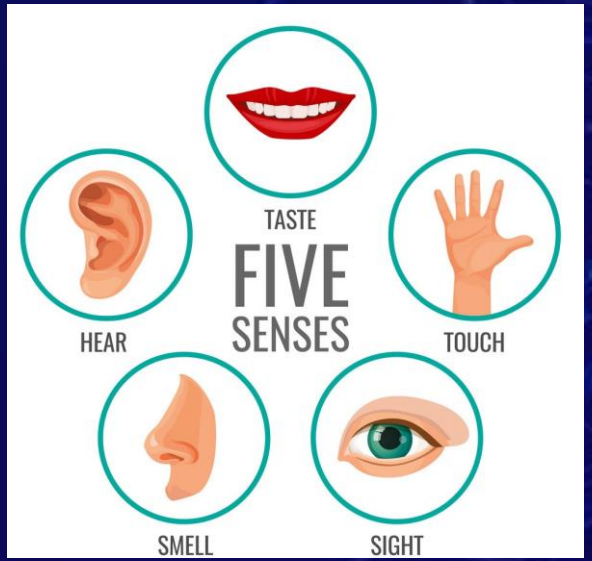
Unit 2

Sensors and Actuators



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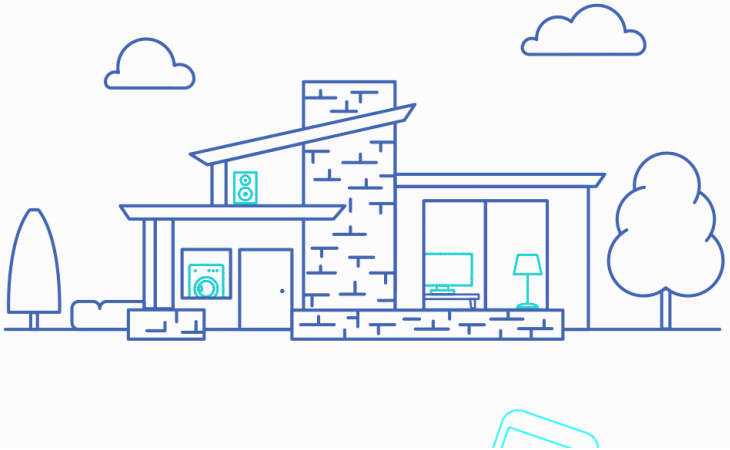
Sensors and Actuators

If you forget to turn off Electrical appliances when you go out.

Use Sensors and Build Smart

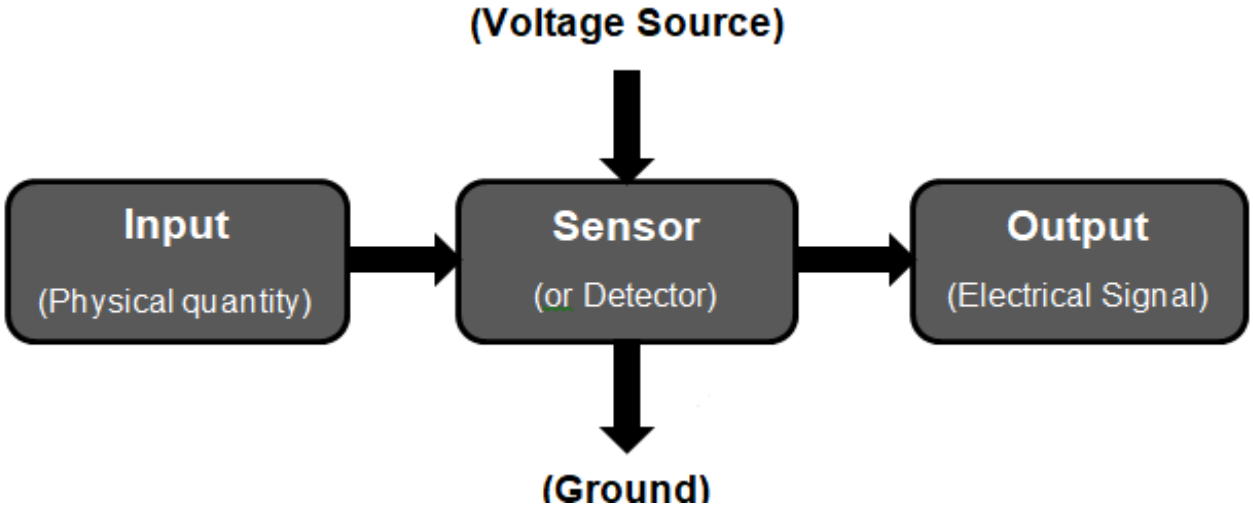


Learning Objectives

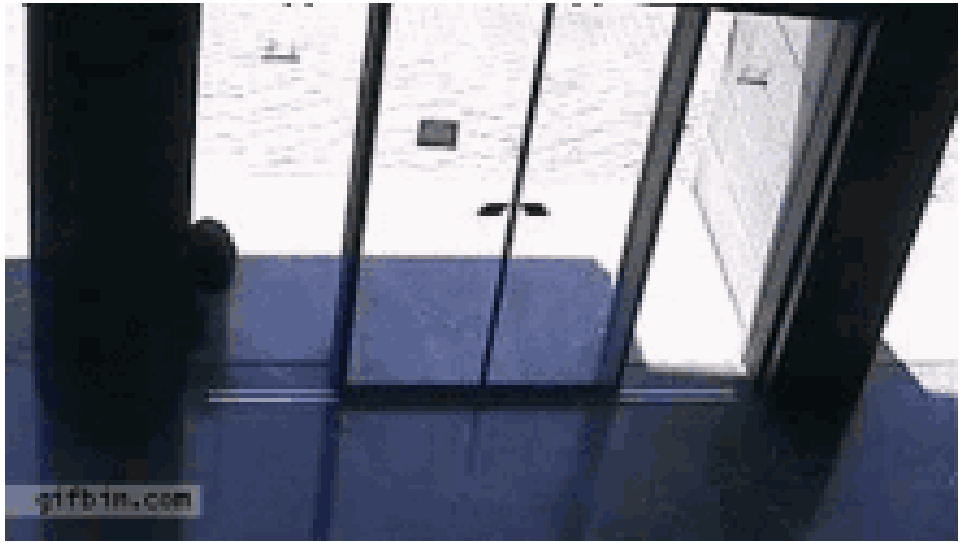
- Sensors and its Applications
- Sensors and Electronic Concepts
- Electronics Components
- Electronic Signal
- Pulse width Modulation
- ADC – Analog to Digital Converter
- Types of Sensors
- Discuss Different types of sensors and its use
- Introduction to Actuators
- Applications of Actuators
- Discuss Different types of Actuators and its use

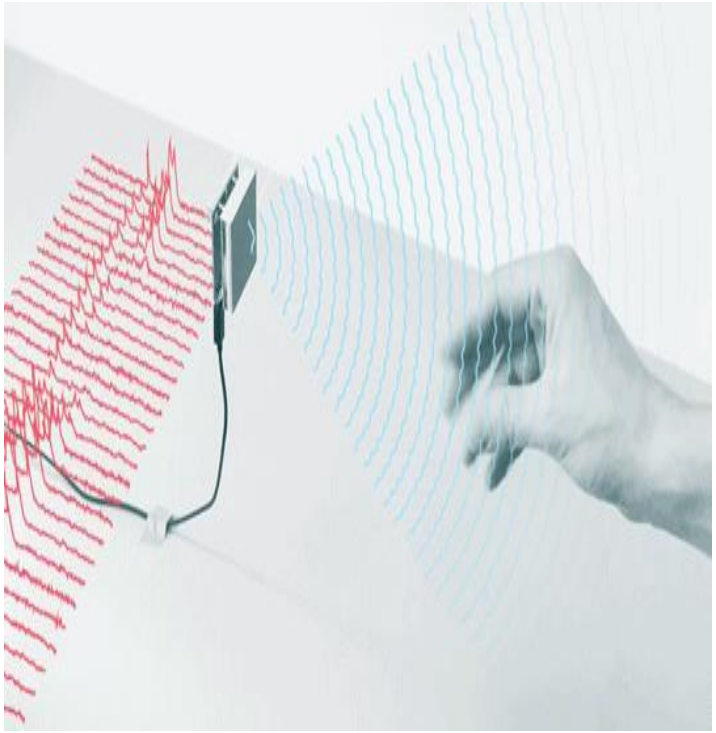
Introduction to Sensors

- The sensor can be defined as a device which can be used to sense/detect the physical quantity like force, pressure, strain, light etc and then convert it into desired output like the electrical signal to measure the applied physical quantity



Application of Sensors





Characteristics of Sensors

- Less Noise and Disturbance
- Less power consumption
- High Sensitivity
- High Resolution
- Linearity

Sensors and Electronic Concepts

- A sensor is a device that measures physical input from its environment and converts it into data that can be interpreted by either a human or a machine. Most sensors are electronic (the data is converted into electronic data).

