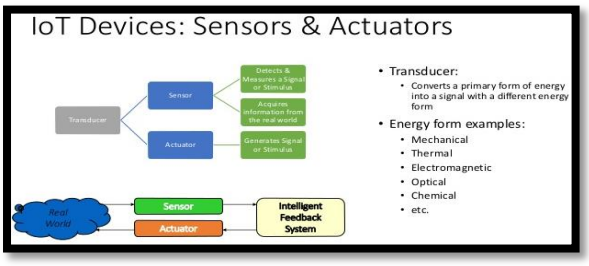


Sensor:

It is a transducer which converts physical energy like heat, sound, strain, pressure, vibrations and motion into electrical energy.

Sensor technology:

It is a technology used for designing sensors and associated electronic readers, circuits and devices.

smart sensor:

A sensor with a built-in integrated circuit (microcontroller, and sensor) to directly give the output as physical parameter on giving input supply voltages and other signals as commands.

Sensors are mainly classified into two types based on the output produced.

- Analog Sensors
- Digital sensor

Analog sensor:

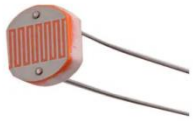
- It produces continuous output signal or voltage which is proportional to quantity to be measured.
- It produces analog output for the sensed physical Quantities such as temperature, speed, displacement, pressure, strain etc. are analog quantities as they are continuous in nature. Example: Temperature of liquid can be measured using thermometer or thermocouple which continuously responds to changes in temperature as liquid is heated up or cooled down.

Analog sensor circuit:

- It uses an ADC internal in a microcontroller or External ADC in the circuit between the sensor and a microcontroller port.
- ADC converts input signals to digital number.
- An 8-bit port accepts 8-bit input which corresponds to 0 to 255 from the ADC
- A microcontroller may consist of in-circuit ADC or multiple inputs ADC.
- Alternatively, a port accepts digital input consisting of 1s and 0s through an external ADC.

An electronic circuit connects to the sensor which receives the output in form of variations through circuit parameters (voltage, resistance, capacitor and current) from the sensor according to the variation in physical condition (temperature, humidity, pressure, PH value etc).

Analog Light Sensor:



- There are different types of light sensors available such as photo-resistors, photo-diodes, photovoltaic cells, photo-tubes, photo-multiplier tubes, photo-transistors, charge-coupled devices, and so on. But, LDR (Light Dependent Resistor or photo-resistor) is a light sensor in this light sensor circuit. These LDR sensors are passive and don't produce any electrical energy.

sensors are classified based on the circuit parameter produced. they are

1.Resistive sensor:

The resistance of the sensor varies according to specific change in the physical parameters of the environment.AC or DC devices are used to measure the resistance change.

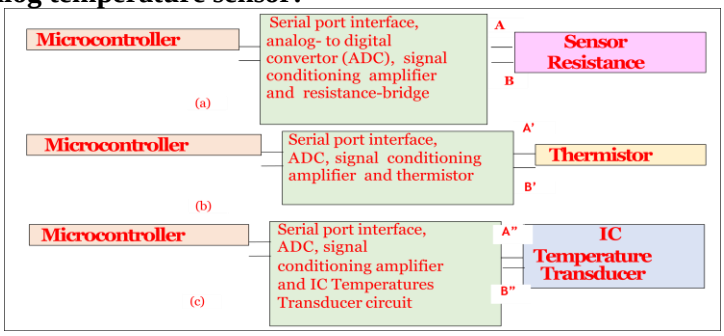
$$R = \frac{\rho L}{A}$$

Examples:

1. **Reading Temperature from Resistance Sensor:**

A resistor in the form of a wire or a component can be a part of the electronic circuit. Ohm's law states that resistance remains constant only as long as physical conditions remain the same. The resistor functions as a sensor when its value changes measurably within the required temperature range for sensing.

Analog temperature sensor:

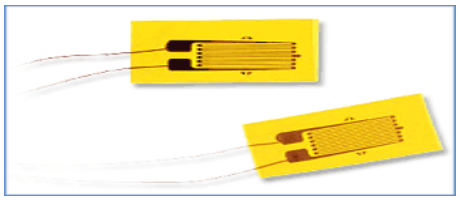


The above figure represents analog temperature sensor based on the circuit parameter.

Fig. a ,b represents analog temperature sensor which produces resistance as output

Fig.c represents an IC-based circuit for a temperature-transducer induces current in the output according to the heat energy, represented by the temperature.

