Using Sensors

Developed by MECB Ltd

A Trainers Toolkit To Foster STEM Skills Using Microcontroller Applications

Co-funded by the Erasmus+ Programme of the European Union

Project No. 2019-1-RO01-KA202-063965

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Using Sensors

Content

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What is a Sensor

- A sensor is a device which outputs a certain signal depending upon the physical quantity that is given to it.
- The sensor is needed for an electronic system to work to have feedback upon what it is doing and happening. The microcontroller can be considered to be the brain but it needs its other limbs to function well (eyes/legs/fingers) to know what is happening in the physical world.

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How a Sensor Works

- Typically, sensors use a transducer, a material which when given a certain physical quantity which will output an electrical signal to function. Depending of the physical quantity, its relationship with the Input to its output can be then determined via mathematical formula.
- Typically, when buying one a circuit is already put in place so that the output is given in a digital format which can be connected directly into the microcontroller without much worry about taking care of electronic circuitry design.

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Common Sensor Outputs

- Since sensors are typically designed to pork in a certain element, they can come in all types of designs but typically, they output their readings in 3 types:
  1. Analog Voltage
  2. Pulse Width Modulation (PWM)
  3. Serial Digital

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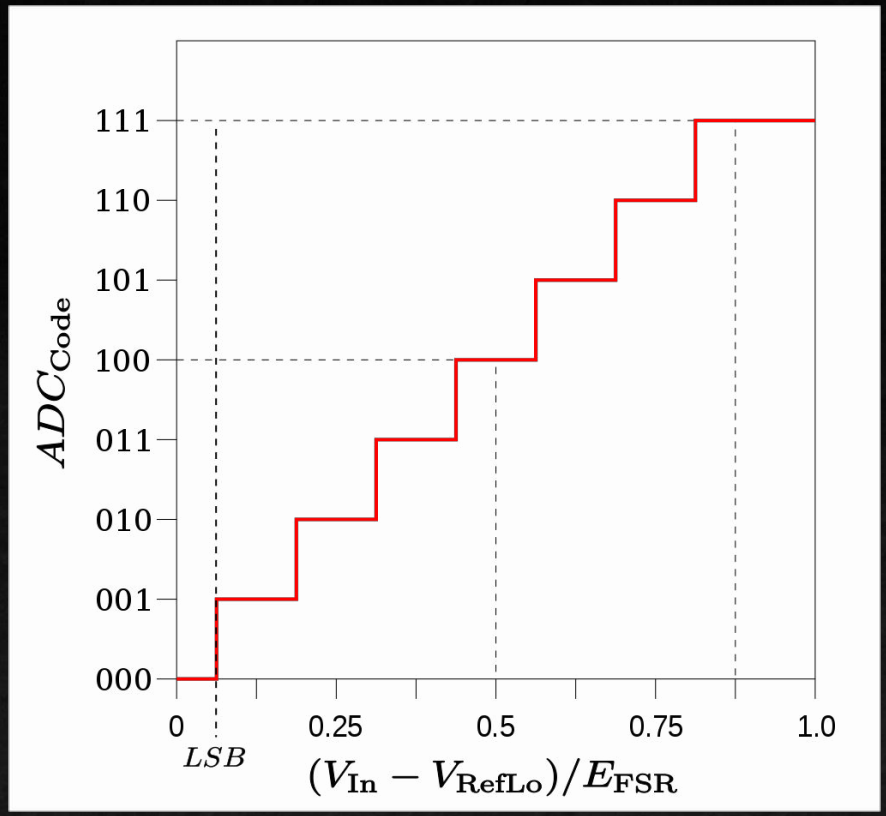
Analog Voltage

- Some sensors output an analog voltage which is proportional to the parameter which they are sensing.
- Typically the output is in the millions of Hz which due to this, this type of output has the tendancy to have noise within the signal which means that the signal first needs to be filtered to make sure that the output of the sensor is accurate.
- There are various methods used to do this but the most simple used is averaging the data collected over time.