- Actuators, on the other hand, take an electrical signal and convert it into a physical form.

Let's look at Electronic Concepts

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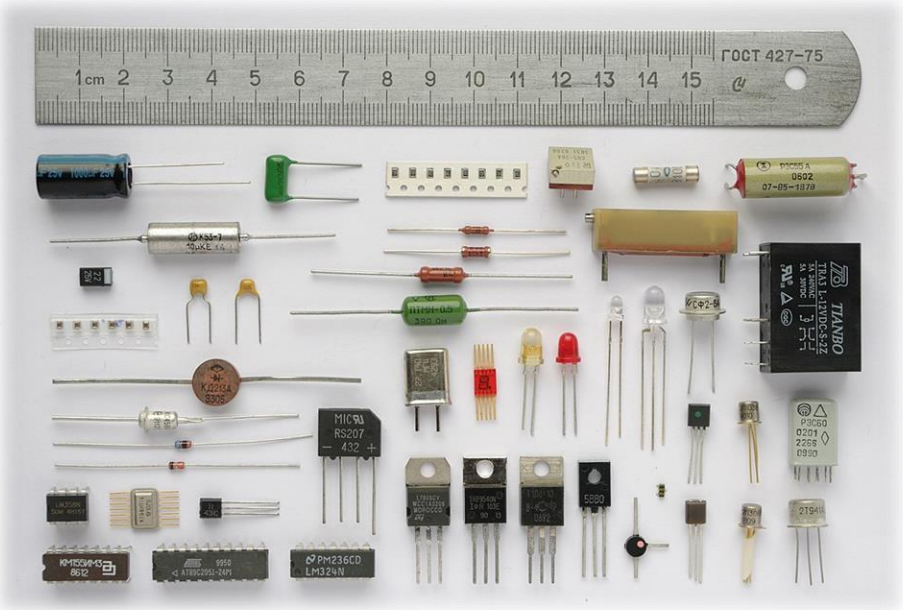
Electronics Components

- An electronic component is a physical entity in an electronic system used to affect movement of electrons.

- Electronic components have number of electronic terminals or leads which connect to other electronic components over wire to create an electronic circuit.



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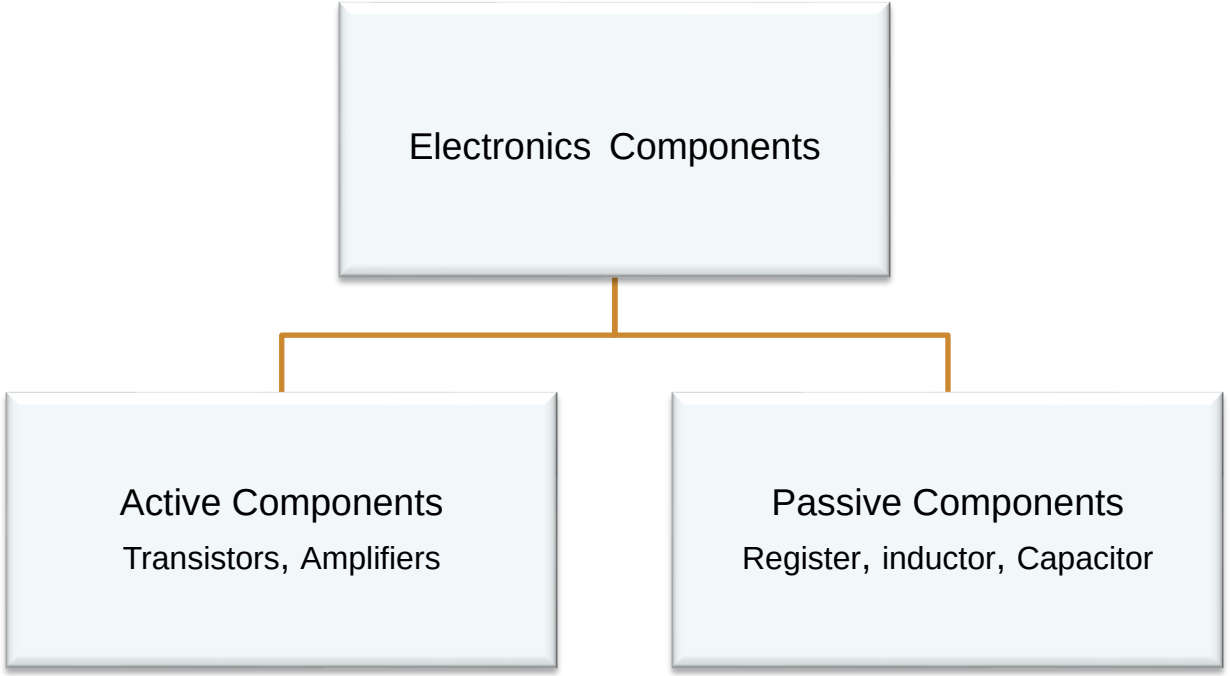
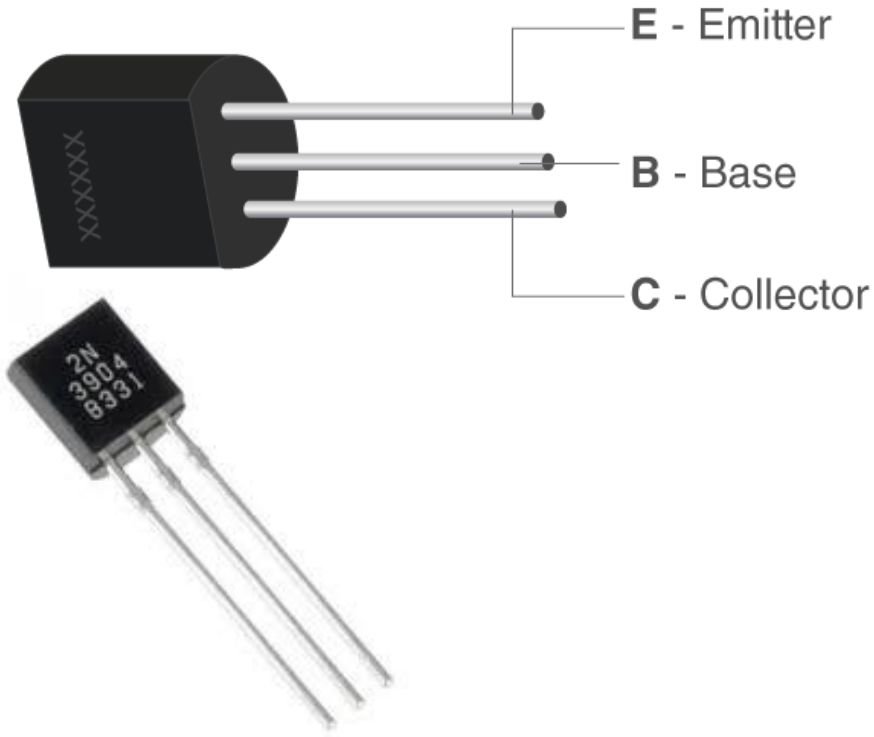
Electronics Components



Transistor

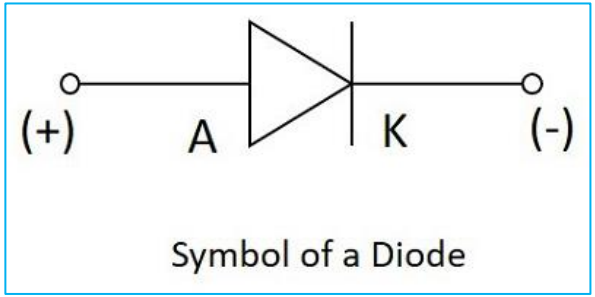
- A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power.

