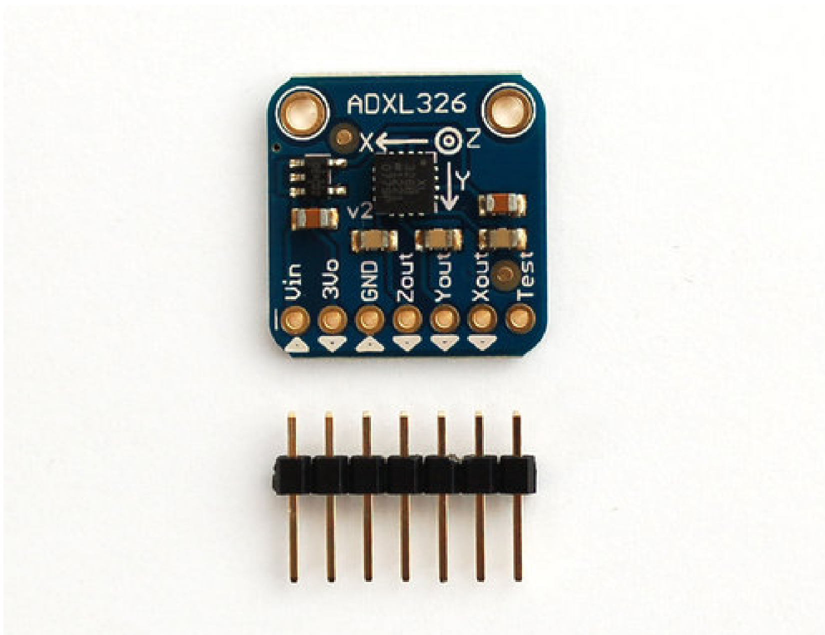
adafruit learning system

Adafruit Analog Accelerometer Breakouts

Created by Bill Earl

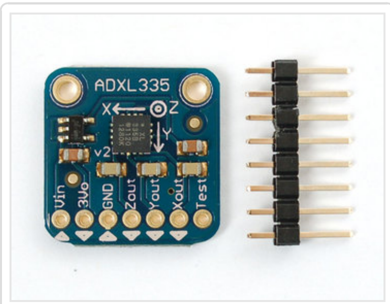


Last updated on 2013-10-02 06:15:18 AM EDT

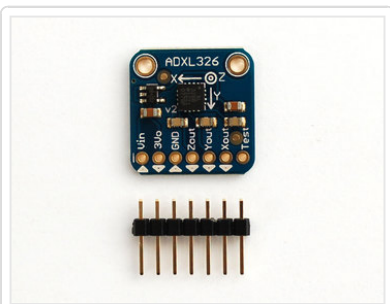
Guide Contents

Overview

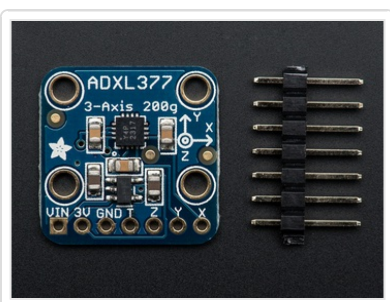
The ADXL335 , ADXL326 and ADXL377 are low-power, 3-axis MEMS accelerometer modules with ratiometric analog voltage outputs. The Adafruit Breakout boards for these modules feature on-board 3.3v voltage regulation which makes them simple to interface with 5v microcontrollers such as the Arduino.



The ADXL335 can measure at least +/-3G in the X, Y and Z axis. It is perfect for high-resolution static acceleration measurements such as tilt-sensing, as well as for moderate dynamic accelerations from motion, shock or vibration.



The ADXL326 can measure at least +/-16G(!) in the X, Y and Z axis. It is ideal for measuring more dynamic accelerations from high-performance land and air vehicles as well as for shock and impact measurements.



The ADXL377 can measure at least +/-200G(!) in the X, Y and Z axis. This is the sensor for measuring extreme dynamic accelerations encountered in applications such as rocketry experiments and high-impact shock measurements.

How it Works:

MEMS - Micro Electro-Mechanical Systems

The sensor consists of a micro-machined structure on a silicon wafer. The structure is suspended by polysilicon springs which allow it to deflect in the when subject to acceleration in the X, Y and/or Z axis. Deflection causes a change in capacitance between fixed plates and plates attached to the suspended structure. This change in capacitance on each axis is converted to an output voltage proportional to the acceleration on that axis.

Ratiometric Output

Ratiometric output means that the output voltage increases linearly with acceleration over the range.

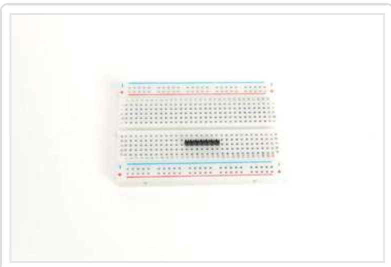
- For the ADXL335, that is approximately 0v at -3G to 3.3v at +3G.
- For the ADXL326, that is approximately 0v at -16G to 3.3v at +16G.
- For the ADXL377, that is approximately 0v at -200G to 3.3v at +200G.
- For all modules, the output at 0G in each axis, is about 1/2 full-scale, or 1.65v.

> Note that the specified device ranges are guaranteed minimum ranges. Most actual devices will have a somewhat wider usable range. Also, due to manufacturing variations the zero point may be slightly offset from exactly 1/2 scale. We will discuss how to calibrate the range and offset in the Calibration and Programming section of this guide.

Assembly and Wiring

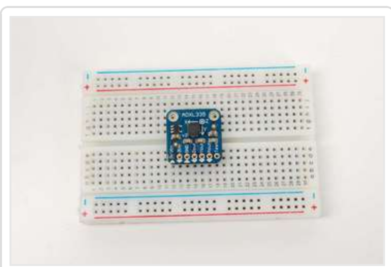
Assembly:

These boards come with all surface-mount components pre-soldered. The included header strip can be soldered on for convenient use on a breadboard or with 0.1" connectors. However, for applications subject to extreme accelerations, shock or vibration, locking connectors or direct soldering plus strain relief is advised.



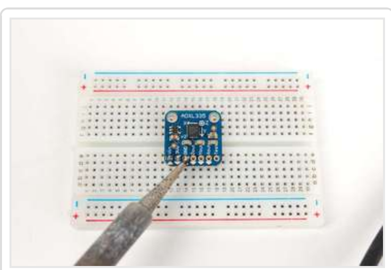
Prepare the header strip:

Cut the strip[to length if necessary. It will be easier to solder if you insert it into a breadboard - long pins down.



Add the breakout board:

Place the breakout board over the pins.



And Solder!