Voltage resolution steps for a 3-bit ADC, by Spinning Spark, from Wikimedia Commons

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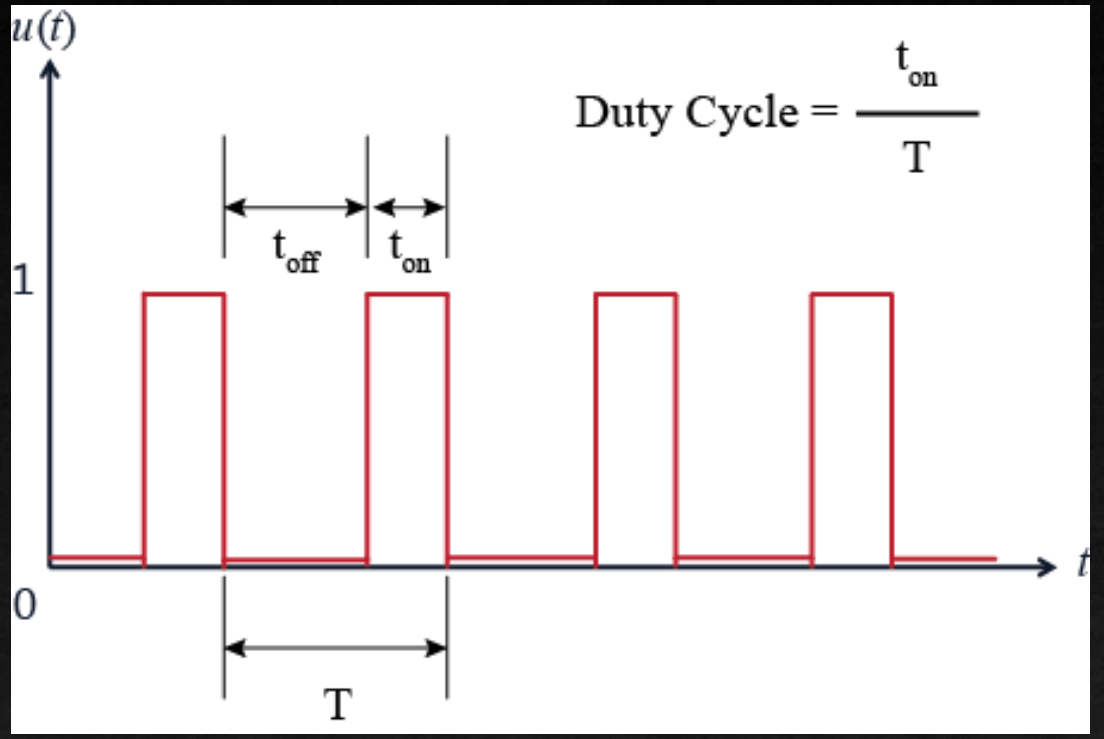
Pulse Width Modulation

- This is a popular technique for digital data transmission in embedded systems. This type of transmission is immune to noise but requires careful consideration in its use since all of the parts using this must be capable to keep up else there is loss of data transmission.
- All connected peripherals using this communication needs to be fast enough to measure the rising and falling edges of the signal.



PWM, by Hill.rick.c,
from Wikimedia Commons

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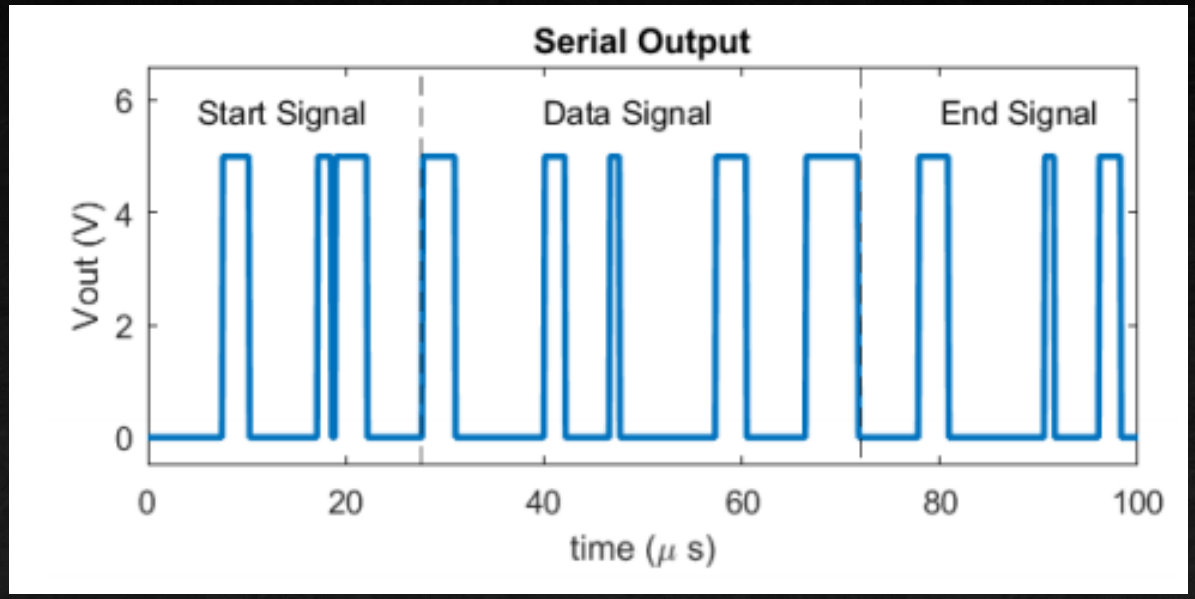
Serial Digital