- Application of Transistor
- Power Regulator Circuits
- Microprocessor ICs
- Mobile Phone charger
- AC to DC adaptors
- Electronics switching devices

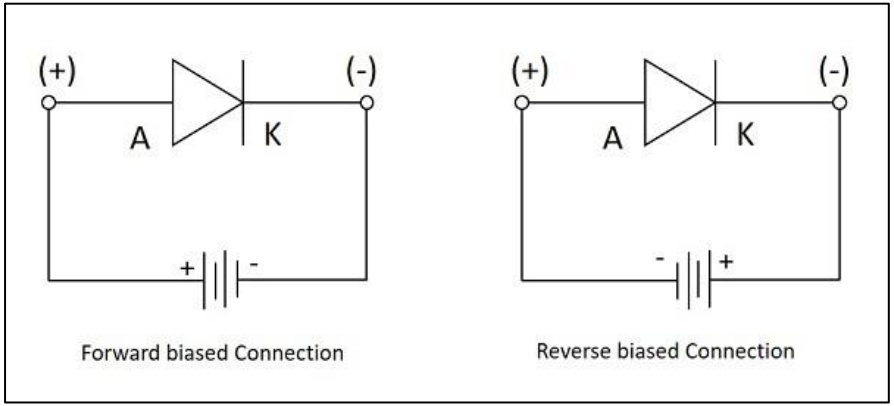


Diode

- A semiconductor diode is a two terminal electronic component with a PN junction. This is also called as a Rectifier.
- Biasing of Diode
- Forward Bias condition
- Reverse Bias Condition



Symbol of a Diode

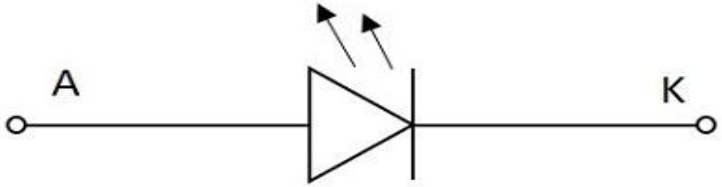


Forward biased Connection

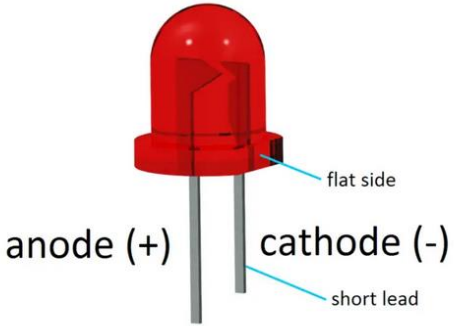
Reverse biased Connection

LED - Light Emitting Diode

- Like a normal PN junction diode, this is connected in forward bias condition so that the diode conducts. The conduction takes place in a LED when the free electrons in the conduction band combine with the holes in the valence band. This process of recombination emits light. This process is called as Electroluminescence



Symbol of LED



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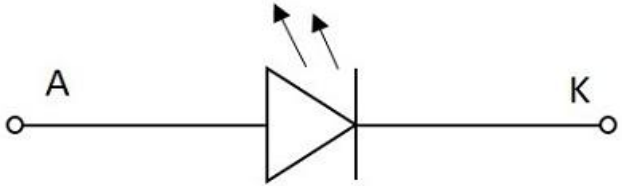
LED - Light Emitting Diode

- Applications
- TV Backlighting
- Smartphone Backlighting
- LED displays
- Automotive Lighting
- Dimming of lights
- Consumer LED products
- Many more….

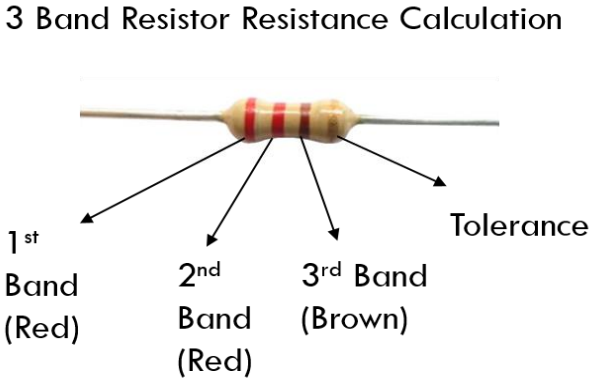


Symbol of LED

Resistor

- Resistor is an electrical component that reduces the electric current. The resistor's ability to reduce the current is called resistance and is measured in units of ohms (symbol: Ω). The resistor's resistance limits the flow of electrons through a circuit.

- How to Calculate the value of Resistor?



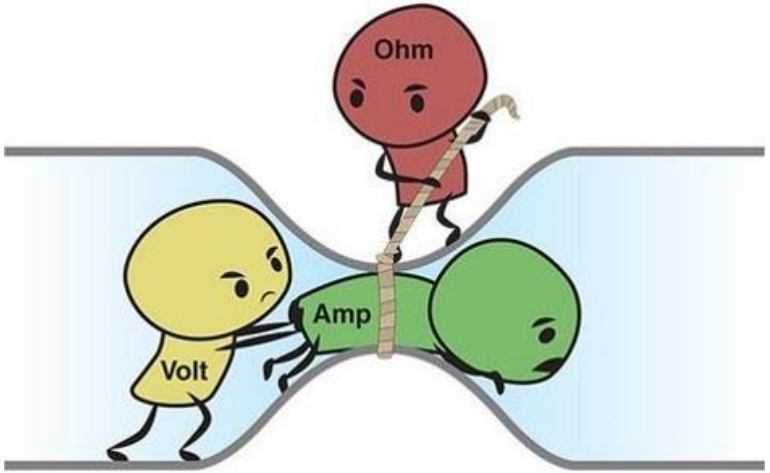
Color	Color	1st Band	2nd Band	3rd Band Multiplier	4th Band Tolerance
Black		0	0	x1Ω	
Brown		1	1	x10Ω	±1%
Red		2	2	x100Ω	±2%
Orange		3	3	x1kΩ	
Yellow		4	4	x10kΩ	
Green		5	5	x100kΩ	±0.5%
Blue		6	6	x1MΩ	±0.25%
Violet		7	7	x10MΩ	±0.10%
Grey		8	8	x100MΩ	±0.05%
White		9	9	x1GΩ	
Gold				x0.1Ω	±5%
Silver				x0.01Ω	±10%

Ohm's Law

- Ohm's law states that the current through a conductor between two points is directly proportional to the voltage or potential difference between the two points provided the temperature is constant for a constant length and area.

