

# Accelerometers

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*Abstract: This application note is meant to inform its user on what an accelerometer is and what its used for, helping them decide what type of accelerometer is right for them, and how to use it.*

*Keywords: Accelerometer, Capacitive, Piezoelectric, Hall Effect, Heat Transfer*

## Introduction

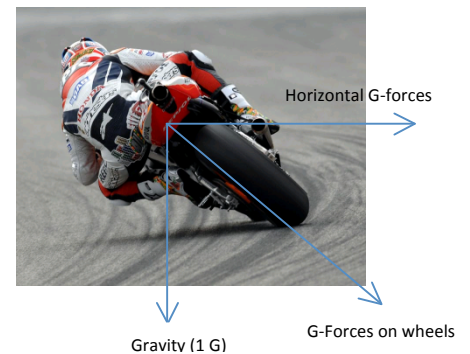
Accelerometers are sensors that measure proper acceleration or the physical acceleration experience by an object relative to a free-fall. This relative measurement unit is called g-force. Here are some examples.

### Vertical

- |   |         |
|---|---------|
| • Loss of consciousness                       | 4.5-6.3 |
| • Limit of sustained human tolerance          | 5       |
| • Roller coaster (max at bottom of first dip) | 4.5     |
| • Surface of Moon                             | 1/6     |
| • Free fall                                   | 0       |

### Horizontal

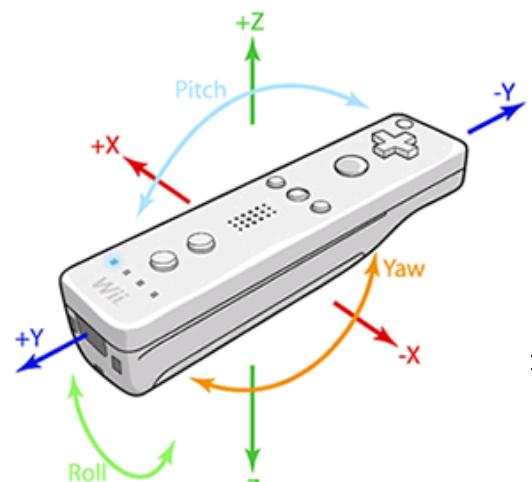
- |   |     |
|---|-----|
| • Max acceleration of typical car       | 0.4 |
| • Max acceleration of F-1 race car      | 1.7 |
| • Extreme Launch roller coaster takeoff | 2   |
| • Limit of sustained human tolerance    | 8   |
| • Space shuttle launch                  | 10  |



There is a whole world of uses for a sensor like this. This application note will go-over some of these applications, briefly describe major types of accelerometers, and then cover which accelerometer is right for you and how to use it.

## Applications

There is a huge market for consumer electronics today and many have accelerometers. They are used for detecting changes in motion and orientation which is critical for devices like tablets, smartphones, Wii remotes, etc. In some of these electronics like smartphones, they can be used in combination with GPS

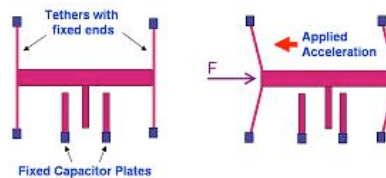


technology for use in navigation. An accelerometer can be used to calculate altitude, distance traveled, speed, and direction. There are even devices made just for these purposes. They can be used as an anti-blurring mechanism for cameras by compensating for small hand movements. They are even used in laptops for detecting when the laptop is free-fall which means it has been dropped. If it detects that the laptop is in free-fall, the heads of the hard disk are parked to avoid damage and data loss.

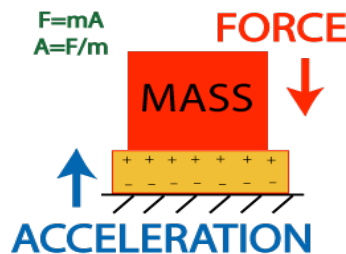
There are applications in many other fields in engineering, biology, industry, structural, medical, transportation, and seismic activity. Engineering applications are involving the measurement during design, process control systems, and safety installations.

