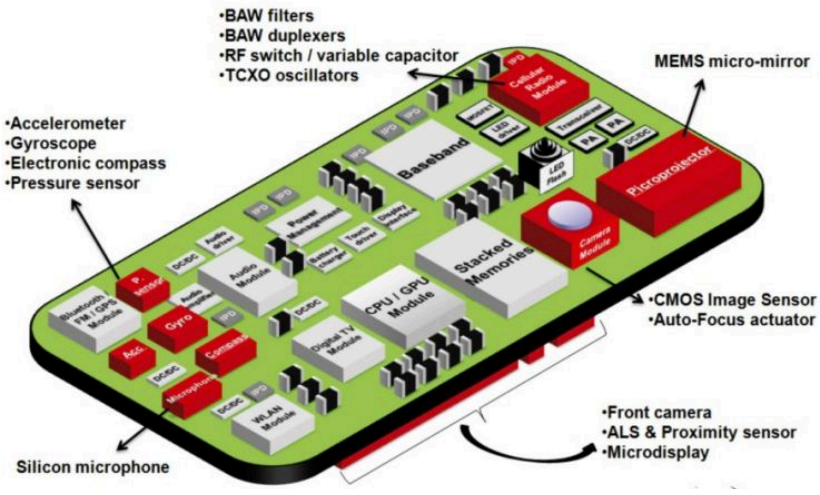
Sensors

- Motion
- Body Vital
- Health measurement
- Environmental

Sensors in Wearable Devices

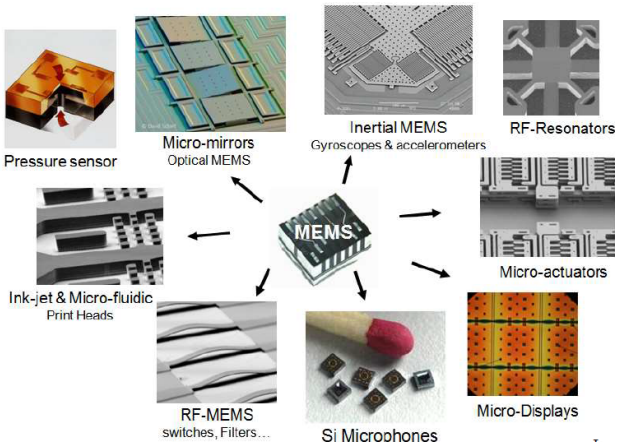
- Motion
  - Inertial Sensors
    - Accelerometer
    - Gyroscope
    - Magnetometers
  - Flex
- Touch
  - Capacitive
  - Mechanical
- Environmental
  - Temperature
  - Light
    - Visible
    - Infrared
  - Sound
    - Audible
    - Ultrasonic
  - Pressure
  - Humidity

MEMS: Driving the future of the Smartphone



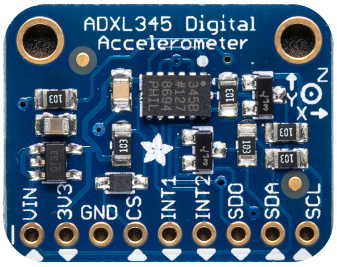
MEMS: Unlocking possibilities for wearable and quantified self

Micro
Electro
Mechanical
Systems



Inertial Sensors: Accelerometer

- Measures acceleration…how fast something is speeding up or slowing down.
- Displays either in units of meters per second squared (m/s^2), or G-force (g) ~ $9.8 m/s^2$
- Senses both static (e.g. gravity) and dynamic (e.g. sudden starts/stops) acceleration.
- Applications: tilt-sensing, linear / lateral motion.

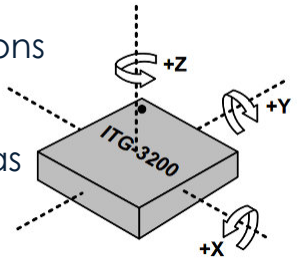


Accelerometer characteristics

- **Range**: The upper and lower limits of what the accelerometer can measure. (± 2G, ± 16G…)
- **Interface**: Analog, Pulse-width modulated (PWM), Digital
- **Number of axes measured** - X, Y, Z
- **Power Usage** - Usually current consumption will be in the 100s of µA range. Some sensors feature sleep functionality.
- **Optional Features** - Selectable measurement ranges, sleep control, 0-g detection, and tap sensing.