- Voltage = Current * Resistance
  V= I * R

  Where, V= voltage (Unit: volts or V)
  I= current (Unit: Amperes or A)
  R= resistance (Unit: ohms or Ω)



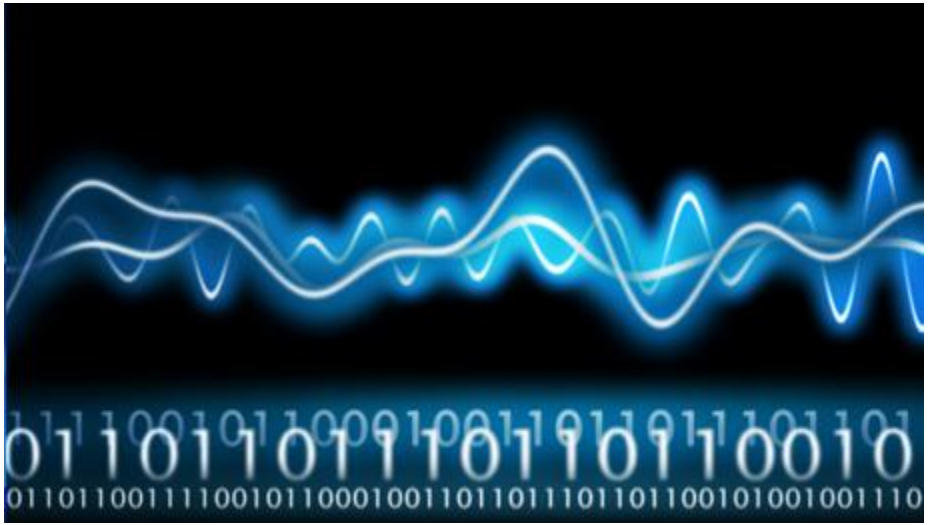
Source

Buzzer

- There are many ways to communicate between the user and a product. One of the best ways is audio communication using a buzzer
- What is buzzer?
- An audio signalling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical type. The main function of this is to convert the signal from audio to sound

Electronic Signal

- A Signal can be understood as "a representation that gives some information about the data present at the source from which it is produced." This is usually time varying.
- Signals can be classified either as Analog or Digital, depending upon their characteristics.



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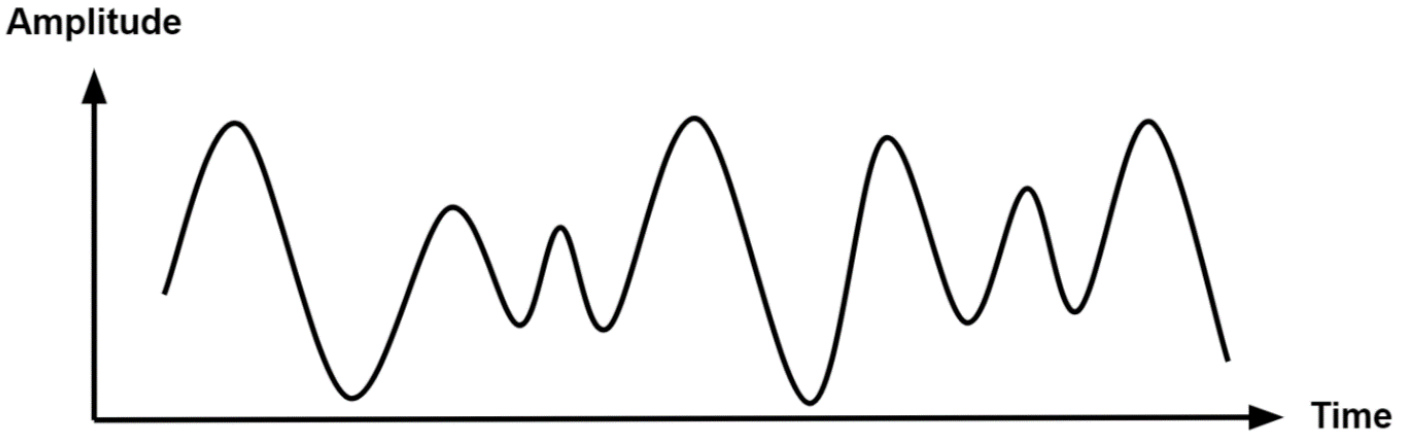
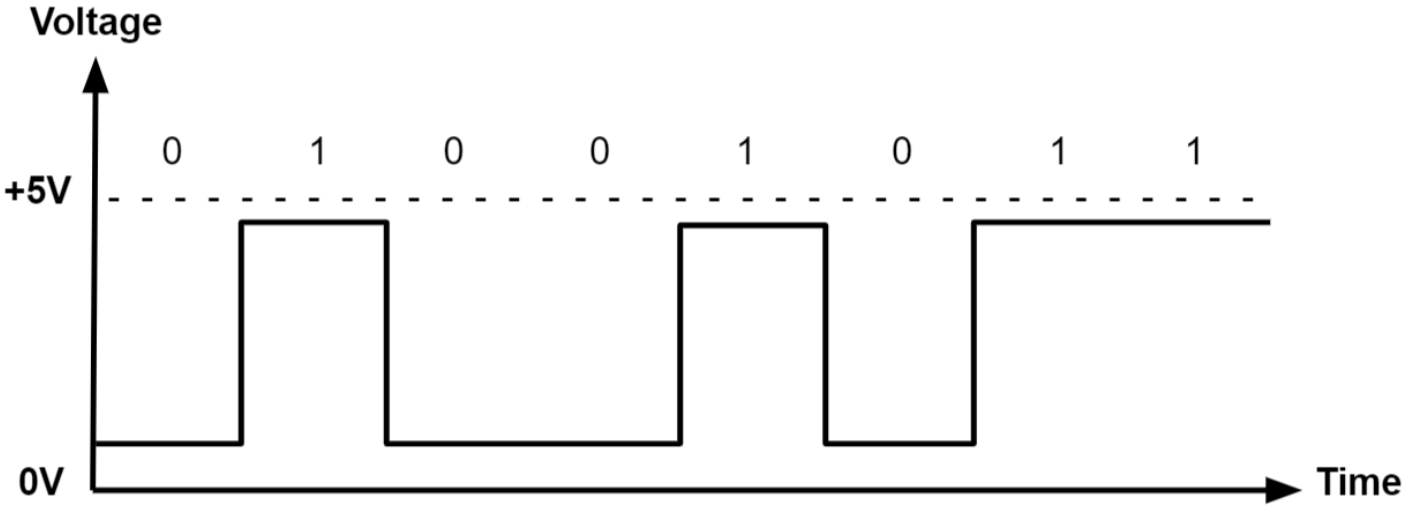
Analog Signal

- An analog signal is time-varying and generally bound to a range (e.g. +12V to -12V), but there is an infinite number of values within that continuous range. An analog signal uses a given property of the medium to convey the signal's information, such as electricity moving through a wire. In an electrical signal, the voltage, current, or frequency of the signal may be varied to represent the information.



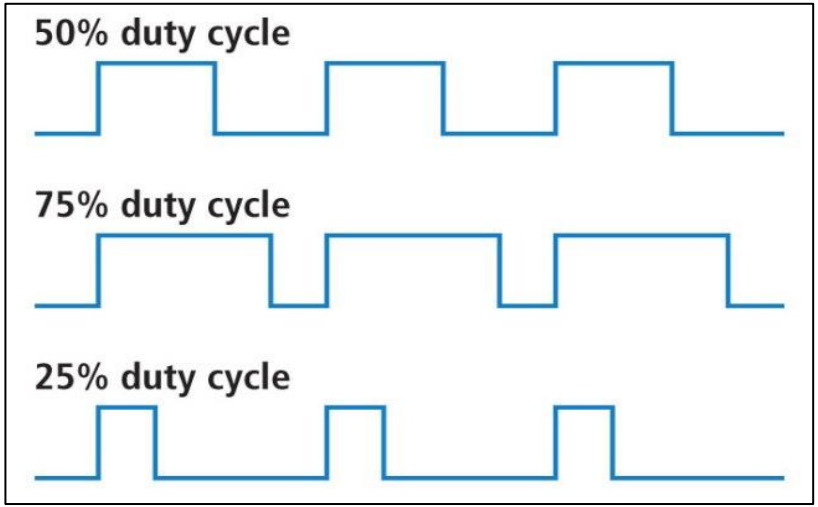
Digital Signal

- A digital signal is a signal that represents data as a sequence of discrete values



Pulse Width Modulation - PWM

- In power electronics, pulse width modulation is a proven effective technique that is used to control semiconductor devices.
- Pulse width modulation or PWM is a commonly used control technique that generates analog signals from digital devices such as microcontrollers.
- The signal thus produced will have a train of pulses, and these pulses will be in the form of square waves.