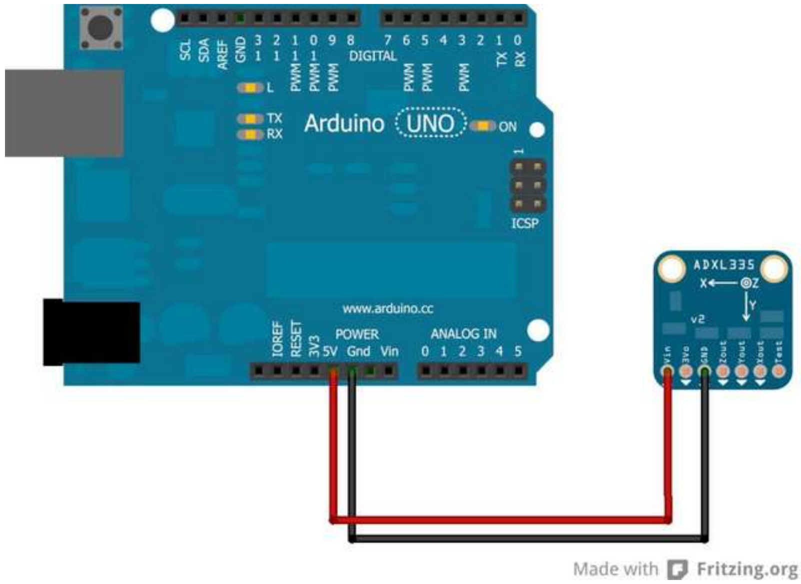
Be sure to solder all pins for reliable electrical contact.

Wiring:

Connect the Power:

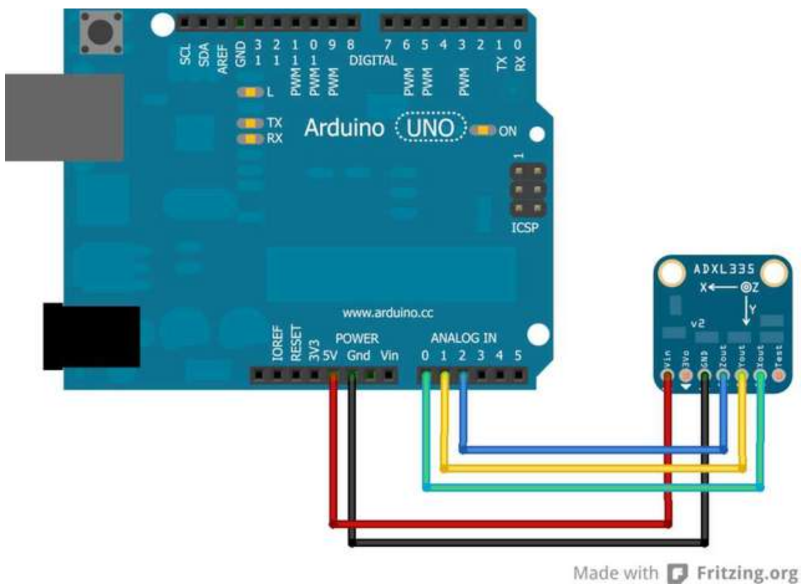
- Connect the GND pin to GND on the Arduino.

- Connect the VIN pin to the 5v pin on the Arduino.
- (For 3.3v microprocessors, connect the pin marked 3Vo to the 3.3v supply)



Connect the X, Y and Z Signal Outputs:

Connect X, Y and Z to the analog pins as shown below:

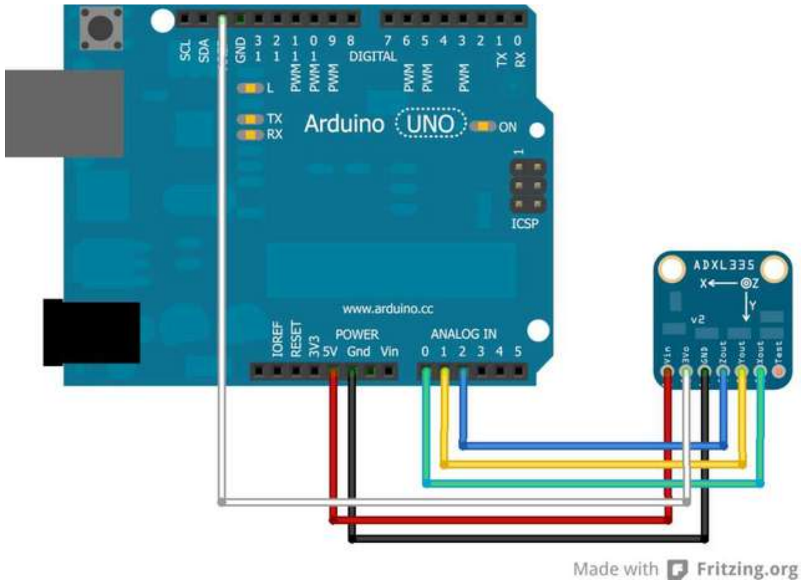


Using the Voltage Reference:

For the best possible accuracy and precision, you can use the output of the accelerometer boards voltage regulator as the analog reference for the Arduino. Connect the 3Vo pin on the accelerometer board to the AREF pin on the Arduino.

> If you connect an external voltage reference to the AREF pin, you must set the analog reference to EXTERNAL before calling analogRead() (e.g. in your setup()

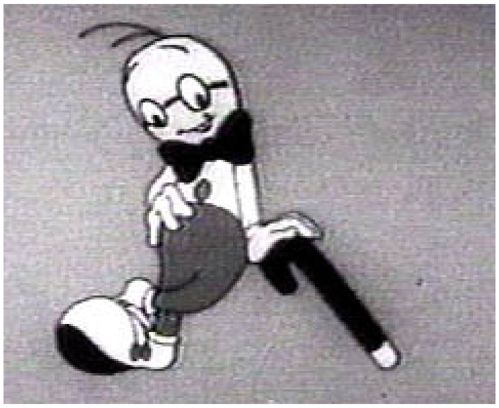
function). Otherwise, you will short the internal reference with the external reference, possibly damaging your Arduino board.



Calibration and Programming

Static Calibration:

As with all sensors, there is some variation in output between samples of these accelerometers. For non-critical applications such as game controllers, or simple motion or tilt sensors, these variations are not important. But for applications requiring precise measurements, calibration to a reliable reference is a good idea.