- This is a type of transmission which is much more complicated than PWM signals. For this type of communication to occur, it is needed that both devices communicating are operating in the same frequency else data transmission occurs.
- Same as in PWM, the peripherals using this communication medium need to be fast enough to detect the rising and falling edges of the signal, though in this case this needs to be occurring at a faster rate than PWM.



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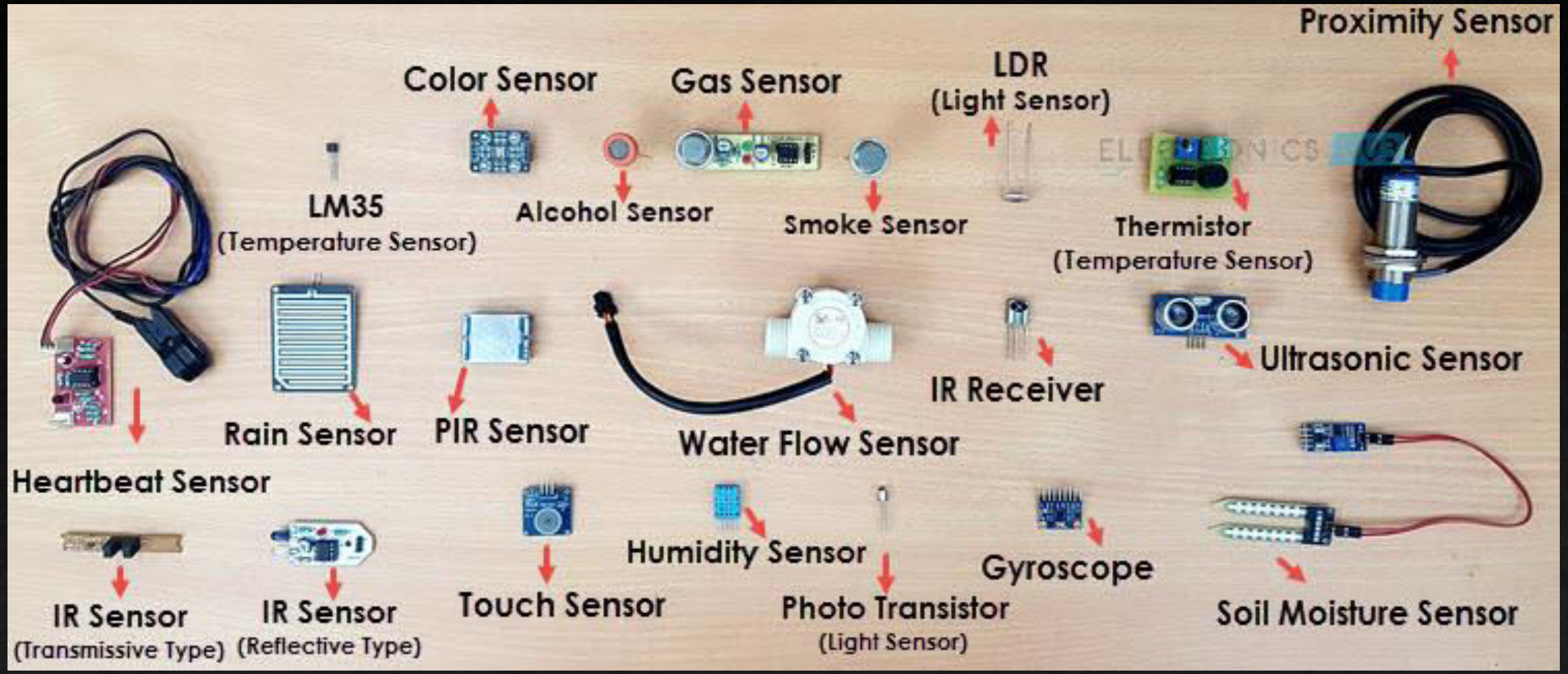
Different Types of Sensors