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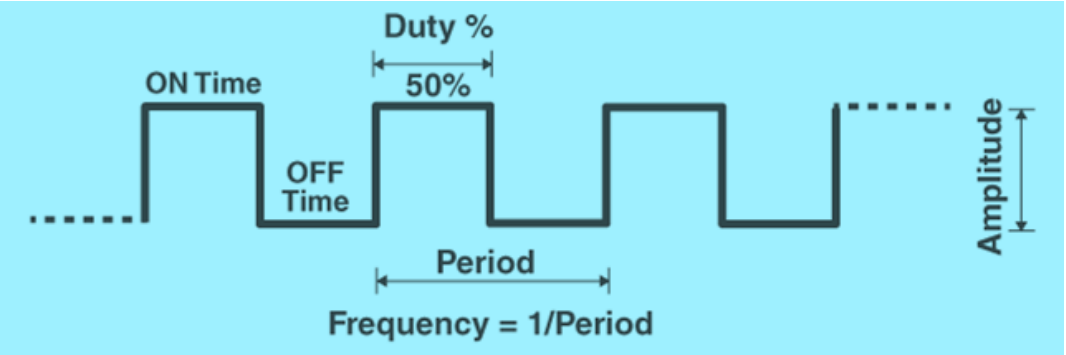
Pulse Width Modulation - Duty Cycle

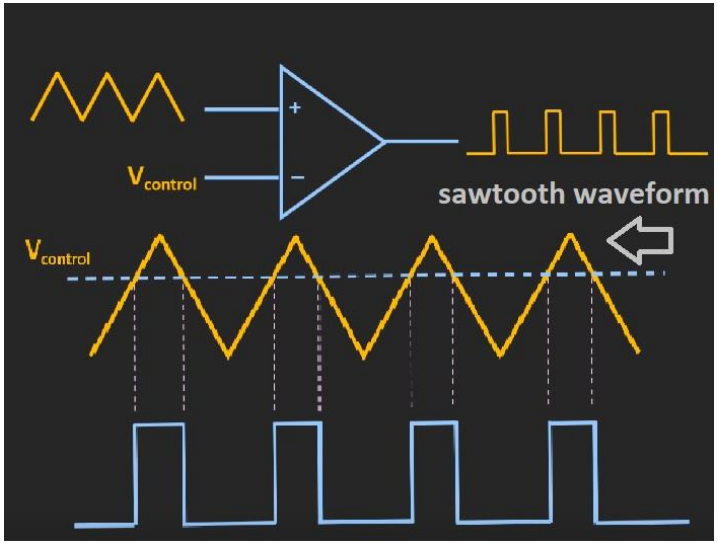
- PWM signal stays “ON” for a given a time and stays “OFF” for a certain time. The percentage of time for which the signal remains “ON” is known as the duty cycle

$$\text{Duty Cycle} = \frac{\text{Turn ON time}}{\text{Turn ON time + Turn OFF time}}$$



Pulse Width Modulation - Application

- The pulse width modulation technique is used in telecommunication for encoding purposes.
- The PWM helps in voltage regulation and therefore is used to control the speed of motors.
- The PWM technique controls the fan inside a CPU of the computer, thereby successfully dissipating the heat.
- PWM is used in Audio/Video Amplifiers.



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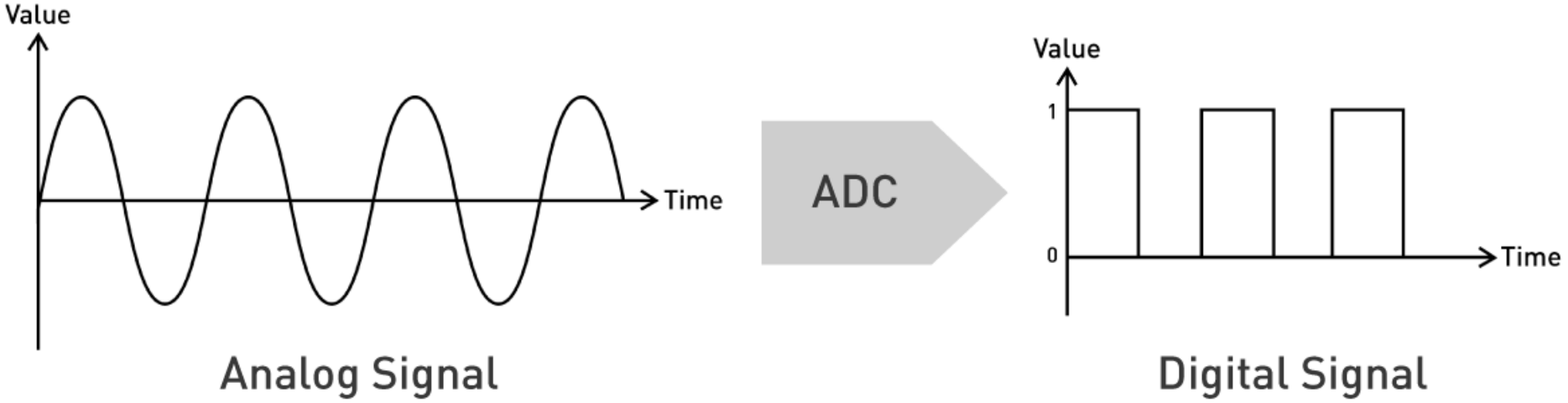
Analog to Digital Converter - ADC

- Analog-to-Digital converters (ADC) translate analog signals, real world signals like temperature, pressure, voltage, current, distance, or light intensity, into a digital representation of that signal



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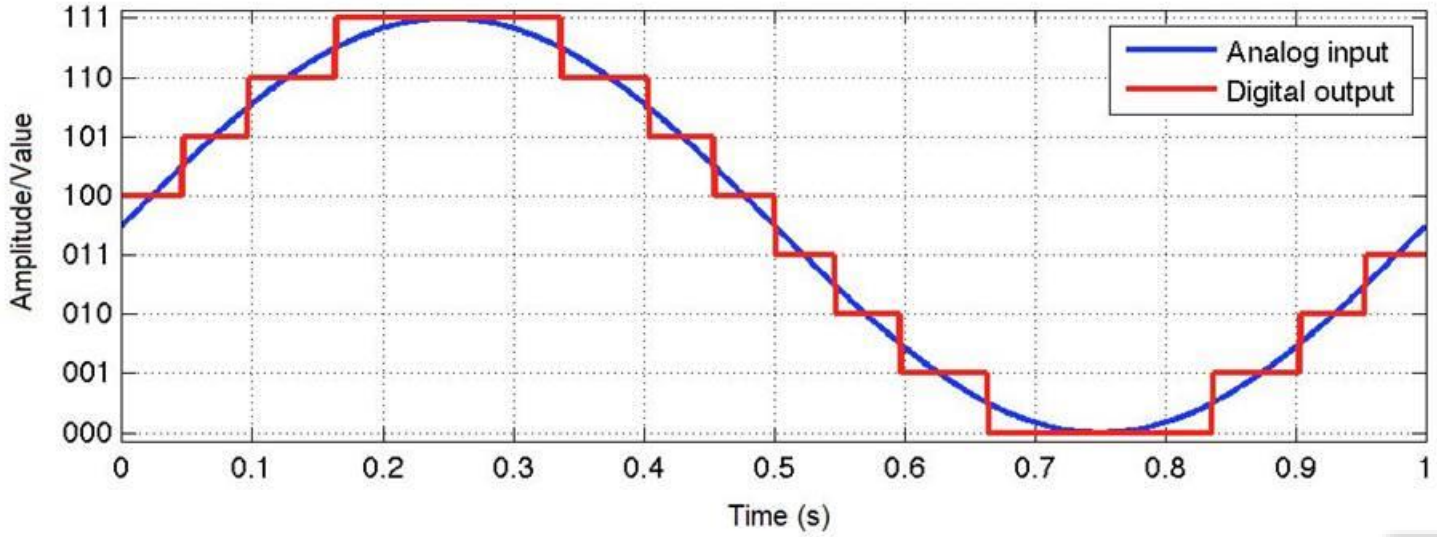
Reference link

Analog to Digital Converter - ADC

- Digital signals are represented by a sequence of discrete values where the signal is broken down into sequences that depend on the time series or sampling rate. The easiest way to explain this it through a visual! Figure shows a great example of what analog and digital signals look like.