Inertial Sensors: Gyroscope

- Measure rotational motion or angular velocity (speed of rotation).
- Measured in degrees per second (°/s) or revolutions per second (RPS).
- The three axes of rotation are either referenced as x, y, and z, or roll, pitch, and yaw.
- Applications: Orientation, motion-capture, vehicle navigation.

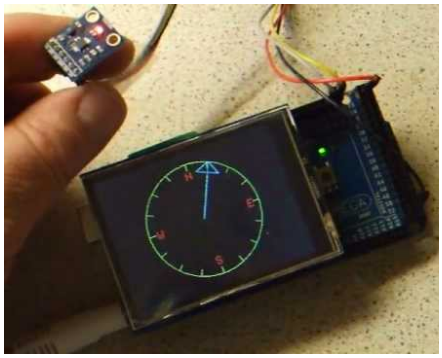


Gyroscope Characteristics

- **Range**: Min & Max angular velocity it can measure (±110°/s, ±500°/s)
- **Interface**: Analog, Digital (SPI or I^2C)
- **Number of axes measured**: 1-, 2- or 3-axis. When selecting 1- or 2-axis you need to pick based on which of the three axes the gyro will measure.
- **Power Usage**: Usual current consumption in 100s of µA range.
- **Optional Features**: Temperature output, which is very useful when compensating for drift.

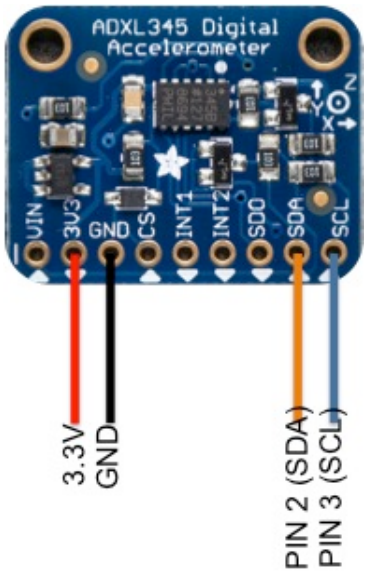
Magnetometers/Compass

- A magnetometer can sense where the strongest magnetic force is coming from, generally used to detect magnetic north.
- Primarily used in combination with Accelerometer (direction of gravity) to orient the project.



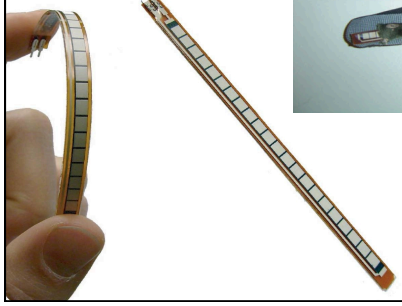
Inertial Measurement Unit (IMU)

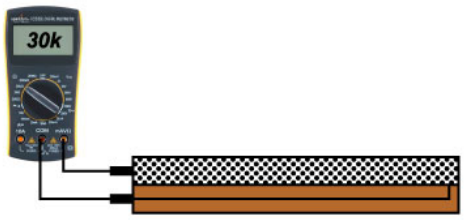
- Gyroscopes, accelerometers and magnetometers are great, but alone they don't give you quite enough information to be able to comfortably calculate things like orientation, position, and velocity.
- To measure those and other variables many people combine the two/three sensors, to create an IMU which provides two to nine degrees of freedom (DOF).
- IMUs are widely used in devices that require knowledge of their exact position, for example robotic arms, guided missiles, and tools used in the study of body motion.