Different Sensors, by The Electronics Hub,
https://www.electronicshub.org/different-types-sensors/

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Types of Sensors

- There are hundreds of different sensors developed for all types of scenarios to take all type of different measurements. Though their overall functionality on how they work can be caregtoried in the following nine categories:
  - Logic Level
  - Resistivity sensor
  - Temperature
  - Proximity
  - Accelerometer
  - Pressure sensor
  - Ultrasonic sensor
  - Chemical sensor
  - Light sensor
  - Image sensor (Cameras)

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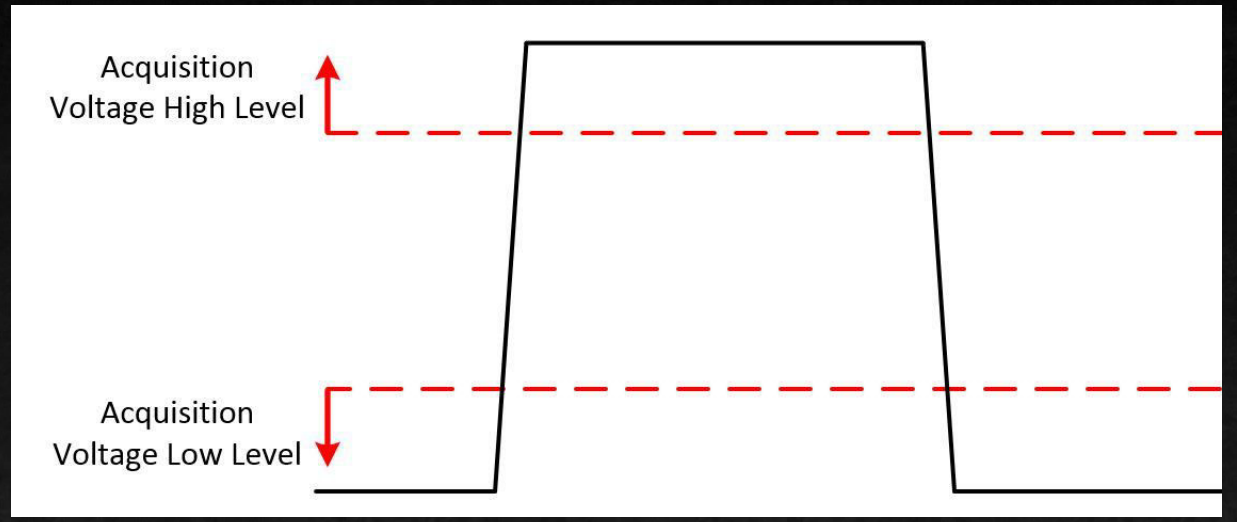
Logic Level

- Logic sensing is simlply when either a logic Low or Logic High is detected by the microcontroller. This can be said to be when an input is detected (1) or no input is detected (0).
- There are various sensors which use this principle to detect an input, which without this principle it would make it difficult to use equipment such as keyboards or mouse.
- Typically this is used extensively in all types of switches.



Logic Level High/Low, by gehmair, https://www.gehmair.org/?p=90

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Resistivity Sensors

- Resistivity sensors are considered to be sensors that work by measuring the variation of the resistance of the circuit inside to output a signal. There are many different versions which use this principle to detect a change to give a relative output.
- An example of this principle can be seen in humidity sensors who depending on how much concentration of water is present, varies the amount of resistance inside the circuit.

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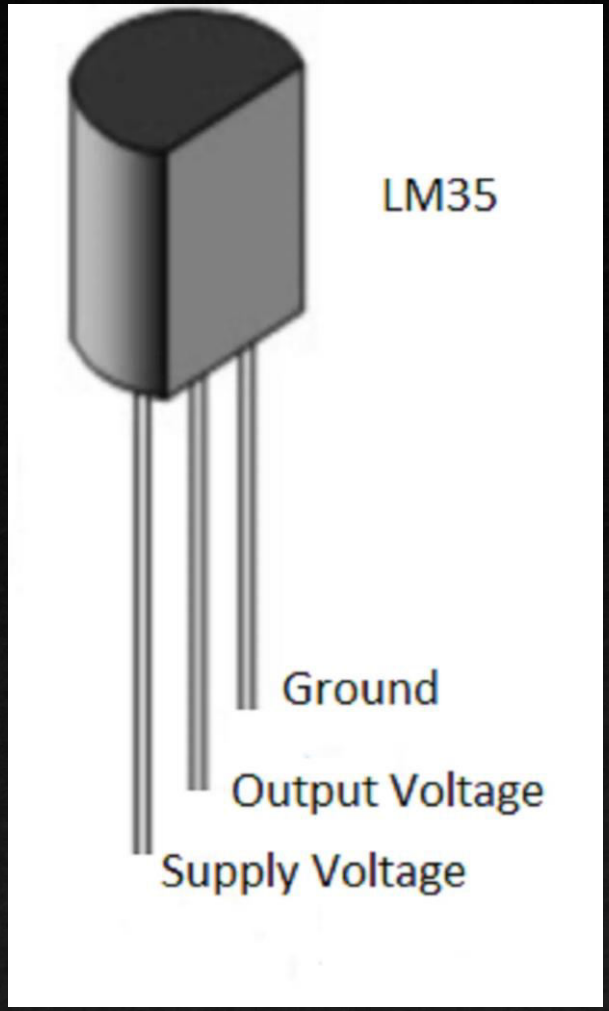
Temperature Sensors