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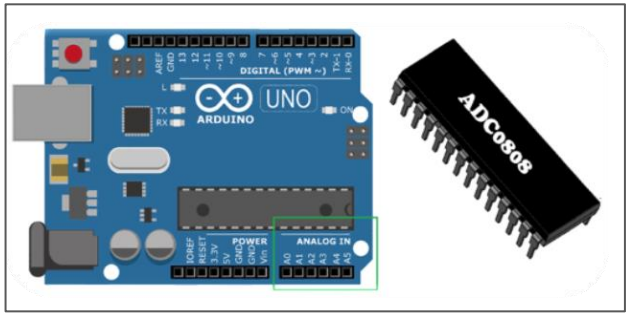
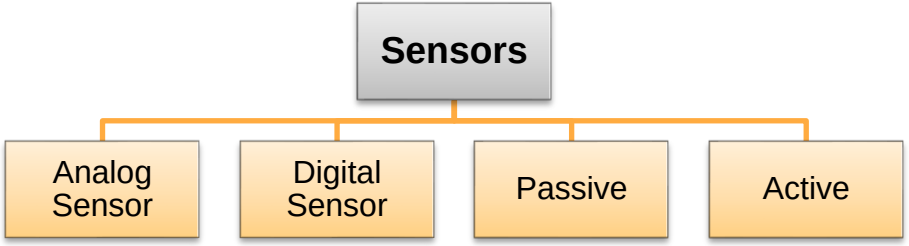
Analog to Digital Converter - Application



Types of Sensors

- **Analog Sensor**: The sensor that produces continuous signal with respect to time with analog output is called as Analog sensors
- **Digital Sensor**: When data is converted and transmitted digitally, it is called as Digital sensors. Digital sensors are the one, which produces discrete output signals
- **Active sensors** are those which do not require external power source for their functioning
- **Passive sensors** require external power source for their functioning.

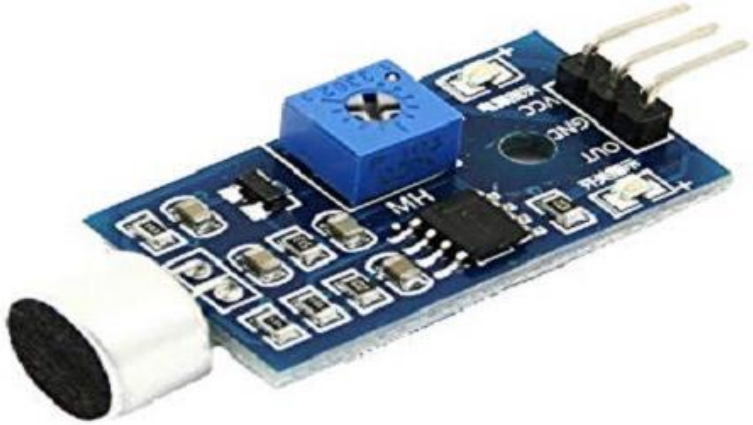


Rotary Angle Sensor - Potentiometer

- The rotary angle sensor produces analog output between 0 and Vcc (5V DC with Seeeduino) on its D1 connector. The D2 connector is not used.
- The angular range is 300 degrees with a linear change in value.
- The resistance value is 10k ohms, perfect for Arduino use. This may also be known as a “potentiometer”.

Sound Sensor

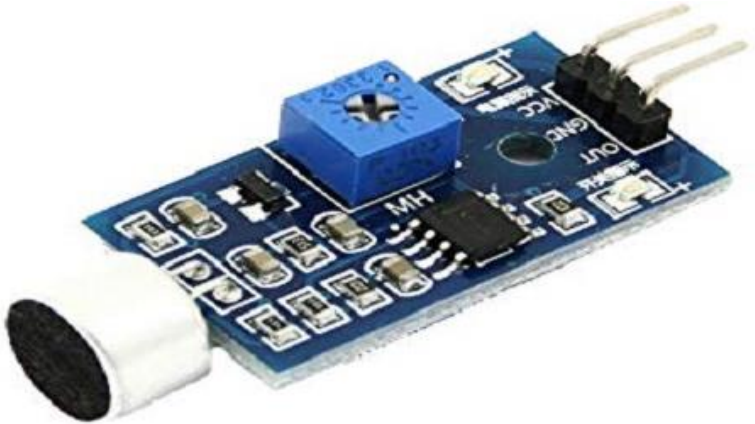
- The sound sensor is one type of module used to notice the sound.
- Generally, this module is used to detect the intensity of sound.
- The applications of this module mainly include switch, security, as well as monitoring.
- The accuracy of this sensor can be changed for the ease of usage.
- This sensor is capable to determine noise levels within DB’s or decibels at 3 kHz 6 kHz frequencies approximately wherever the human ear is sensitive



- Pin1 (VCC): 3.3V DC to 5V DC
- Pin2 (GND): This is aground pin
- Pin3 (DO): This is an output pin

Application of Sound Sensor

- Security system for Office or Home
- Spy Circuit
- Home Automation
- Robotics
- Smart Phones
- Ambient sound recognition
- Audio amplifier
- Sound level recognition (not capable to obtain precise dB value)

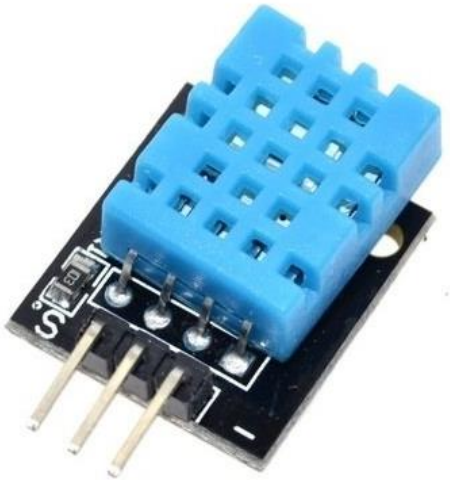


Temperature Humidity Sensor

- Temperature and humidity sensor (or rh temp sensor) is devices that can convert temperature and humidity into electrical signals that can easily measure temperature and humidity.

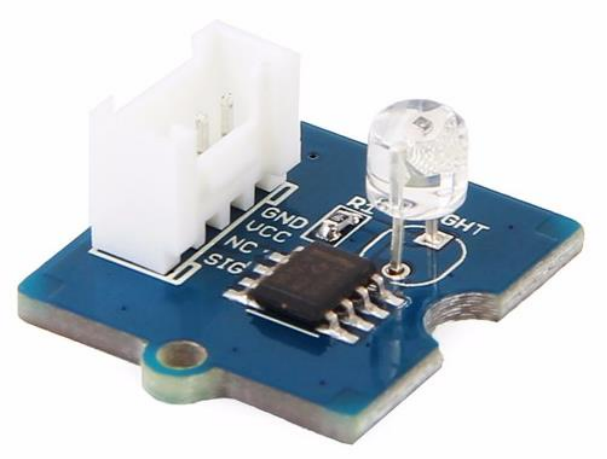
- DHT11 is a Humidity and Temperature Sensor, which generates calibrated digital output. DHT11 can be interface with any microcontroller like Arduino, Raspberry Pi, etc.