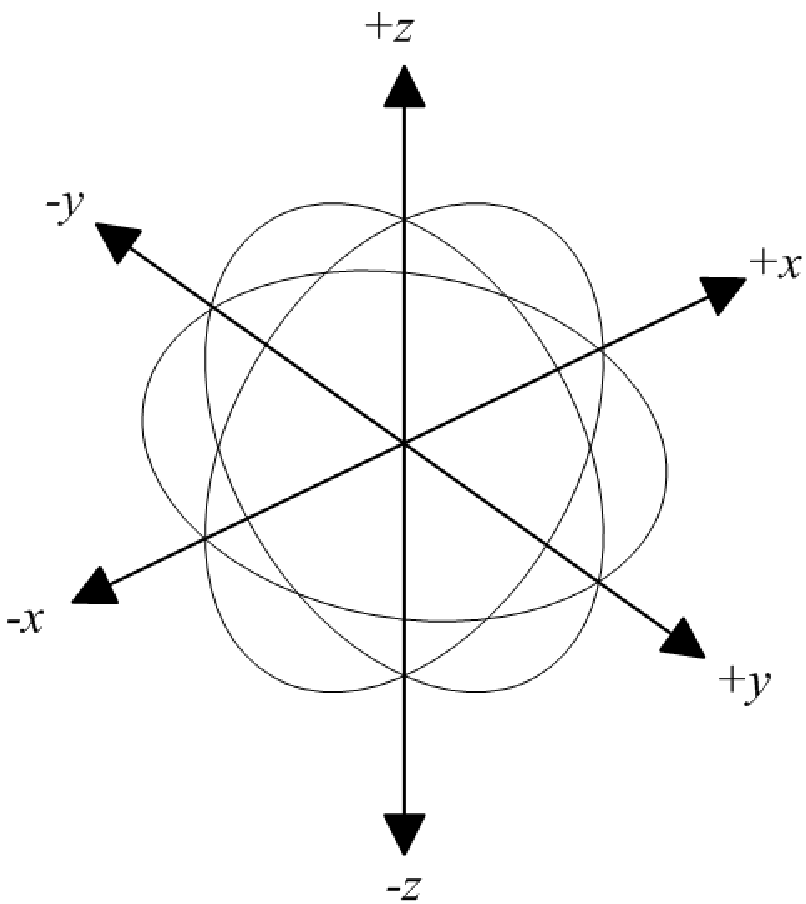
Gravity as a Calibration Reference

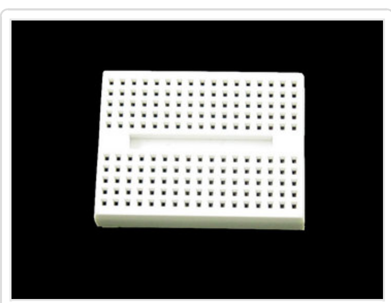
Acceleration is measured in units of gravitational force or "G", where 1G represents the gravitational pull at the surface of the earth. Despite what you may have heard (http://adafru.it/aRE), gravity is a pretty stable force and makes a convenient and reliable calibration reference if you happen to be a surface-dwelling earthling.

> For High-G accelerometers such as the ADXL377, the +/- 1G range of static calibration is too small to assure good accuracy over the +/- 200G range of the sensor. Accurate calibration for extreme G-forces requires more specialized equipment to repeatably create these extreme forces in a controlled environment. One commonly used technique is to drop the accelerometer from a known height and measure the negative acceleration at impact.

Calibration Method:

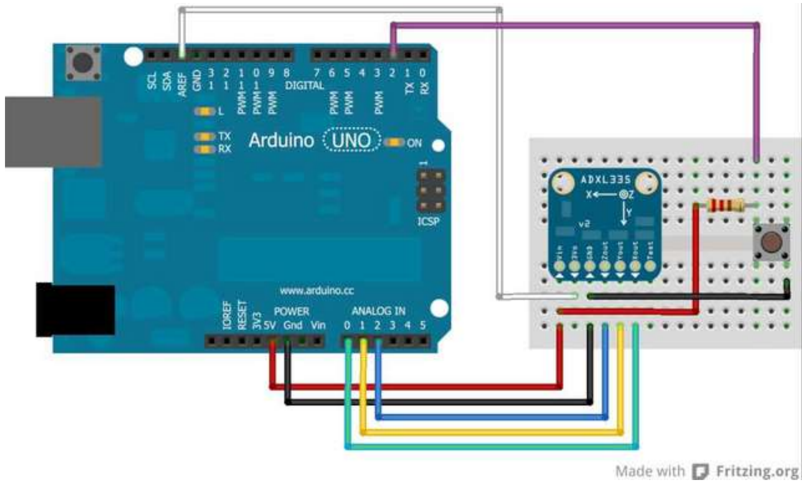
To calibrate the sensor to the gravitational reference, you need to determine the sensor output for each axis when it is precisely aligned with the axis of gravitational pull. Laboratory quality calibration uses precision positioning jigs. The method described here is simple and gives surprisingly good results.





Mount the Sensor:
First mount the sensor to a small breadboard (http://adafru.it/65) like the one on the left. The back and squared edges of the breadboard make a reasonably accurate set of reference planes to orient the sensor for calibration.

Wire the Sensor:
Wire the sensor as shown below. This is equivalent to the circuit shown on the previous page, with the addition of a switch.



Run the Calibration Sketch

- Load the sketch below onto the Arduino and run it.
- Open the Serial Monitor.
- Lay the breadboard with the sensor on a flat surface
    - Press and hold the button until you see "Calibrate" in the serial monitor.
    - This will calibrate the minimum value for the z axis.
- Stand the breadboard on the front edge and press the button again. to calibrate +y
- Repeat this for the three other edges to calibrate +x, -y and -x.
- Turn the breadboard upside down and press the button again to calibrate +z. (Hint, the underside of a table works well to steady it.)

Calibration Sketch Output:

Once calibrated, the output will show the calibrated raw range for each axis, followed by the measured "G" forces. The raw ranges can be used as constants in sketches.

Raw Ranges: X: 408-616, Y: 398-610, Z: 422-625
511, 511, 625 :: -0.01G, 0.07G, 1.00G
Raw Ranges: X: 408-616, Y: 398-610, Z: 422-625
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511, 511, 625 :: -0.01G, 0.07G, 1.00G
Raw Ranges: X: 408-616, Y: 398-610, Z: 422-625

