ACCELEROMETER

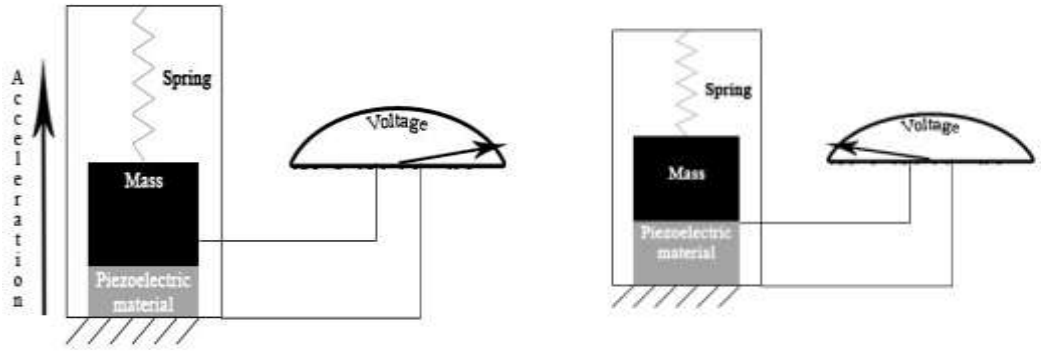
(*references: https://learn.sparkfun.com/tutorials/accelerometer-basics, http://www.digikey.com/en/articles/techzone/2011/may/using-an-accelerometer-for-inclination-sensing)

What is an accelerometer?

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic - caused by moving or vibrating the accelerometer.

How does an accelerometer work?

Most accelerometers are Micro-Electro-Mechanical Sensors (MEMS). The basic principle of operation behind the MEMS accelerometer is the displacement of a small proof mass etched into the silicon surface of the integrated circuit and suspended by small beams. Consistent with Newton's second law of motion (F = ma), as an acceleration is applied to the device, a force develops which displaces the mass. The support beams act as a spring, and the fluid (usually air) trapped inside the IC acts as a damper, resulting in a second order lumped physical system. This is the source of the limited operational bandwidth and non-uniform frequency response of accelerometers.



(image courtesy: https://learn.sparkfun.com/tutorials/accelerometer-basics)

What are accelerometers useful for?

By measuring the amount of static acceleration due to gravity, you can find out the angle the device is tilted at with respect to the earth. By sensing the amount of dynamic acceleration, you can analyze the way the device is moving. At first, measuring tilt and acceleration doesn't seem all that exciting. However, engineers have come up with many ways to make really useful products with them.

An accelerometer can help your project understand its surroundings better. Is it driving uphill? Is it going to fall over when it takes another step? Is it flying horizontally or is it dive bombing your professor? A good programmer can write code to answer all of these questions using the data provided by an accelerometer. An accelerometer can help analyze problems in a car engine using vibration testing, or you could even use one to make a musical instrument.

In the computing world, IBM and Apple have recently started using accelerometers in their laptops to protect hard drives from damage. If you accidentally drop the laptop, the accelerometer detects the sudden free-fall, and switches the hard drive off so the heads don't crash on the platters. In a similar fashion, high g accelerometers are the industry standard way of detecting car crashes and deploying airbags at just the right time.

How does the accelerometer communicate with the microcontroller?

Accelerometers will communicate over an analog, digital, or pulse-width modulated connection interface.

Accelerometers with an analog interface show accelerations through varying voltage levels. These values generally fluctuate between ground and the supply voltage level. An ADC on a microcontroller can then be used to read this value. These are generally less expensive than digital accelerometers.

Accelerometers with a digital interface can either communicate over SPI or I2C communication protocols. These tend to have more functionality and be less susceptible to noise than analog accelerometers.

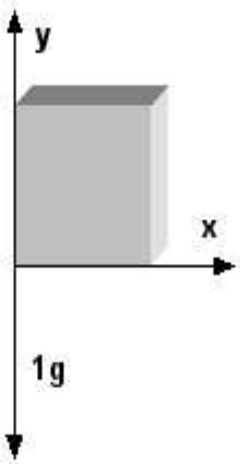
What does the accelerometer measure? Does the raw data needs further changes before calculating tilt angle?

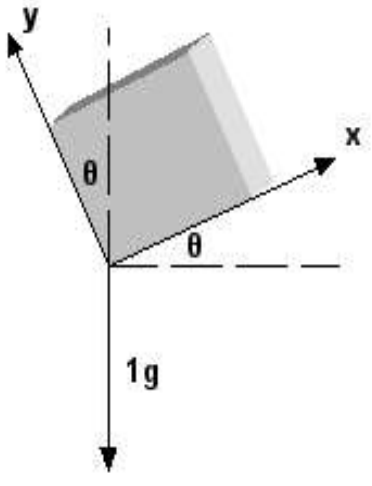
Accelerometers measures acceleration, which is the rate of change of velocity of an object. However, they measure acceleration not by calculating how speed changes over time but by measuring force. The raw data needs certain calculations before estimating the orientation. Multiply the raw data with the scale factor corresponding to the sensitivity you have chosen. Scale factor corresponding to different available sensitivity (as per the datasheet) are given below. Note that you should multiply the raw data with the scale factor in g/LSB.

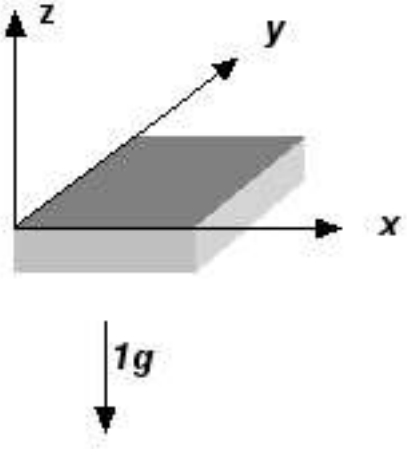
- ±2g : 3.9 mg/LSB
- ±4g : 7.8 mg/LSB
- ±8g : 15.6 mg/LSB
- ±16g : 31.2 mg/LSB

How to find orientation or tilt angle using the accelerometer?

We can compute the rotation around the X-axis and Y-axis easily using accelerometer using the concept of trigonometric operations. Try to figure out how?







It is important to note that the accelerometer results provide accurate orientation angles as long as gravity is the only force acting on the sensor. However, when moving and rotating the sensor, we are applying forces to it, which cause the measurements to fluctuate. The net result is that accelerometer data tends to be very noisy, with brief but significant perturbations. If these can be averaged out, the accelerometer provides accurate results over timescales longer than the perturbations.