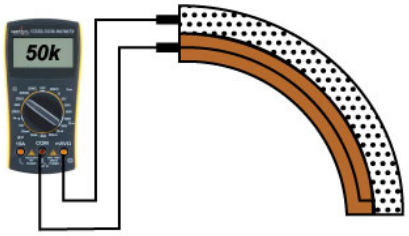
Accelerometer Hands-On

Flex Sensor



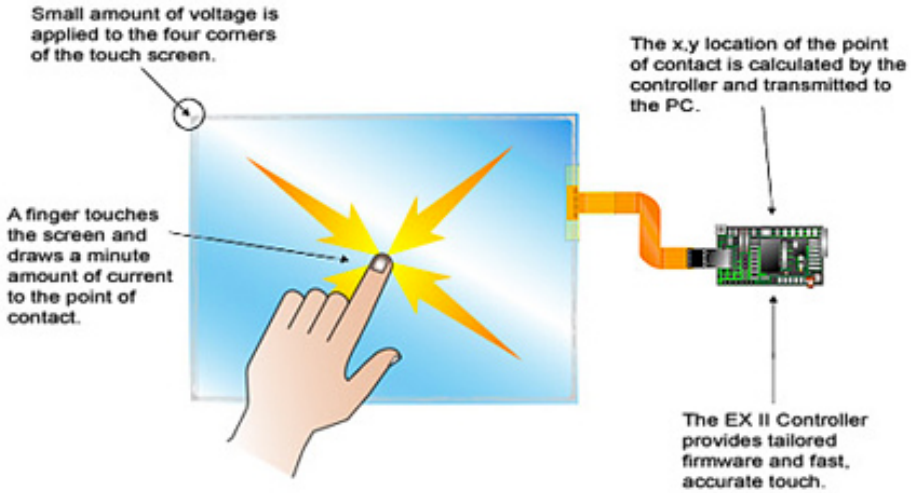


Conductive particles close together - 30K Ohms

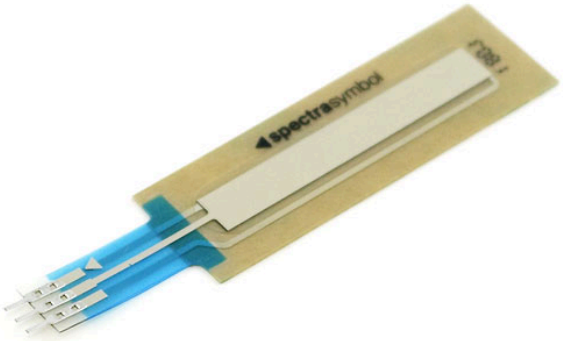


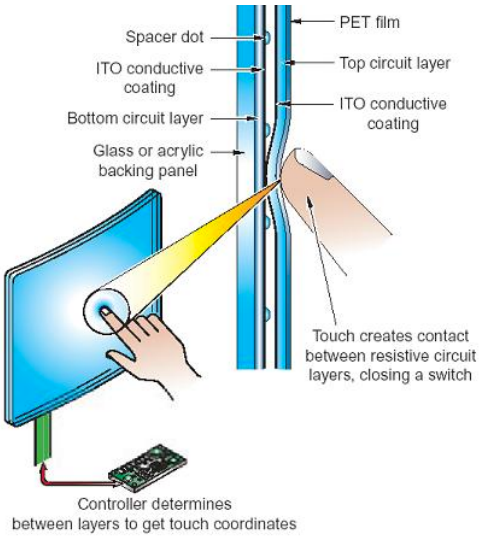
Conductive particles further apart - 50K Ohms

Touch : Capacitive



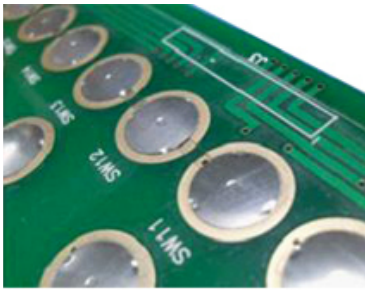
Touch: Resistive

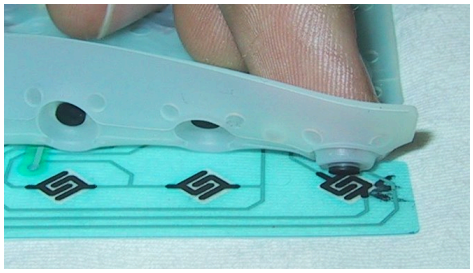




Touch: Mechanical

- Tactile Switch
- Dome Switch
- Membrane Switch



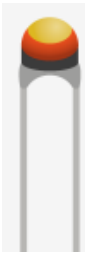


Temperature

- Analog or Digital Output
- Contact or Contact-less (IR)
- Ambient or Body Temp

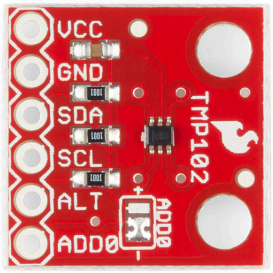
Temperature: Thermistor

- A Thermistor is a thermal-resistor. It's just a simple device that changes it's resistance based on temperature.
- Analog
- Easy to use
- No accurate
- Low cost
- Types: NTC or PTC