- Only three connections are required to be made to use the sensor - Vcc, Gnd and Output.



Light Sensor

- A light sensor is a photoelectric device that converts light energy (photons) detected to electrical energy (electrons)
- The light sensors used in robots are two types photovoltaic cells & photoresistors.
- Photovoltaic cells are used to change the solar radiation energy to electrical and these sensors are used in solar robot manufacturing.
- Photoresistors are used to alter their resistance by modifying light intensities.
- LDR is one the sensor belongs to light sensor family.



Ultrasonic Sensor

- An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal.

- Ultrasonic waves travel faster than the speed of audible sound

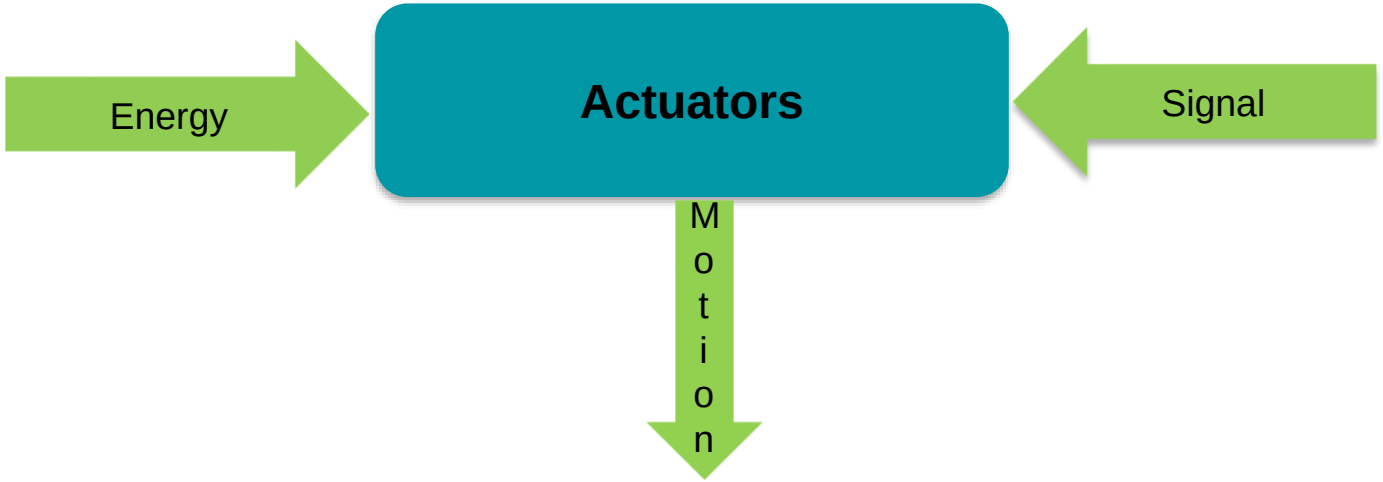
Ultrasonic Sensor - Working Principle

Click here

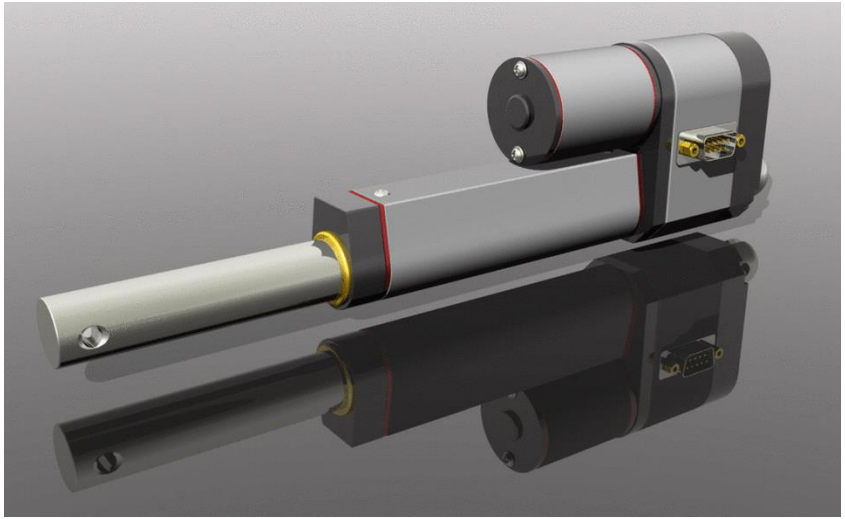
Reference link

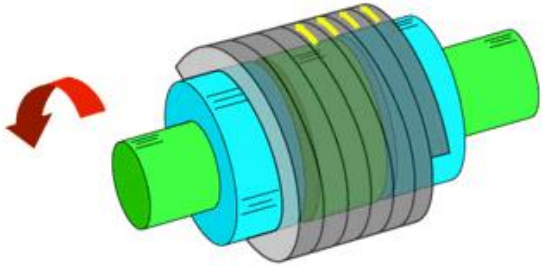
Introduction to Actuators

- An actuator is a device that produces a motion by converting energy and signals going into the system.
- The motion it produces can be either rotary or linear. Linear actuators, as the name implies, produce linear motion.



Actuators





Relay

- A Relay is a simple electromechanical switch. While we use normal switches to close or open a circuit manually, a Relay is also a switch that connects or disconnects two circuits. But instead of a manual operation, a relay uses an electrical signal to control an electromagnet, which in turn connects or disconnects another circuit.

Relay Applications:

- Lighting control systems
- Telecommunication
- Industrial process controllers
- Traffic control
- Computer interfaces
- Home appliances

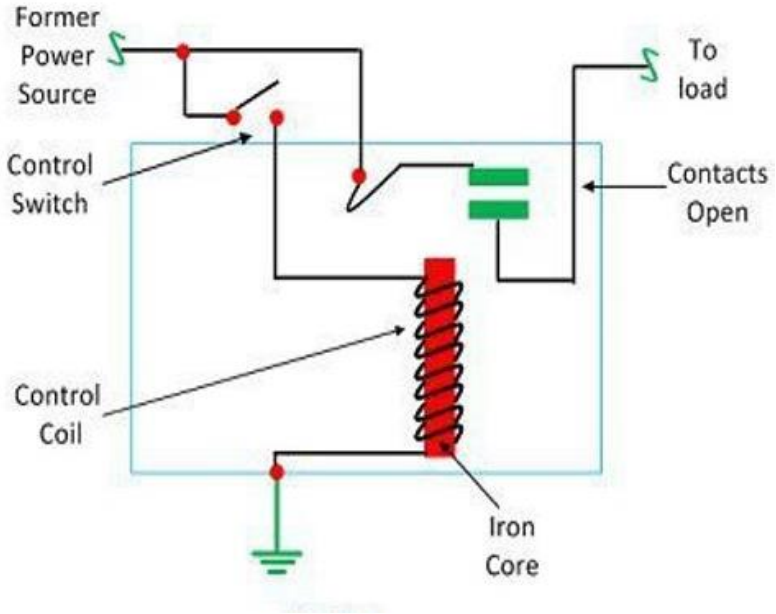
Click here

Reference link

Working Principle of Relay

- It works on the principle of an electromagnetic attraction. When the circuit of the relay senses the fault current, it energizes the electromagnetic field which produces the temporary magnetic field.

- This magnetic field moves the relay armature for opening or closing the connections. The small power relay has only one contacts, and the high-power relay has two contacts for opening the switch.