- Temperature sensors are one of the most commonly used sensors in the world since these can give critical information about the inner workings of a machine to avoid overheating.
- As an example of this type of sensor, the LM35 is one of the most popular one for this particular scenario. This sensor works by increasing its voltage output in increments of 10mV/°C between -40 °C and 120 °C.



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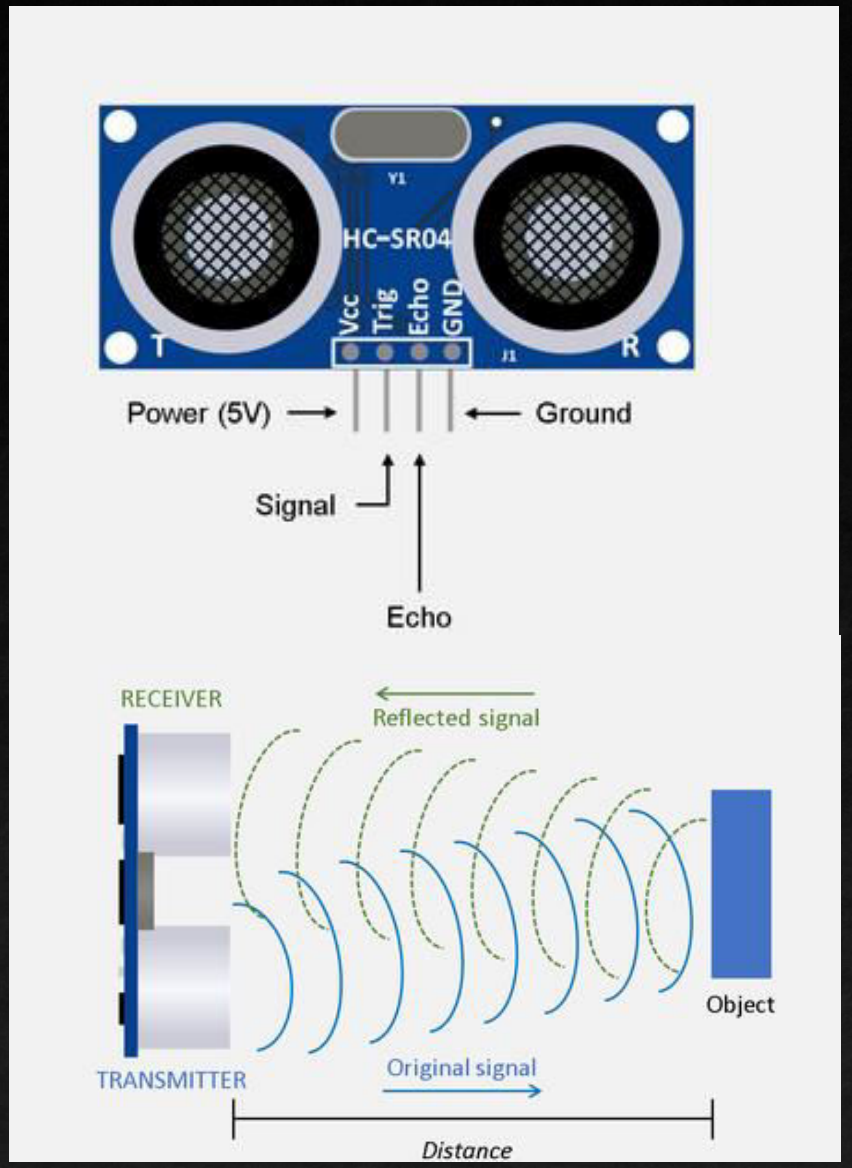
Proximity Sensors