Calibration Sketch

```
const int xInput = A0;
const int yInput = A1;
const int zInput = A2;
const int buttonPin = 2;

// Raw Ranges:
// initialize to mid-range and allow calibration to
// find the minimum and maximum for each axis
int xRawMin = 512;
int xRawMax = 512;

int yRawMin = 512;
int yRawMax = 512;

int zRawMin = 512;
int zRawMax = 512;

// Take multiple samples to reduce noise
const int sampleSize = 10;

void setup()
{
  analogReference(EXTERNAL);
  Serial.begin(9600);
}

void loop()
{
  int xRaw = ReadAxis(xInput);
  int yRaw = ReadAxis(yInput);
  int zRaw = ReadAxis(zInput);

  if (digitalRead(buttonPin) == LOW)
  {
    AutoCalibrate(xRaw, yRaw, zRaw);
  }
  else
  {
    Serial.print("Raw Ranges: X: ");
    Serial.print(xRawMin);
    Serial.print("-");
    Serial.print(xRawMax);

    Serial.print(", Y: ");
    Serial.print(yRawMin);
    Serial.print("-");
    Serial.print(yRawMax);

    Serial.print(", Z: ");
    Serial.print(zRawMin);
    Serial.print("-");
    Serial.print(zRawMax);
    Serial.println();
    Serial.print(xRaw);
    Serial.print(", ");
    Serial.print(yRaw);
    Serial.print(", ");
    Serial.print(zRaw);
```

```
    // Convert raw values to 'milli-Gs"
    long xScaled = map(xRaw, xRawMin, xRawMax, -1000, 1000);
    long yScaled = map(yRaw, yRawMin, yRawMax, -1000, 1000);
    long zScaled = map(zRaw, zRawMin, zRawMax, -1000, 1000);

    // re-scale to fractional Gs
    float xAccel = xScaled / 1000.0;
    float yAccel = yScaled / 1000.0;
    float zAccel = zScaled / 1000.0;

    Serial.print(" :: ");
    Serial.print(xAccel);
    Serial.print("G, ");
    Serial.print(yAccel);
    Serial.print("G, ");
    Serial.print(zAccel);
    Serial.println("G");

  delay(500);
  }
}

//
// Read "sampleSize" samples and report the average
//
int ReadAxis(int axisPin)
{
  long reading = 0;
  analogRead(axisPin);
  delay(1);
  for (int i = 0; i < sampleSize; i++)
  {
    reading += analogRead(axisPin);
  }
  return reading/sampleSize;
}

//
// Find the extreme raw readings from each axis
//
void AutoCalibrate(int xRaw, int yRaw, int zRaw)
{
  Serial.println("Calibrate");
  if (xRaw < xRawMin)
  {
    xRawMin = xRaw;
  }
  if (xRaw > xRawMax)
  {
    xRawMax = xRaw;
  }

  if (yRaw < yRawMin)
  {
    yRawMin = yRaw;
  }
  if (yRaw > yRawMax)
```

```
  {
   yRawMax = yRaw;
  }

  if (zRaw < zRawMin)
  {
   zRawMin = zRaw;
  }
  if (zRaw > zRawMax)
  {
   zRawMax = zRaw;
  }
}
```

Downloads

Data Sheets:

ADXL335 Documentation Page (http://adafru.it/aRF)
ADXL326 Documentation Page (http://adafru.it/aRG)
ADXL377 Data Sheet: (http://adafru.it/cLj)

Board Files:

ADXL335 and ADXL326 Breakout Board Eagle Files (http://adafru.it/aRH)

Small, Low Power, 3-Axis ±200 *g* Accelerometer

Data Sheet **ADXL377**

FEATURES

3-axis sensing
Small, low profile package
3 mm × 3 mm × 1.45 mm LFCSP
Low power: 300 µA (typical)
Single-supply operation: 1.8 V to 3.6 V
10,000 *g* shock survival
Excellent temperature stability
Bandwidth adjustment with a single capacitor per axis
RoHS/WEEE and lead-free compliant

APPLICATIONS

Concussion and head trauma detection
High force event detection

GENERAL DESCRIPTION

The ADXL377 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The ADXL377 measures acceleration resulting from motion, shock, or vibration with a typical full-scale range of ±200 *g*.

The user selects the bandwidth of the accelerometer using the C_X, C_Y, and C_Z capacitors at the X_{OUT}, Y_{OUT}, and Z_{OUT} pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1300 Hz for the x-axis and y-axis and a range of 0.5 Hz to 1000 Hz for the z-axis.

The ADXL377 is available in a small, low profile, 3 mm × 3 mm × 1.45 mm, 16-lead lead frame chip scale package (LFCSP_LQ).

FUNCTIONAL BLOCK DIAGRAM

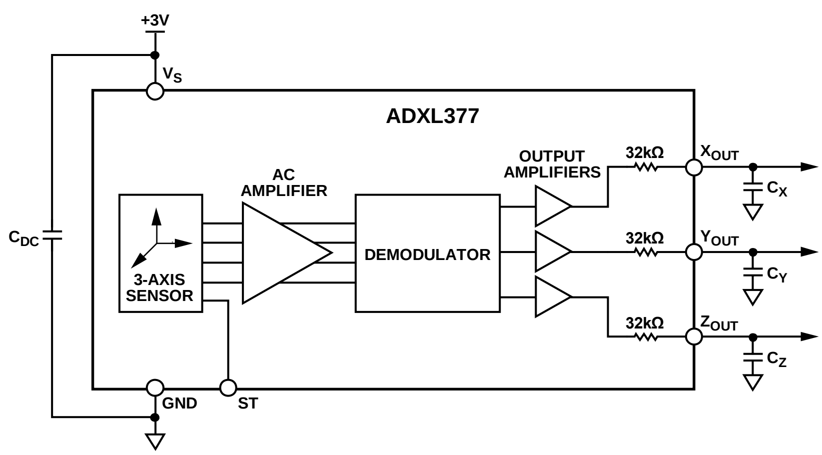

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Figure 1.

Rev. 0 **Document Feedback**

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Tel: 781.329.4700
Technical Support **www.analog.com**

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REVISION HISTORY

9/12—Revision 0: Initial Version

SPECIFICATIONS

T_A = 25°C, V_S = 3 V, $C_X = C_Y = C_Z$ = 0.1 μF, acceleration = 0 *g*, unless otherwise noted. All minimum and maximum specifications are guaranteed. Typical specifications are not guaranteed.

Table 1.

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
SENSOR INPUT	Each axis				
Measurement Range			±200		*g*
Nonlinearity	% of full scale up to 180 *g*		±0.5		%
Cross-Axis Sensitivity[1]			±1.4		%
SENSITIVITY, RATIOMETRIC[2]	Each axis				
Sensitivity at X_{OUT}, Y_{OUT}, and Z_{OUT}	V_S = 3 V	5.8	6.5	7.2	mV/*g*
Sensitivity Change Due to Temperature[3]	V_S = 3 V		±0.02		%/°C
ZERO *g* BIAS LEVEL, RATIOMETRIC					
Zero *g* Voltage	V_S = 3 V, T_A = 25°C	1.4	1.5	1.6	V
Zero *g* Offset vs. Temperature					
X-Axis and Y-Axis			±12		m*g*/°C
Z-Axis			±30		m*g*/°C
NOISE PERFORMANCE					
Noise Density					
X_{OUT} and Y_{OUT}			2.7		m*g*/√Hz
Z_{OUT}			4.3		m*g*/√Hz
FREQUENCY RESPONSE[4]					
Bandwidth[5]	No external filter				
X_{OUT} and Y_{OUT}			1300		Hz
Z_{OUT}			1000		Hz
R_{FILT} Tolerance			32 ± 15%		kΩ
Sensor Resonant Frequency			16.5		kHz
SELF-TEST[6]					
Logic Input Low			0.6		V
Logic Input High			2.4		V
ST Actuation Current			60		μA
Output Change	Self-test, 0 to 1				
At X_{OUT}			−6.5		mV
At Y_{OUT}			6.5		mV
At Z_{OUT}			11.5		mV
OUTPUT AMPLIFIER	No load				
Output Swing Low			0.1		V
Output Swing High			2.8		V
POWER SUPPLY					
Operating Voltage Range[7]		1.8	3.0	3.6	V
Supply Current	V_S = 3 V		300		μA
Turn-On Time[8]	No external filter		1		ms
OPERATING TEMPERATURE RANGE		−40		+85	°C

[1] Defined as coupling between any two axes.
[2] Sensitivity is essentially ratiometric to V_S.
[3] Defined as the output change from ambient temperature to maximum temperature or from ambient temperature to minimum temperature.
[4] Actual frequency response controlled by user-supplied external filter capacitors (C_X, C_Y, and C_Z).
[5] Bandwidth with external capacitors = $1/(2\pi \times 32\ k\Omega \times C_X)$.
[6] Self-test response changes cubically with V_S.
[7] Tested at 3.0 V and guaranteed by design only (not tested) to work over the full voltage range from 1.8 V to 3.6 V.
[8] Turn-on time is dependent on C_X, C_Y, and C_Z and is approximately 160 × (C_X or C_Y or C_Z) + 1, where C_X, C_Y, and C_Z are in μF and the resulting turn-on time is in ms.

ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
Acceleration (Any Axis)	
Unpowered	10,000 *g*
Powered	10,000 *g*
V_S	−0.3 V to +3.6 V
All Other Pins	(GND − 0.3 V) to (V_S + 0.3 V)
Output Short-Circuit Duration (Any Pin to Ground)	Indefinite
Operating Temperature Range	−55°C to +125°C
Storage Temperature Range	−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; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

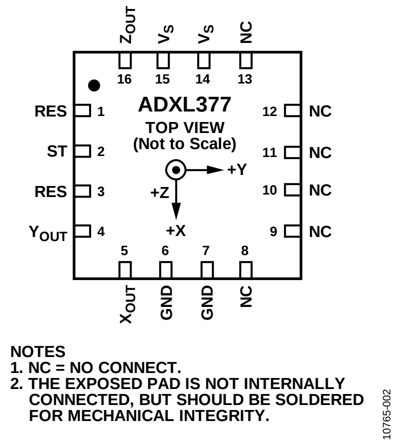

Figure 2. Pin Configuration

Table 3. Pin Function Descriptions

Pin No.	Mnemonic	Description
1, 3	RES	Reserved. This pin must be connected to GND or left open.
2	ST	Self-Test.
4	Y_{OUT}	Y Channel Output.
5	X_{OUT}	X Channel Output.
6, 7	GND	Must be connected to ground.
8 to 13	NC	No Connect. Not internally connected.
14, 15	V_S	Supply Voltage. 3.0 V typical.
16	Z_{OUT}	Z Channel Output.
	EPAD	Exposed Pad. The exposed pad is not internally connected, but should be soldered for mechanical integrity.

TYPICAL PERFORMANCE CHARACTERISTICS

N > 250 for all typical performance figures, unless otherwise noted. N is the number of parts tested and used to produce the histograms.

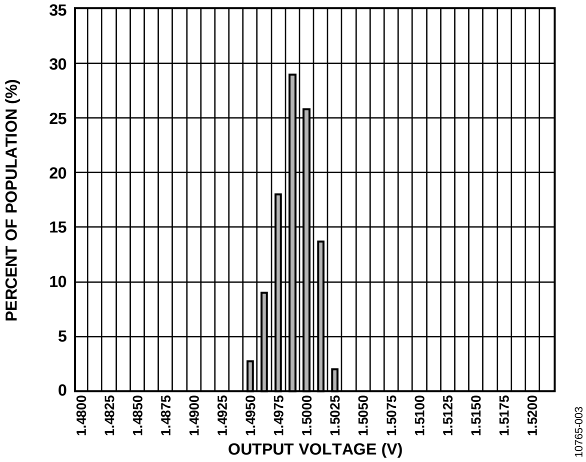

Figure 3. X-Axis Zero g *Output Voltage at 25°C, V_S = 3 V*

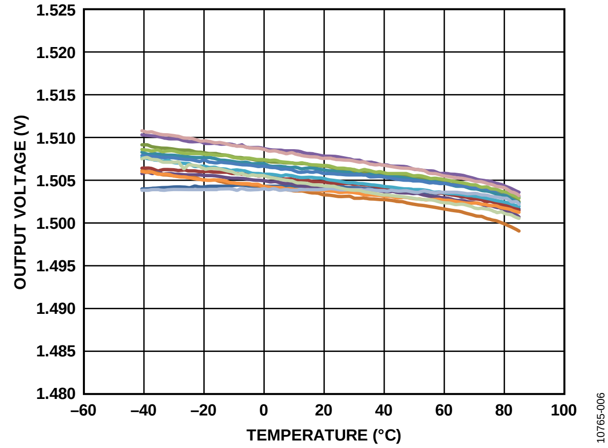

Figure 6. X-Axis Zero g *Offset vs. Temperature, V_S = 3 V (14 Parts Soldered to PCB)*

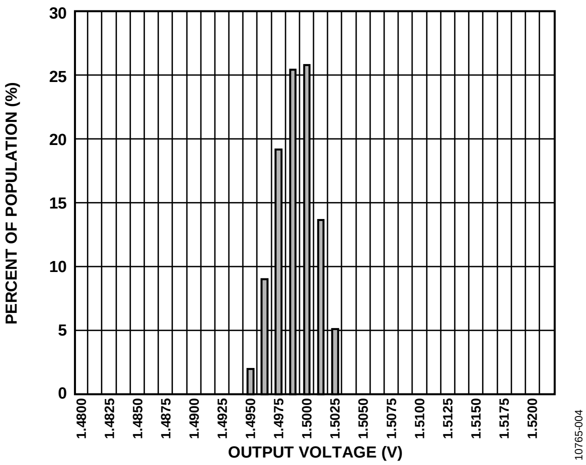

Figure 4. Y-Axis Zero g *Output Voltage at 25°C, V_S = 3 V*

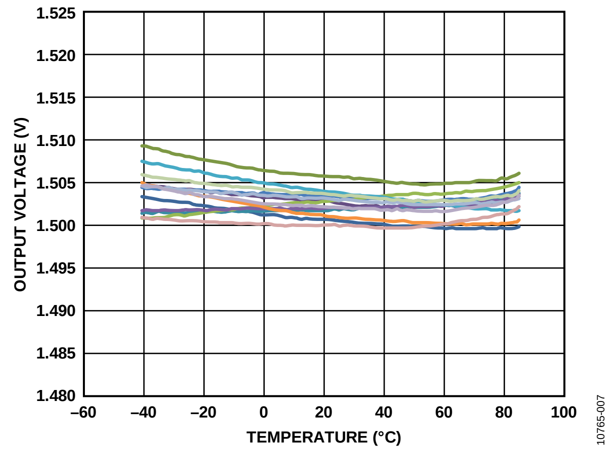

Figure 7. Y-Axis Zero g *Offset vs. Temperature, V_S = 3 V (14 Parts Soldered to PCB)*