2. Resistance of a photo-conductor shows measurable drop in presence of light. The conductivity (reciprocal of resistance) of sensor increasing depending on the radiation intensity.
3. A Strain gauge (sometimes refered to as a Strain gage) is a sensor whose resistance varies with applied force; It converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured. When external forces are applied to a stationary object, stress and strain are the result.



capacitive sensor:

Example:

1.A level sensor capacitor shows variation with level of filler in a container and computes the level upto which the container fills.

2. **Capacitive touch sensor:**

Capacitive Touch Sensor

These are some of the most popular types among touch sensors. As the name suggests, capacitive touch sensors resemble similar to a capacitor. The capacitance of this sensor can be expressed by the formula.

$$c=\varepsilon 0 * \varepsilon r * A/d$$

Where,

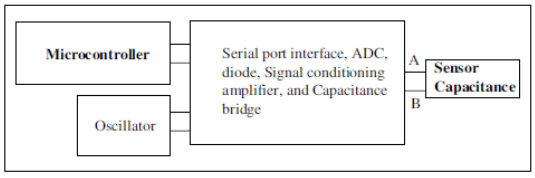
ε0' = Free space permittivity

'εr' = Relative Permittivity or permittivity of dielectric constant

'A' = Area of the parallel plates

'd'= Distance among the plates that are parallel to each other

- From the above formula for the capacitive touch sensor, two conclusions can be derived.
- The capacitance is directly proportional to the area o the plates. The increase in the area results in an increase in capacitance and vice-versa. It can be understood from the formulae that the increment in the distance of the plates decreases, the value of capacitance at the distance is inversely proportional to the capacitance.
- In this sensor, there are two plates with 'Co' as the capacitance. When the human touch is identified, the touching part to the sensor is referred to as a conducting object and the capacitance is denoted as CT.
- The 'Co' is monitored continuously by using measuring equipment as the change in the capacitance is detected, it will be converted in the form of a signal.
- Microcontroller is a computing device which reads the input at its ports, saves the input at memory, and then uses the data for communication over the Internet as shown in bellow figure.

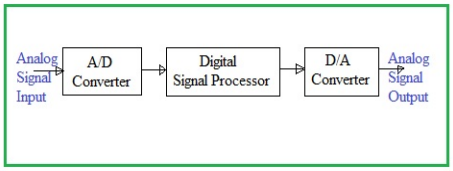


Microcontroller electronic circuit; port connected to sub-circuits; serial port interface, ADC, diode, signal conditioning amplifier and capacitance bridge, and sensor capacitance at A and B

Digital sensor:

- It produces discrete digital output signal or voltage which is digital representation of quantity to be measured.
- It produces binary output in the form of ones (1s) and zeros (0s).
- 1 corresponds to certain range of Voltage, current, frequency, phase or other electronic parameter. and 0 corresponds to another range of Voltage, current, frequency, phase or other electronic parameter

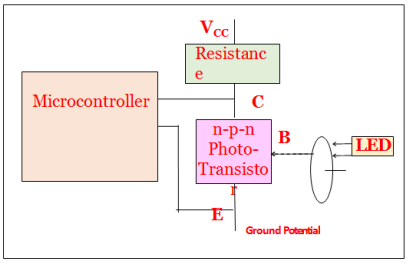
- For example, 1 correspond to 12 to 8 V output and 0 corresponds to 0 to 4 V.



Different applications of digital sensor are

- Sensing of presence of traffic on a street .
- Sensing the filling of a waste container up to certain preset level that sends an alert on Internet to a City Waste Management Service.
- Sensing of organic vapours presence on sensing gas leakage.
- Sensing fire for generating emergency alert by sudden rise of temperature in vicinity or detecting the smoke.
- Sensing ambient light condition.

Measuring the speed of a vehicle:

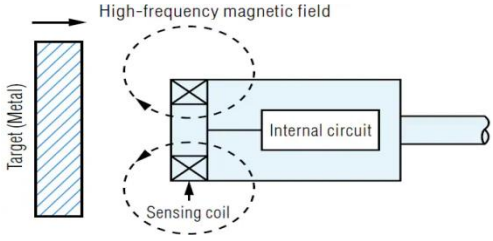


- Sensing wheel rotation for computing the speed of a vehicle Microcontroller electronic circuit for a rotating wheel, rotation-completion sensing which senses two states (completion or incomplete) and generate two outputs 1 or 0 for the port pin.