- A proximity sensor is a sensor that emits an electromagnetic field/beam and measures the changes within this effect to detect whether an object is present or not. These are highly used in automative and manufacturing environments to detect objects. This is also used in
- One of the most common is the HC-SR04 sensor, which uses ultrasonic waves to detect an object by measuring the time it takes for the waves to bounce back.



https://www.teachwithict.com/hcsr045v.html

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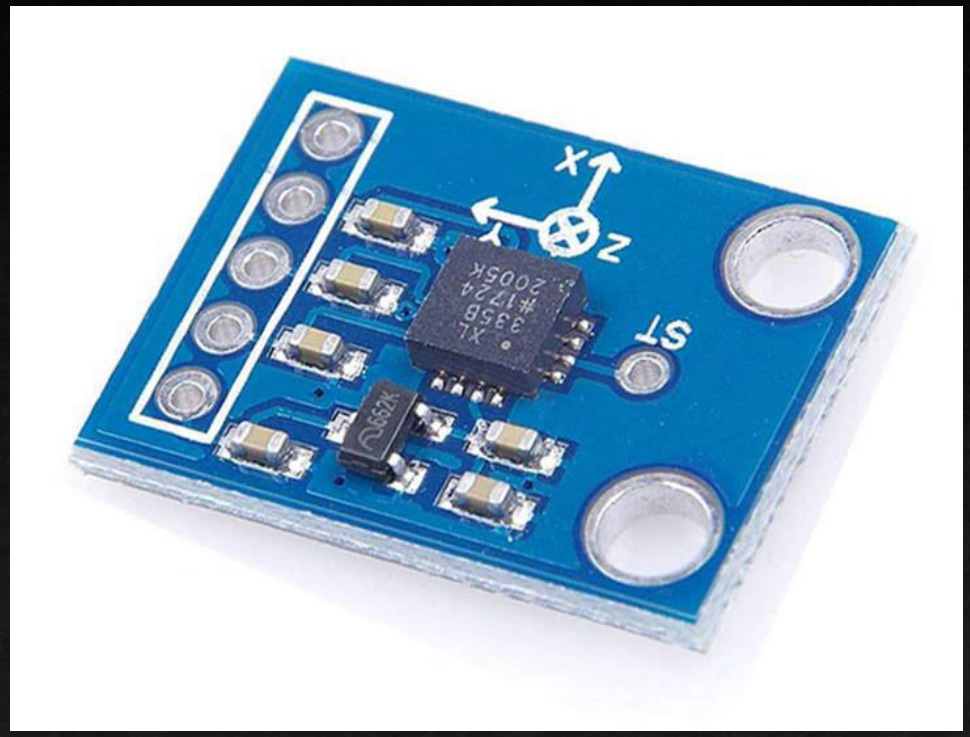
Accelerometers

- Accelerometers are devices which emit a signal depending upon the acceleration that occurs upon it. To be able to detect the acceleration, they use the piezoelectric effect which is the ability of materials to emit an electrical charge when put under mechanical stress. For trackability, accelerometers typically come with the ability to track in the X Y Z directions. These types of sensors have been used extensively in portable applications (Drones, Cars, Mobiles, etc..). This type of sensor are highly susceptible to change so these need to be calibrated beforehand to give out an accurate reading.
- As a more thorough description on how an accelerometer works, find a link attached:

  https://www.youtube.com/watch?v=i2U49usFo10



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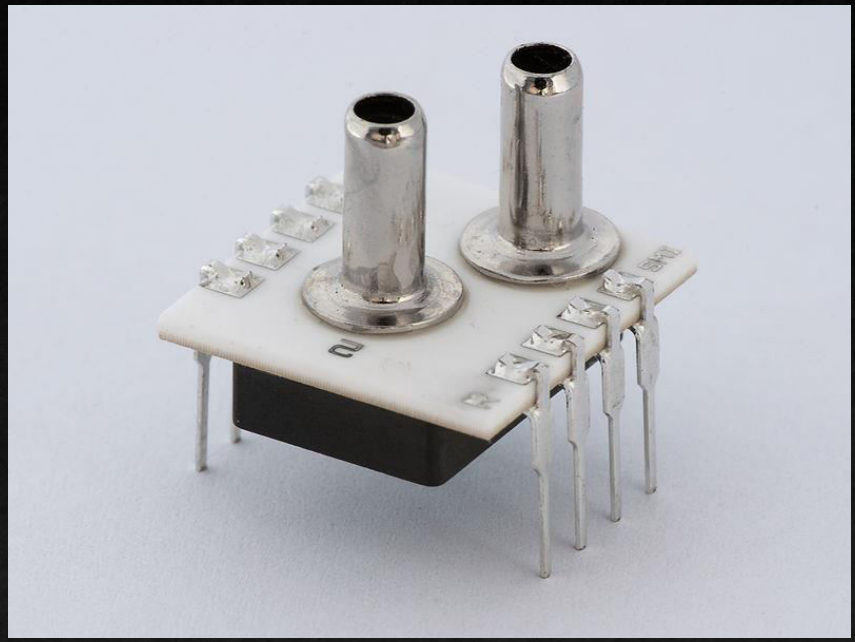
Pressure Sensors