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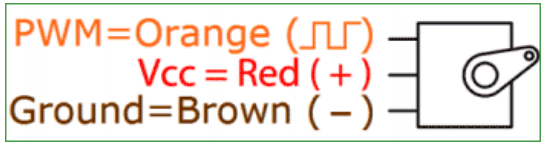
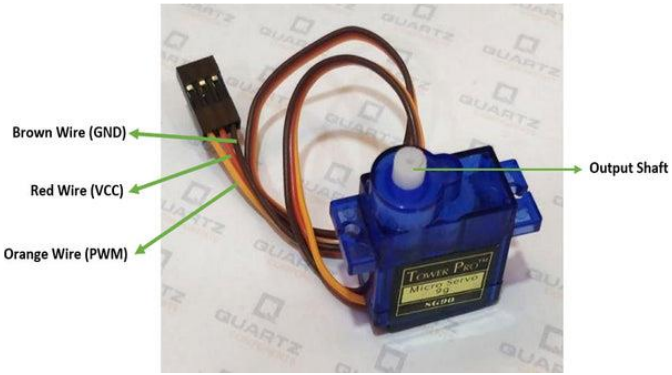
Servo Motor

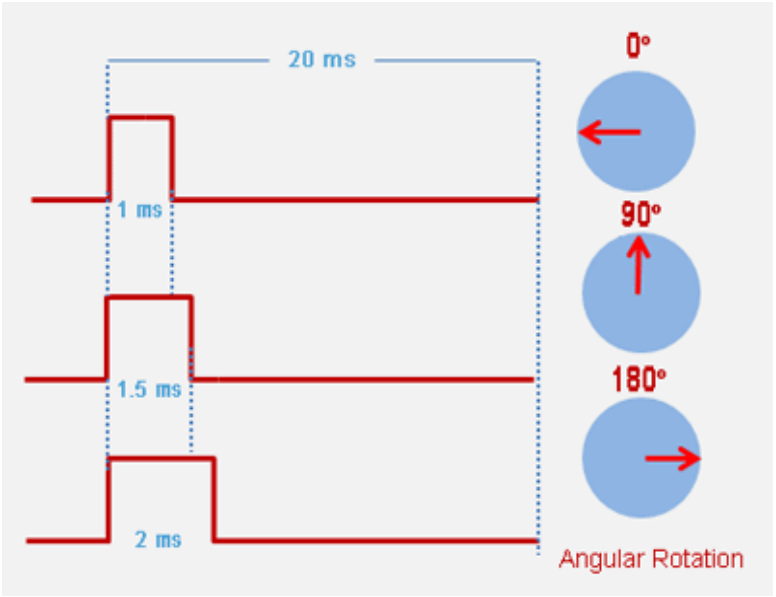
- A servo motor is a type of motor that can rotate with great precision.
- Normally this type of motor consists of a control circuit that provides feedback on the current position of the motor shaft, this feedback allows the servo motors to rotate with great precision.
- A servo motor usually comes with a gear arrangement that allows us to get a very high torque servo motor in small and lightweight packages.



Servo Motor

- Servo motor works on PWM (Pulse width modulation) principle, means its angle of rotation is controlled by the duration of applied pulse to its Control PIN.
- Each 0.5 ms signal move 90 degree rotation





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LCD – Liquid Crystal Display

- LCD stands for Liquid Crystal Display that uses a plane panel display technology, used in screens of computer monitors & TVs, smartphones, tablets, mobile devices, etc.
- What is 16x2 LCD?
- An electronic device that is used to display data and the message is known as LCD 16×2.
- As the name suggests, it includes 16 Columns & 2 Rows so it can display 32 characters (16×2=32) in total & every character will be made with 5×8 (40) Pixel Dots. So the total pixels within this LCD can be calculated as 32 x 40 otherwise 1280 pixels.

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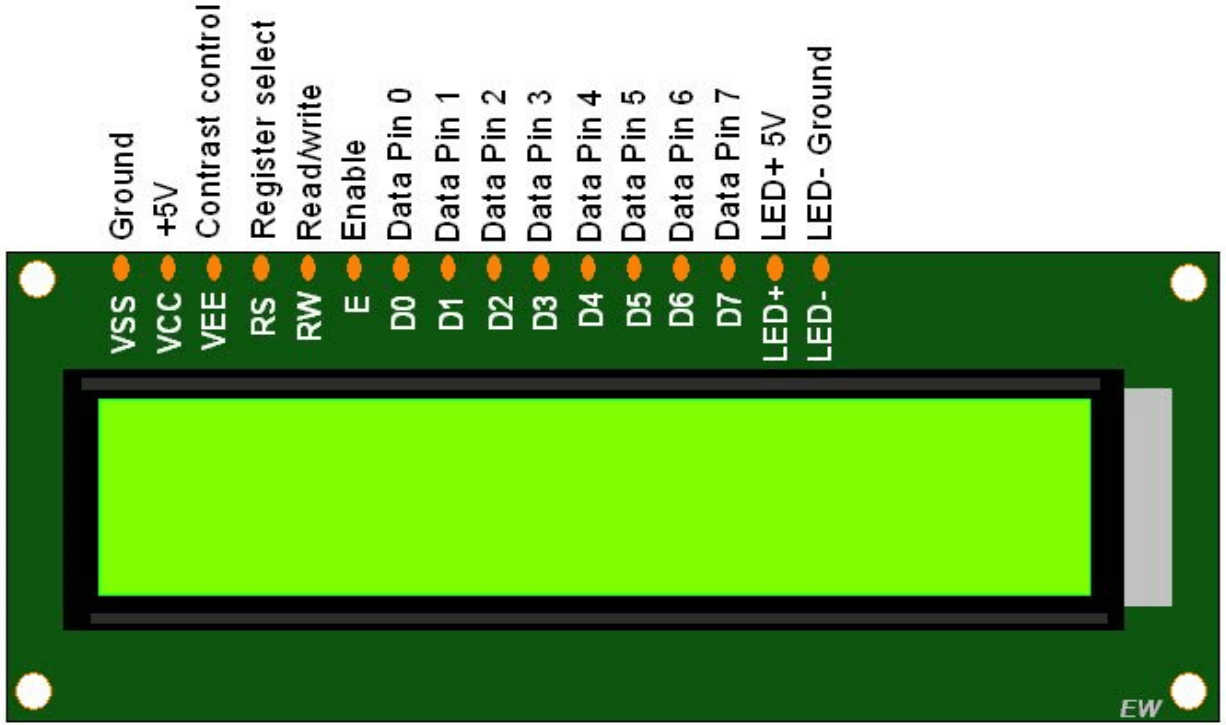
Reference link

LCD – Pin Configuration



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Summary

We have completed this section and now we have understood about:

- What is sensors and Application of sensors.
- What is mechanism of sensors.
- Electronic concepts behind the sensor's mechanism.
- We have studied varies types of sensors like potentiometer, sound sensor, temperature and Humidity sensor, Light sensor and Ultrasonic sensor.
- Types of Actuators and its applications
- We have studied various types of Actuator like Relay, Servo Moter and LCD.

Quiz

1. What is a buzzer primarily used for?

a) Producing sound
b) Generating light
c) Measuring temperature
d) Transmitting data

Answer: a

Quiz

2. Which type of signal is commonly used as the carrier signal in PWM?

a) Sine wave
b) Square wave
c) Triangular wave
d) Sawtooth wave

Answer: b

Quiz

3. What does PWM stand for in electronics?

a) Power Wave Modulation
b) Pulse Width Modulation
c) Positive Width Modulation
d) Phase Width Modulation

Answer: b

Quiz

4. What is the primary function of an Analog-to-Digital Converter (ADC)?

a) Convert digital signals to analog signals
b) Convert analog signals to digital signals
c) Generate analog signals
d) Measure frequency of signals

Answer: b

Quiz

5. Which of the following sensor combinations is often used to monitor and control indoor climate conditions?

a) Pressure sensor and light sensor
b) Humidity sensor and ultrasonic sensor
c) Temperature sensor and gas sensor
d) Temperature sensor and humidity sensor

Answer: d

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Thank you...!