- A rotating wheel gives two outputs 1 or 0, when it has a pair of LED or IR-LED (light emitting diode or infrared LED) and phototransistor (FPT) is on two sides of a slot in the wheel as shown in above figure.
- The circuit gives 1 in output when a slot of rotating wheel reaches near the FPT on completing a rotation and gives 0 in outputs till that is revolving towards the completion of the next revolution.
- The light to FPT does not block till the wheel completes the revolution.
- A Microcontroller port P0 pin receives the input 1 or 0.
- Number of 1s within a specific time interval divided by the interval gives the rotational speed revolutions per minute (rpm).
- The values of the rpm and circumference of the tyre enable the computation of speed in km/hour in the automobile, as rotator motion converts to linear motion in the automobile.

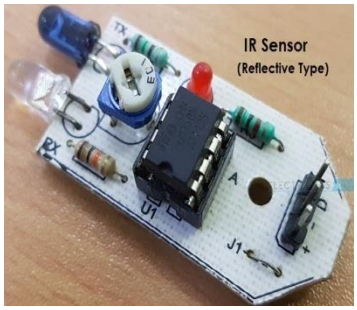
Environmental Monitoring Sensors:

1. Proximaty sensor:

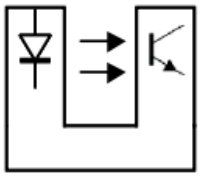


- A Proximity Sensor is a non-contact type sensor that detects the presence of an object. Proximity Sensors can be implemented using different techniques like Optical (like Infrared or Laser), Sound (Ultrasonic), Magnetic (Hall Effect), Capacitive, etc.
- Some of the applications of Proximity Sensors are Mobile Phones, Cars (Parking Sensors), industries (object alignment), Ground Proximity in Aircrafts, etc.
- There are many types of proximity sensors, and they each sense targets in distinct ways.
  1. photoelectric proximate sensor (ex: IR Sensor)
  2. Inductive proximate sensor (to detect metals) the above figure represents the inductive proximate sensor internal circuit.
  3. Capacitive proximate sensors(to detect any thing which carry electrical charge)
  4. magnetic proximate sensors (to identify permanent magnets)
  5. ultrasonic proximate sensors (to measure the distance)

Infrared Sensor (IR Sensor):



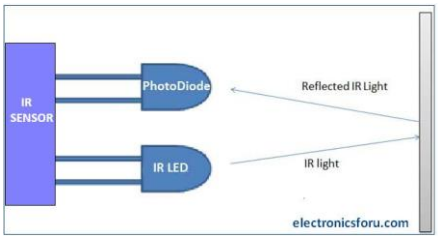
- There are two types of Infrared or IR Sensors:
  1. **Transmissive Type and Reflective Type**:



Transmissive optical sensor

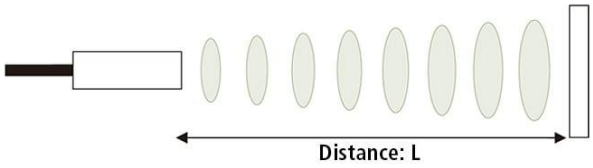
In this type the IR Transmitter (usually an IR LED) and the IR Detector (usually a Photo Diode) are positioned facing each other so that when an object passes between them, the sensor detects the object.

  2. **Reflective Type IR Sensor:**



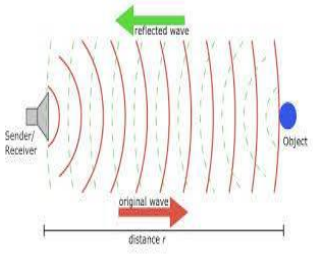
  3. In this, the transmitter and the detector are positioned adjacent to each other facing the object. When an object comes in front of the sensor, the infrared light from the IR Transmitter is reflected from the object and is detected by the IR Receiver and thus the sensor detects the object.
- Different applications where IR Sensor is implemented are Mobile Phones, Robots, Industrial assembly, automobiles etc.

Ultrasonic Sensor:



- An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves.
- An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity.
- To detect transparent and other items where optical technologies may fail, ultrasonic sensors are a reliable choice.

working principle:



- The working principle of this module is simple. It sends an ultrasonic pulse out at 40kHz which travels through the air and if there is an obstacle or object, it will bounce back to the sensor. By calculating the travel time and the speed of sound, the distance(range) can be calculated.