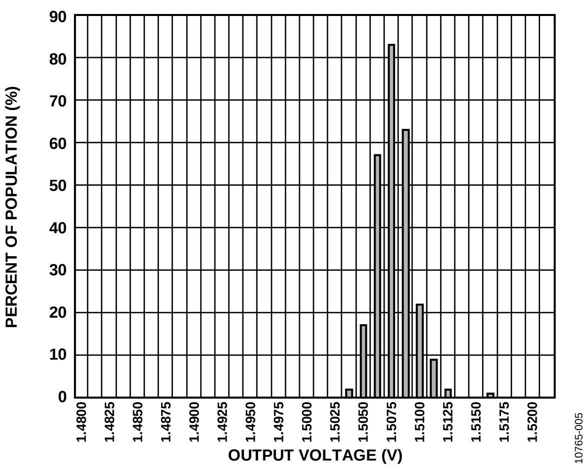

Figure 5. Z-Axis One g *Output Voltage at 25°C, V_S = 3 V*

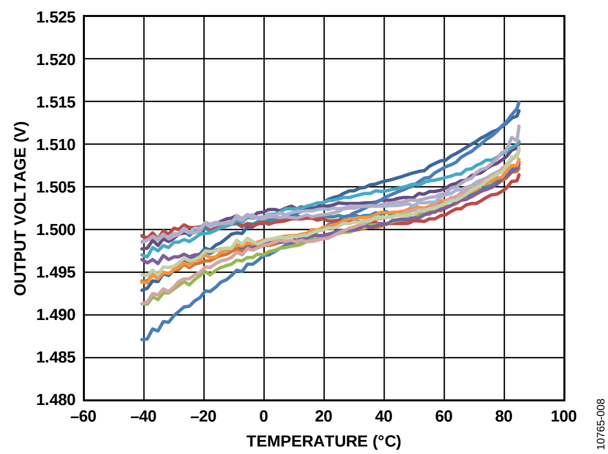

Figure 8. Z-Axis Zero g *Offset vs. Temperature, V_S = 3 V (14 Parts Soldered to PCB)*

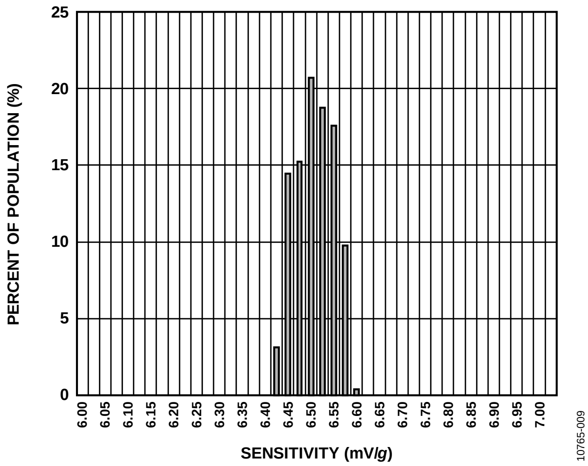

Figure 9. X-Axis Sensitivity at 25°C, V_S = 3 V

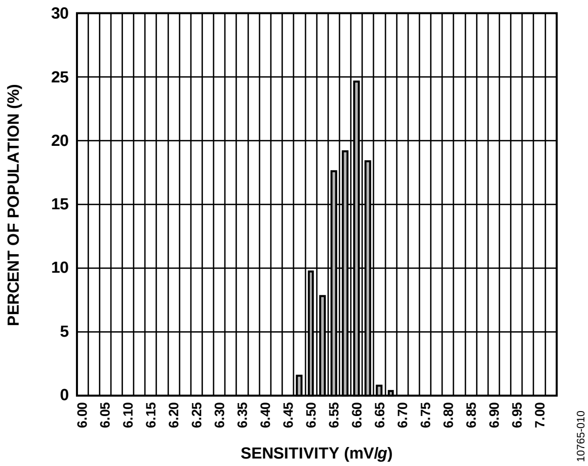

Figure 10. Y-Axis Sensitivity at 25°C, V_S = 3 V

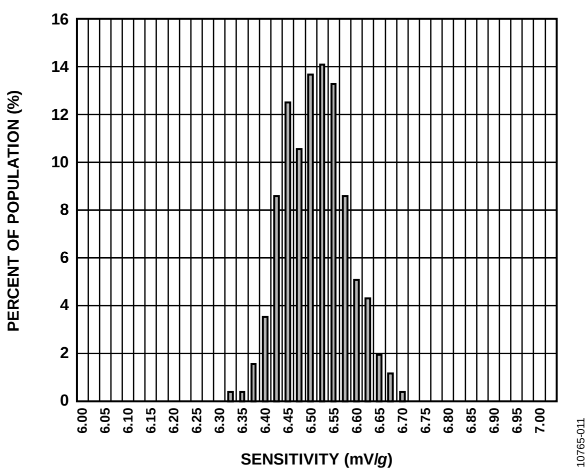

Figure 11. Z-Axis Sensitivity at 25°C, V_S = 3 V

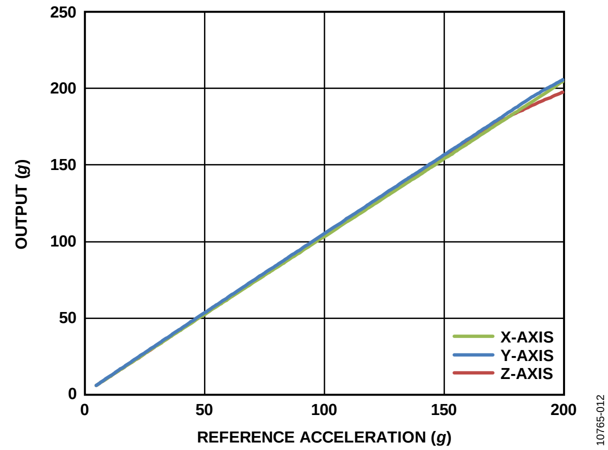

Figure 12. Typical Output Linearity over the Dynamic Range

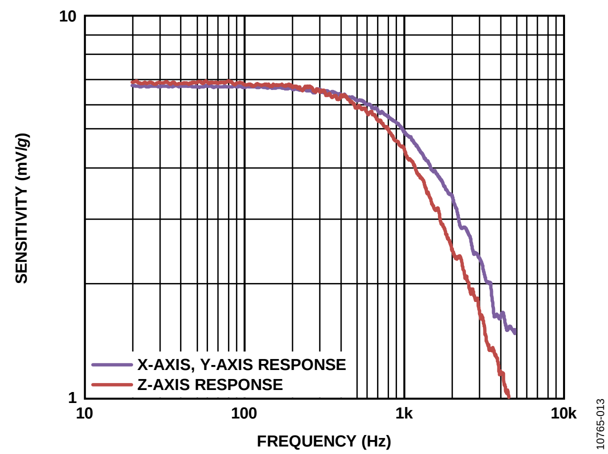

Figure 13. Typical Frequency Response

THEORY OF OPERATION

The ADXL377 is a complete 3-axis acceleration measurement system with a typical measurement range of ±200 *g*. The ADXL377 contains a polysilicon, surface-micromachined sensor and signal conditioning circuitry to implement an open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

The sensor is a polysilicon, surface-micromachined structure built on top of a silicon wafer. Polysilicon springs suspend the structure over the surface of the wafer and provide resistance against acceleration forces. Deflection of the structure is measured using a differential capacitor that consists of independent fixed plates and plates attached to the moving mass. The fixed plates are driven by 180° out-of-phase square waves. Acceleration deflects the moving mass and unbalances the differential capacitor, resulting in a sensor output whose amplitude is proportional to acceleration. Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration.