- Pressure sensors work by using a sensing element which has a constant area. When force is applied to this area, the pressure transducer (used to convert physical force to electrical signal) will give a signal which can be used to extrapolate the pressure being applied to the sensor. Since this measures pressure, there are various uses for this type of application. Typically the most common use is to measure the pressure inside containers so that the quantity inside can be extrapolated. Though applications include also to measure the weight of objects.
- A video explaining pressure sensors can be found in the following link; https://www.youtube.com/watch?v=UZLiLRlJzbU



Differential Pressure Sensor, by Medvedev, Wikimedia Commons

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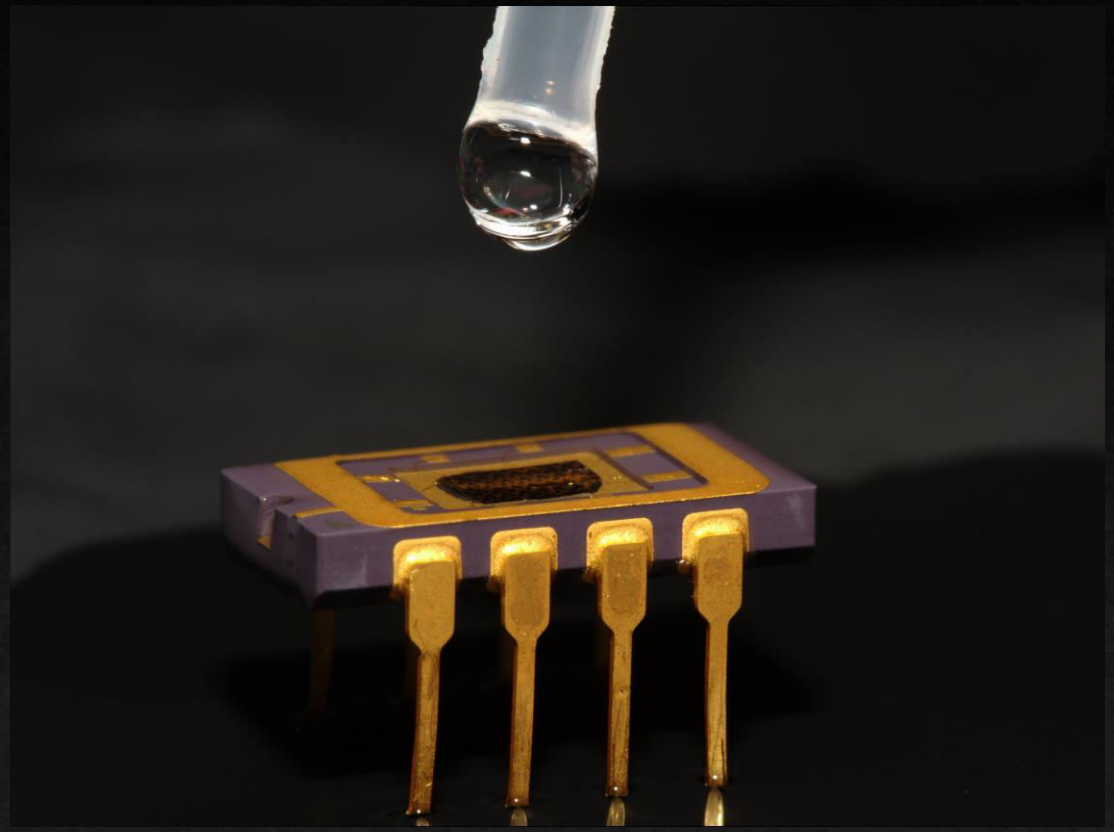
Chemical **Sensors**

- Chemical sensors use a sensing material which will give an interaction, targeted specifically for that type of analysis. Therefore, depending upon the wanted sensing of the chemical being tested, each sensor will have a different configuration to achieve this.
- These have diverse applications but typically they are used in medical environments, automotive monitoring and fire alarms (Carbon monoxide detectors).