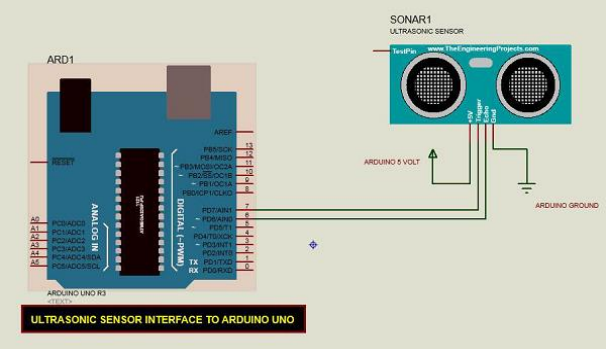
$$\textbf{Distance } L = 1/2 \times T \times C$$

where L is the distance, T is the time between the emission and reception, and C is the sonic speed. (The value is multiplied by 1/2 because T is the time for go-and-return distance.)

- This sensor is an electronic device that will measure the distance of a target by transmitting ultrasonic sound waves, and then will convert the reflected sound into an electrical signal.
- Ultrasonic sensors are a great solution for the detection of clear objects. For liquid level measurement, applications that use infrared sensors, for instance, struggle with this particular use case because of target translucence.
- For presence detection, ultrasonic sensors detect objects regardless of the color, surface, or material (unless the material is very soft like wool, as it would absorb sound.)

Example: HC-SR04

- It is an ultrasonic sensor uses SONAR to determine the distance of an object just like the bats do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2 cm to 400 cm or 1" to 13 feet.
- The configuration pin of HC-SR04 is VCC (1), TRIG (2), ECHO (3), and GND (4). The **supply voltage** of VCC is **+5V** and you can attach TRIG and ECHO pin to any Digital I/O in your Arduino Board as shown in bellow figure.

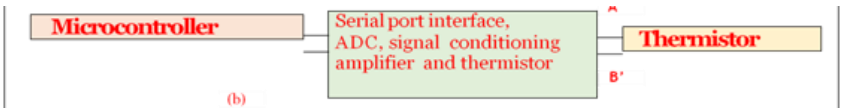


2. Temperature Sensor:

- One of the most common and most popular sensors is the Temperature Sensor. A Temperature Sensor, as the name suggests, senses the temperature i.e., it measures the changes in the temperature.
- There are different types of Temperature Sensors like Temperature Sensor ICs (like LM35, DS18B20), Thermistors, Thermocouples, RTD (Resistive Temperature Devices), etc.

Temperature Sensors can be analog or digital. In an Analog Temperature Sensor, the changes in the Temperature correspond to change in its physical property like resistance or voltage. LM35 is a classic Analog Temperature Sensor.

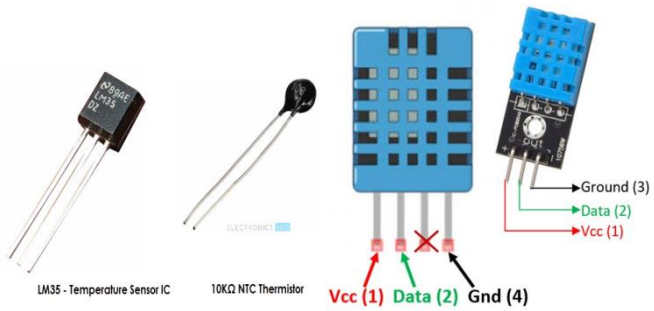
Thermistor:



- A component called thermistor, shows larger changes in resistance within narrow environment temperature range (120°C to –90°C).
- An NTC thermistor shows negative temperature coefficient which means a drop in the resistance value with rise in temperature.
- Thermistor finds applications in home automation or in sensing the clouds.
- The output of thermistor connects to the circuit of a signal conditioning amplifier, ADC and then
- to microcontroller serial port as shown in above figure.
- A temperature sensor is called PTC, when it exhibits a Positive Temperature Coefficient. Resistance value of a PTC resistor rises with rise in temperature. A thin wire of platinum or other metallic alloys shows linear changes with its temperature. These can be used for sensing temperature and measuring the values over very wide ranges of temperatures, say (0–1600°C).

Coming to the Digital Temperature Sensor, the output is a discrete digital value (usually, some numerical data after converting analog value to digital value). DS18B20, DHT11 are simple Digital Temperature Sensor.

Temperature Sensors are used everywhere like computers, mobile phones, automobiles, air conditioning systems, industries etc.