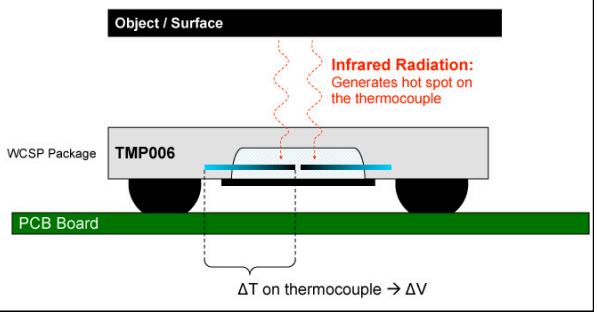
Temperature: TMP102

- Digital Output (I^2C)
- Ambient temperature sensor capable of detecting 0.0625°C changes between -25 and +85°C, with an accuracy of 0.5°C
- Ultra low-power (10µA)



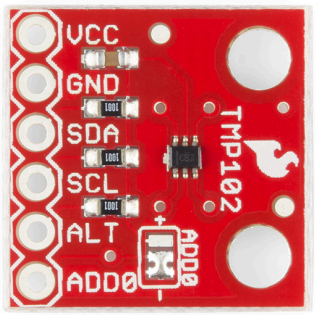
Temperature: Infrared Thermometer

- Non-Contact
- Able to read the temperature of an object without touching by reading the infrared light coming off an object.
- Eg: MLX90614, TMP006



Temperature

- There are several temperature sensors available using different type of technology.
- Based on your application & project you will have to find the one that matches your needs
- Some other common temp sensors are TMP36 (Analog), DS18B20 (Digital one-wire)



Temperature Hands-on

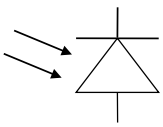
Light

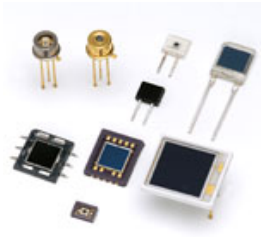
- Light Dependent Resistor (LDR)
- Made up of Cadmium Sulphide (Cds Cells)
- Range: 600ohms in light to 2M ohms in darkness
- Sensitive to the whole spectrum of light
- Cheap and easy to use

Light

IR Photodiode

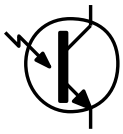
- Used in either zero bias or reverse bias mode
- In zero bias it acts like a solar cell
- In reverse bias, its resistance changes with the change in intensity of incident light
- More sensitive in the reverse bias mode





Light

IR Phototransistor

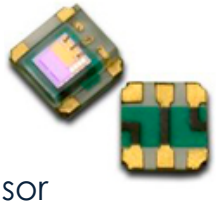


- Similar to a transparent BJT without the base connection
- Much more sensitive than a photodiode due to internal amplification
- Slower response