Chemical Sensor Testing, by Phys.Org, https://phys.org/news/2014-06-chemical-sensor-chip.html

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Light Sensors

- This sensor converts light energy (photons) into electrical energy. There are three main types;
  1. Light Dependant Resistor; vary the resistance of the circuit inside depending on the intensity of the light upon it. Example: Street Lights
  2. Photodiodes; which work by using the photoelectric effect which converts light into electrical energy.

     Example: Solar Panels
  3. PhotoTransistors; These can be considered to work like photodiodes, but with a much higher sensitivity. These are used mostly in consumer electronics since continuos monitoring is needed without consuming energy.

     Example: Ambient Light Sensors

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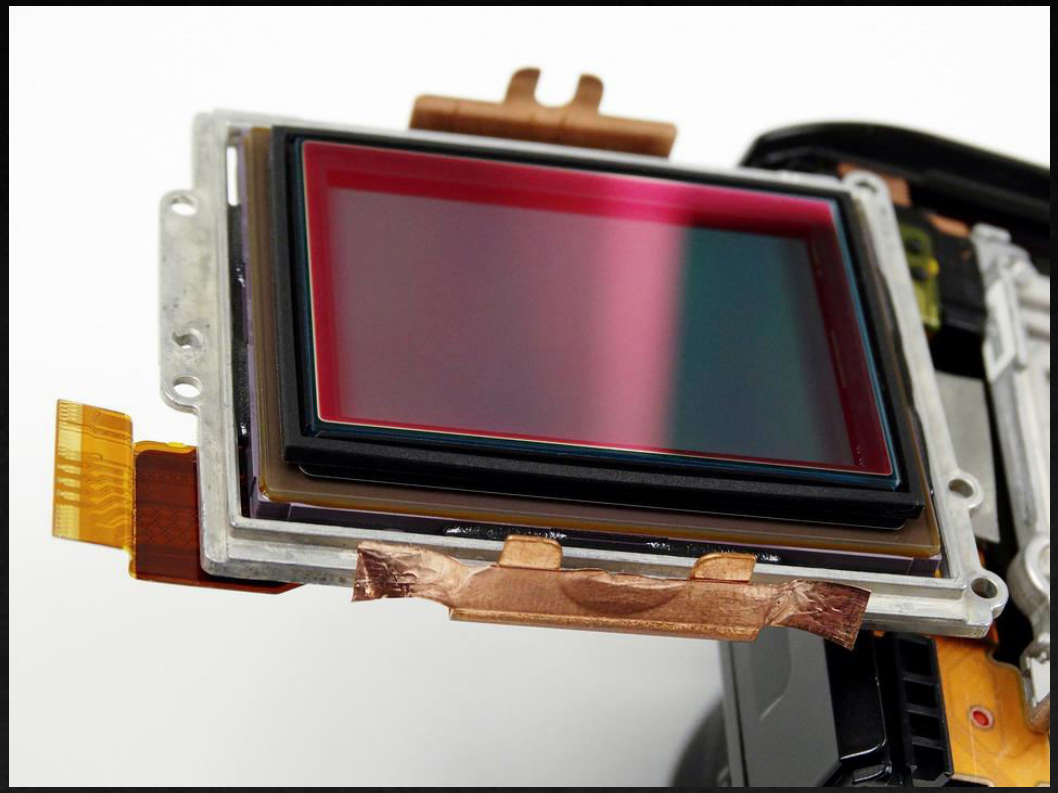
Image Sensors

- An image sensor is similar to a light sensor, though much more complex in design. It converts the small changes of the light waves into small electrical signals which are then picked up and built to form what it had received. From this phenomena this can be used to pick up from different spectrums.
- These are used heavily in many different applications since images relay a lot of information which can be extracted from. Currently research is ongoing to see the limits to what data can be extracted from them. These have started gaining popularity in automotive applications such as driverless technology which Tesla have implemented into their cars.



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Topic Summary

This concludes the topic about “Using Sensors”. So far, you should have a general understanding about the following topics;

1. What Sensors are
2. Variety of sensors
3. How sensors work

This should give you an understanding on how to use sensors and what design considerations to factor in when choosing one.

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