## Types

**Capacitive Accelerometers** – These consist of two parallel plate capacitors acting in a differential mode. The detection circuit captures the induced peak voltage and then processes a final output signal with a summing amplifier.



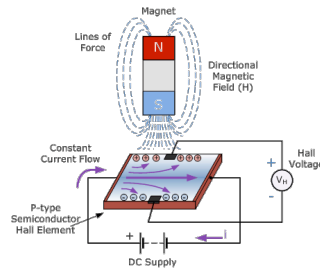
**Piezoelectric Accelerometers** – Have a crystal that emits charge when subjected to a compressive force such as acceleration.



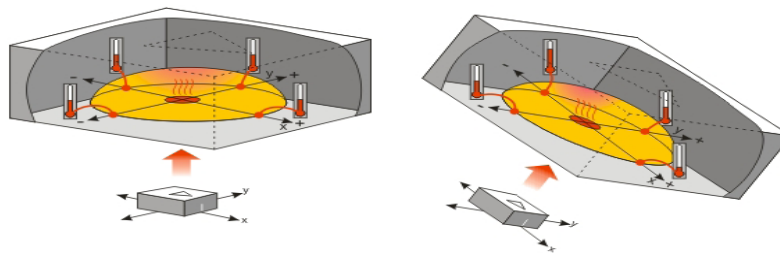
**Piezoresistive Accelerometers** - (strain gauge accelerometers) work by measuring the electrical resistance of a material when mechanical stress is applied. The resistors are normally configured into a Wheatstone bridge circuit, which provides a change in output voltage that is proportional to acceleration.



*Hall Effect Accelerometer* – These measure voltage variations stemming from a change in the magnetic field around the accelerometer.



*Heat Transfer Accelerometer* – Heat transfer accelerometers measure internal changes in heat transfer due to acceleration. Thermoresistors are spaced equally on all four sides of the suspended heat source. Under zero acceleration the heat gradient will be symmetrical.



### Picking an Accelerometer

The output of accelerometers can be either analog or digital. Analog accelerometers are easier to use and are better for users that do not have experience with accelerometers. They output a continuous voltage that is proportional to the acceleration felt by the device. Digital ones are more complex and less user friendly but can have great capabilities. They tend to use pulse width modulation for their output. The output will be a square wave of a certain frequency. The amount of acceleration felt by the device will be shown by the amount of time the voltage is “high.” What it really comes down to in deciding which to use is what the hardware that the accelerometer is interfacing with. If you are using a microcontroller with digital inputs, a digital accelerometer is needed and vice versa.

A few things to consider when picking an accelerometer is:

**Acceleration range** – What axes does the accelerometer detect x, y, and z.

**G-level Sensitivity** – Sensitivity is how much the output changes as acceleration changes. Sensitive goes up as the range of expected Gs goes down. If you are only detecting 2 Gs, get an accelerometer with a maximum swing of 2 Gs as your sensitivity is greater compared to getting one with a maximum swing of 9 Gs.

Power consumption – If the device needs to be battery powered for a long period time, the accelerometer should consume a low amount of power.

Bandwidth – This is how fast the accelerometer outputs data. If you are trying to sense vibrations you may need to have a bandwidth in the hundreds of hertz.

Impedance – The output impedance of the accelerometer can create a problem for certain circuits. Be sure to pay attention to this!

## **Conclusion**

So now you now if an accelerometer is right for your design and if so, which one to use. Whether you are designing a new phone, making a device to detect seismic activity, or any of the many other uses for an accelerometer, you should know what you need. If not there are many more online websites the can go further into accelerometers. Another good application note is found at <http://www.dimensionengineering.com/info/accelerometers>. Texas Instruments has a good one as well: <http://www2.usfirst.org/2005comp/Manuals/Acceler1.pdf>.

## Reference

<http://www.dimensionengineering.com/info/accelerometers>

<http://hacknmod.com/hack/easily-connect-a-wiimote-to-your-pc/>

<http://www2.usfirst.org/2005comp/Manuals/Acceler1.pdf>