The demodulator output is amplified and brought off chip through a 32 kΩ resistor. The user then sets the signal bandwidth of the device by adding a capacitor. This filtering improves measurement resolution and helps prevent aliasing.

MECHANICAL SENSOR

The ADXL377 uses a single structure for sensing the acceleration in the x-axis, y-axis, and z-axis. As a result, the three sense directions are highly orthogonal with little cross-axis sensitivity. Mechanical misalignment of the sensor die to the package or misalignment of the package to the PCB is the chief source of cross-axis sensitivity. Mechanical misalignment can be calibrated at the system level.

PERFORMANCE

Rather than using additional temperature compensation circuitry, the ADXL377 uses innovative design techniques to ensure high performance. As a result, there is neither quantization error nor nonmonotonic behavior, and temperature hysteresis is very low.

APPLICATIONS INFORMATION

POWER SUPPLY DECOUPLING

For most applications, a single 0.1 µF capacitor, C_{DC}, placed close to the ADXL377 supply pins adequately decouples the accelerometer from noise on the power supply. However, in applications where noise is present at the 50 kHz internal clock frequency (or any harmonic thereof), additional care in power supply bypassing is required because this noise can cause errors in acceleration measurement.

If additional decoupling is needed, a 100 Ω (or smaller) resistor or ferrite bead can be inserted in the supply line. In addition, a larger bulk bypass capacitor (1 µF or greater) can be added in parallel to C_{DC}. Ensure that the connection from the ADXL377 ground to the power supply ground is low impedance because noise transmitted through ground has a similar effect as noise transmitted through V_S.

SETTING THE BANDWIDTH USING C_X, C_Y, AND C_Z

The ADXL377 has provisions for band-limiting the X_{OUT}, Y_{OUT}, and Z_{OUT} pins. A capacitor must be added at each of these pins to implement low-pass filtering for antialiasing and noise reduction. The equation for the −3 dB bandwidth is

$$f_{-3\ dB} = 1/(2\pi \times 32\ k\Omega \times C_x)$$

or more simply,

$$f_{-3\ dB} = 5\ \mu F/C_x$$

The tolerance of the internal resistor (R_{FILT}) typically varies by as much as ±15% of its nominal value (32 kΩ), and the bandwidth varies accordingly. A minimum capacitance of 1000 pF for C_X, C_Y, and C_Z is recommended in all cases.

Table 4. Filter Capacitor Selection for C_X, C_Y, and C_Z

Bandwidth (Hz)	Capacitor (µF)
50	0.10
100	0.05
200	0.025
500	0.01
1000	0.005

SELF-TEST

The ST pin controls the self-test feature. When this pin is set to V_S, an electrostatic force is exerted on the accelerometer beam. The resulting movement of the beam allows the user to test whether the accelerometer is functional. The typical change in output is −1.08 *g* (corresponding to −6.5 mV) for the x-axis, +1.08 *g* (or +6.5 mV) for the y-axis, and +1.83 *g* (or +11.5 mV) for the z-axis. The ST pin can be left open circuit or connected to ground (GND) in normal use.

Never expose the ST pin to voltages greater than V_S + 0.3 V. If the system design is such that this condition cannot be guaranteed (for example, if multiple supply voltages are present), it is recommended that a clamping diode with low forward voltage be connected between ST and V_S.

SELECTING FILTER CHARACTERISTICS: NOISE/BANDWIDTH TRADE-OFF

The selected accelerometer bandwidth ultimately determines the measurement resolution (smallest detectable acceleration). Filtering can be used to lower the noise floor, thereby improving the resolution of the accelerometer. Resolution is dependent on the analog filter bandwidth at X_{OUT}, Y_{OUT}, and Z_{OUT}.

The output of the ADXL377 has a typical bandwidth of 1000 Hz. The user must filter the signal at this point to limit aliasing errors. The analog bandwidth must be no more than half the analog-to-digital sampling frequency to minimize aliasing. The analog bandwidth can be decreased further to reduce noise and improve resolution.

The ADXL377 noise has the characteristics of white Gaussian noise, which contributes equally at all frequencies and is described in terms of µg/√Hz (that is, the noise is proportional to the square root of the accelerometer bandwidth). Limit the bandwidth to the lowest frequency required by the application to maximize the resolution and dynamic range of the accelerometer.

With the single-pole roll-off characteristic, the typical noise of the ADXL377 is determined by

$$rms\ Noise = Noise\ Density \times (\sqrt{BW \times 1.6})$$

It is often useful to know the peak value of the noise. Peak-to-peak noise can only be estimated by statistical methods. Table 5 can be used to estimate the probability of exceeding various peak values, given the rms value.

Table 5. Estimation of Peak-to-Peak Noise

Peak-to-Peak Value	Percentage of Time That Noise Exceeds Nominal Peak-to-Peak Value (%)
2 × rms	32
4 × rms	4.6
6 × rms	0.27
8 × rms	0.006

AXES OF ACCELERATION SENSITIVITY

Figure 14 shows the axes of sensitivity for the accelerometer. Figure 15 shows the output response when the accelerometer is oriented parallel to each of these axes.

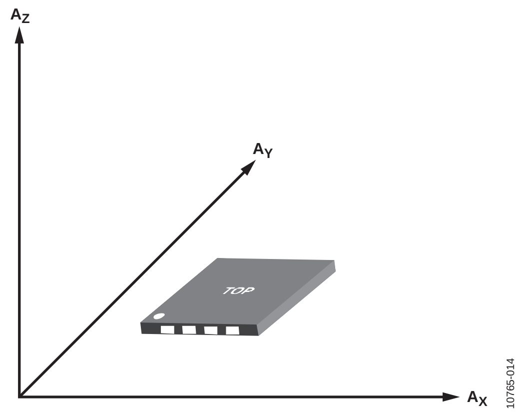

Figure 14. Axes of Acceleration Sensitivity (Corresponding Output Voltage Increases When Accelerated Along the Sensitive Axis)

