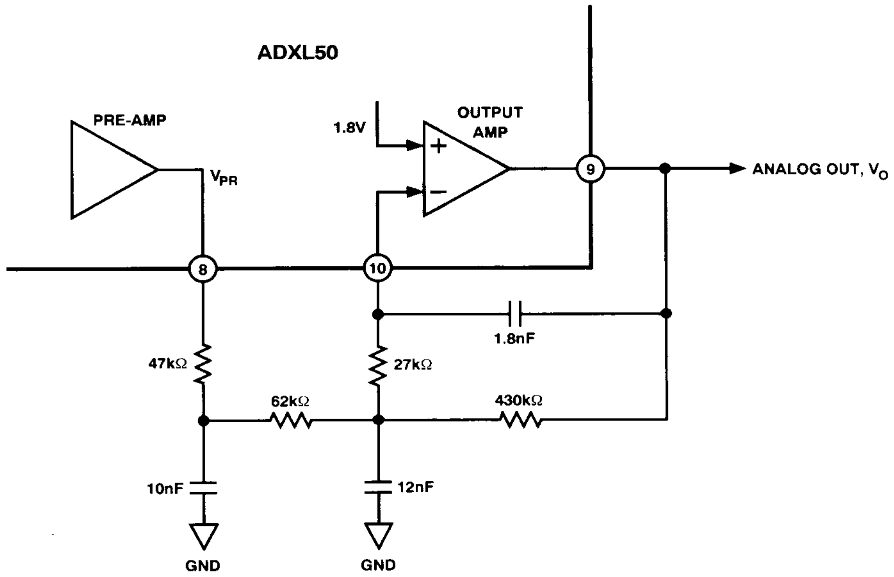

Figure 2. Using the Uncommitted Output Amplifier to Provide an Extra 2 Poles of Filtering, with a Gain of 3.94

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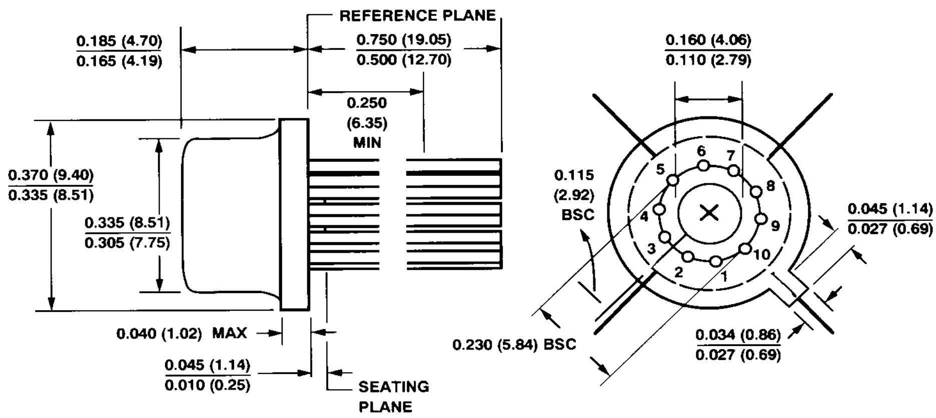
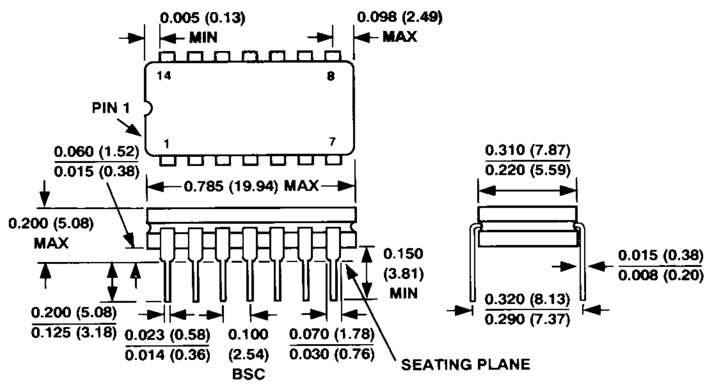
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

TO-100
Metal Can



D-14
Ceramic DIP



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