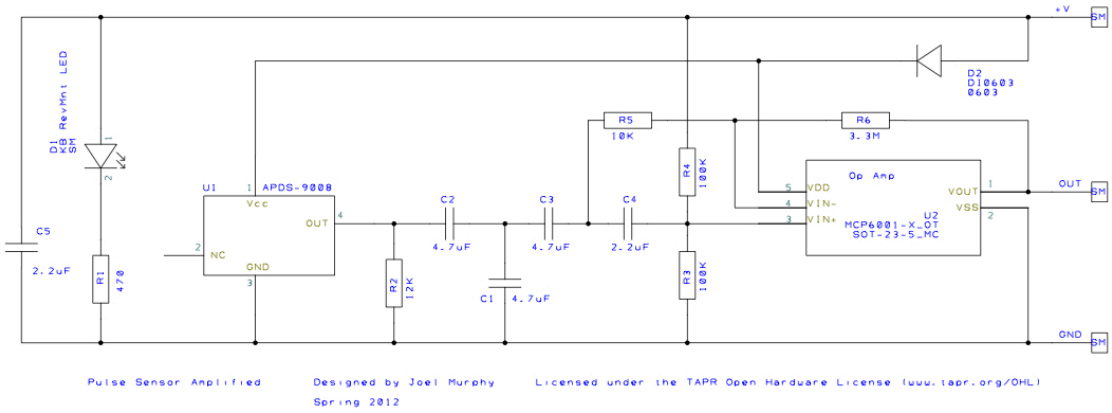
Signal Conditioning

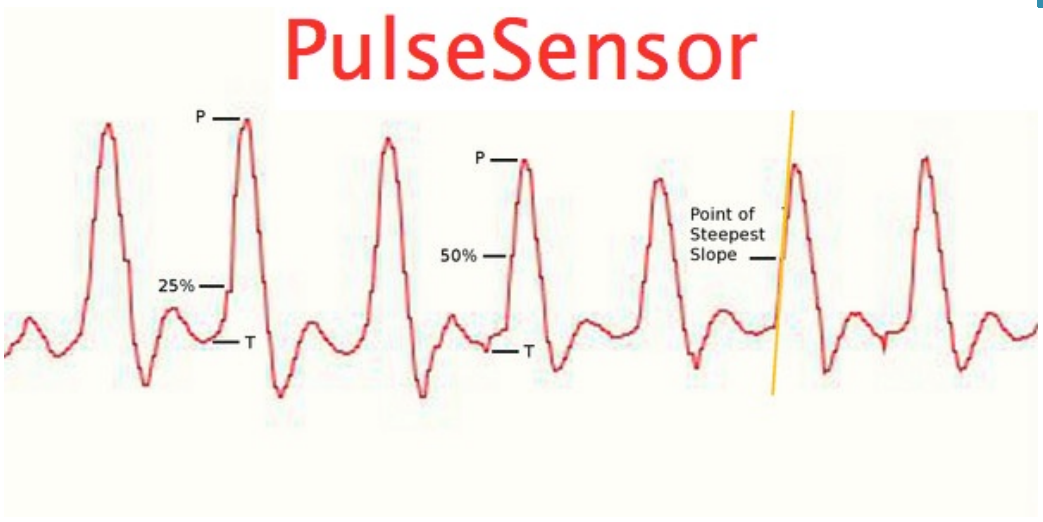
- In electronics, signal conditioning means manipulating an analog signal in such a way that it meets the requirements of the next stage for further processing.
  - **Filtering:** Not all the signal frequency spectrum contains valid data. The common example are 60 Hz AC power lines, present in most environments, which will produce noise if amplified.
  - **Amplifying**: Increases the
    i. resolution of the inputed signal, and
    ii. signal-to-noise ratio.
  - **Isolation:** used in order to
    i. pass the signal from the source to the measurement device without a physical connection:
    ii. isolate possible sources of signal perturbations.
    iii. isolate the potentially expensive equipment used to process the signal after conditioning from the sensor.

Pulse Sensor

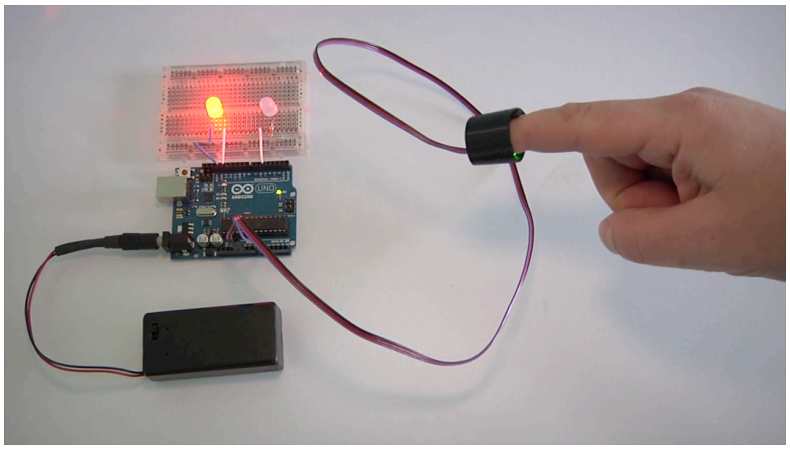


- Uses an APDS-9008: Ambient Light Photo Sensor





Pulse / Heart Rate Sensor



Changes to Interrupt

We are using Timer 0

```
void interruptSetup(){
      TCCR0A = 0x02;
      TCCR0B = 0x04;
      OCR0A = 0x7C;
      TIMSK0 = 0x02;
      sei();
   }
ISR(TIMER0_COMPA_vect)
```