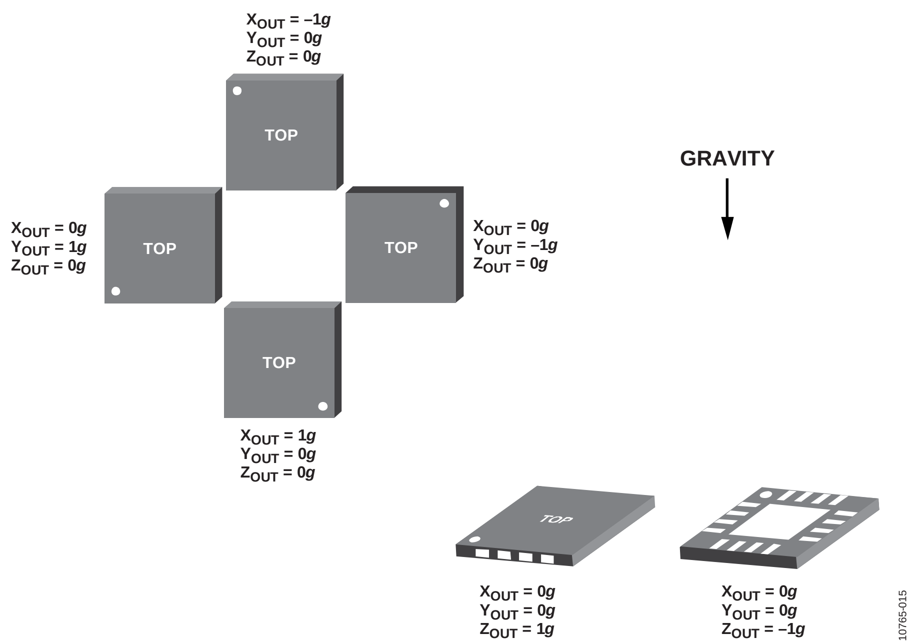

Figure 15. Output Response vs. Orientation to Gravity

LAYOUT AND DESIGN RECOMMENDATIONS

Figure 16 shows the recommended soldering profile; Table 6 describes the profile features. Figure 17 shows the recommended PCB layout or solder land drawing.

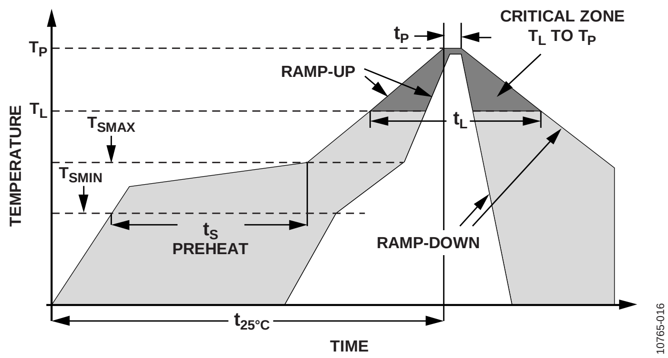

Figure 16. Recommended Soldering Profile

Table 6. Recommended Soldering Profile

Profile Feature	Sn63/Pb37	Pb-Free
Average Ramp Rate (T_L to T_P)	3°C/sec max	3°C/sec max
Preheat		
Minimum Temperature (T_{SMIN})	100°C	150°C
Maximum Temperature (T_{SMAX})	150°C	200°C
Time, T_{SMIN} to T_{SMAX} (t_S)	60 sec to 120 sec	60 sec to 180 sec
Ramp-Up Rate (T_{SMAX} to T_L)	3°C/sec max	3°C/sec max
Time Maintained Above Liquidous (t_L)	60 sec to 150 sec	60 sec to 150 sec
Liquidous Temperature (T_L)	183°C	217°C
Peak Temperature (T_P)	240°C + 0°C/−5°C	260°C + 0°C/−5°C
Time Within 5°C of Actual Peak Temperature (t_P)	10 sec to 30 sec	20 sec to 40 sec
Ramp-Down Rate (T_P to T_L)	6°C/sec max	6°C/sec max
Time 25°C to Peak Temperature ($t_{25°C}$)	6 minutes max	8 minutes max

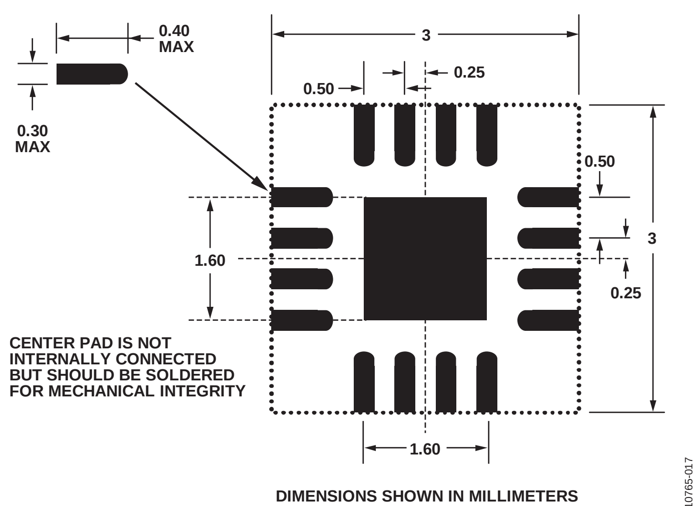

Figure 17. Recommended PCB Layout

OUTLINE DIMENSIONS

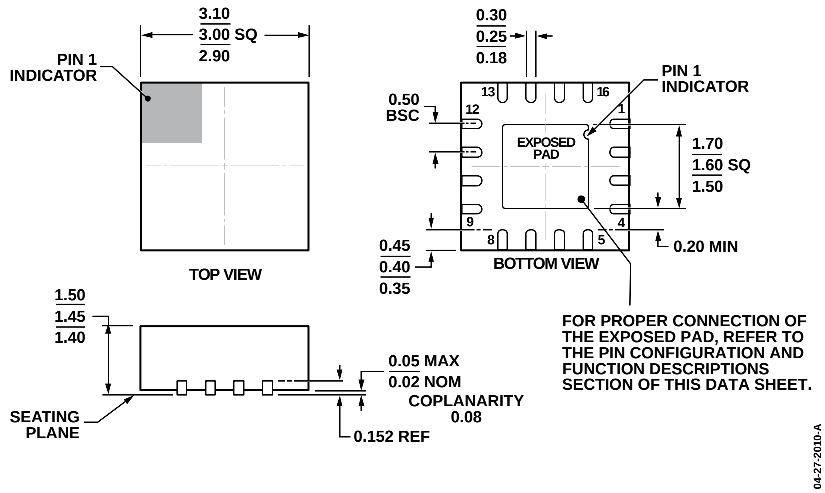

Figure 18. 16-Lead Lead Frame Chip Scale Package [LFCSP_LQ]
3 mm × 3 mm Body, Thick Quad
(CP-16-28)
Dimensions shown in millimeters

ORDERING GUIDE

Model[1]	Measurement Range	Specified Voltage	Temperature Range	Package Description	Package Option	Branding
ADXL377BCPZ-RL	±200 *g*	3 V	−40°C to +85°C	16-Lead LFCSP_LQ	CP-16-28	Y4P
ADXL377BCPZ-RL7	±200 *g*	3 V	−40°C to +85°C	16-Lead LFCSP_LQ	CP-16-28	Y4P
EVAL-ADXL377Z				Evaluation Board		

[1] Z = RoHS Compliant Part.