3. Humidity Sensor:

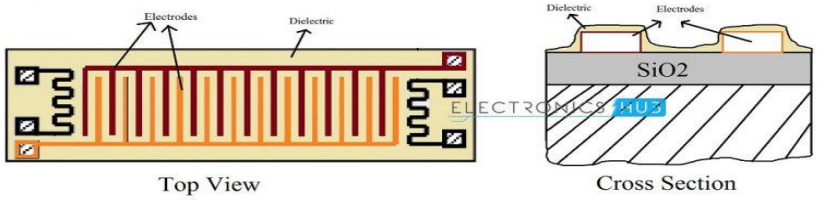
Humidity is measured in percentage. It is the relative percentage ratio (RH%) of content of water vapours in air compared to one in a situation of maximum possible water vapour content for the air temperature at the instance of measurement.

There are two types of RH sensors

1.capacitive RH sensor

2.Resistive RH sensor

capacitive RH sensor:



Capacitive sensors use two electrodes to monitor the capacitance (i.e. the ability to store an electric charge) of a thin metal strip placed between them. The metal's capacitance increases or decreases at a rate that is directly proportional to the change of humidity in the sensor's environment. The difference in charge (voltage) generated by an increase in humidity is then amplified and sent to the **embedded computer** for processing.

Resistive humidity sensors operate on a different principle. These sensors utilize a small polymer comb that increases and decreases in size as the humidity changes, which directly affects the system's ability to store charge.

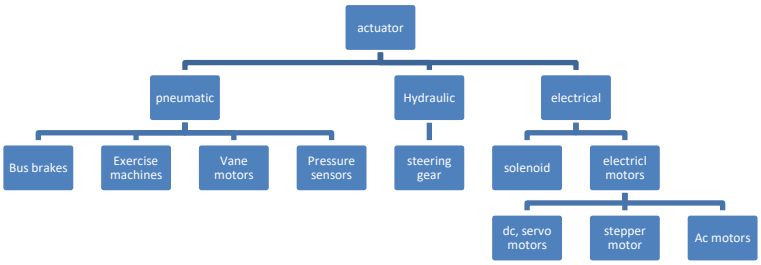
Actuators:

- An actuator is a device that takes actions as per the input command, pulse or state (1 or 0), or set of 1s and 0s, or a control signal.
- An attached motor, speaker, LED or an output device converts electrical energy into physical action.

Examples for actuators are:

1. Light sources
2. LEDs
3. Piezoelectric vibrators and sounders
4. Speakers
5. Solenoids
6. Servomotor
7. Relay switch
8. Switching on a set of streetlights
9. Application of brakes in a moving vehicle
10. Ringing of alarm bell
11. Switching off or on a heater or air-conditioner or boiler current in a steam boiler in a thermal plant.

Types of Actuators:

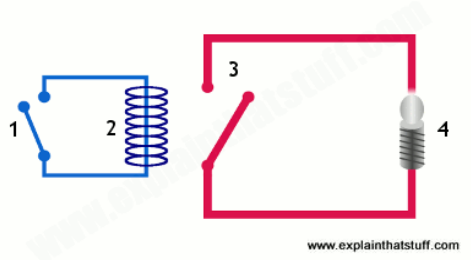


LED:

- LED is an actuator which emits light or infrared radiation.
- It Uses of different colour LEDs, RGB (Red-Green-Blue) LEDs, intensity variation of LED and colours, graphic and text display using big screens are actions which are controlled using the inputs.
- RGB LED has three inputs to control, i.e. R, G and B components and thus the composite colour.
- Pulse width modulated pulses control the LED light emission intensity. A microcontroller is used for generating PWM outputs.

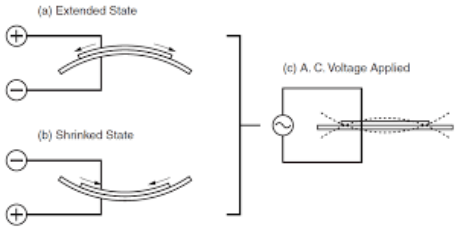
Relay Switch:

A relay switch makes mechanical contact when the input circuit magnetizes with a control circuit and pulls a lever to make the contact as shown in bellow figure.

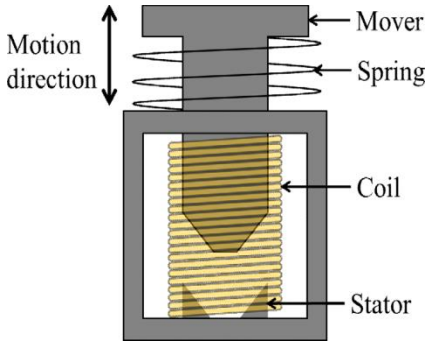


- An electronic switch can be controlled by the input 1 or 0 from the port pin of a microcontroller or through a push button switch and battery.
- The current flows through the switch or voltage applies through the switch depending upon the input state 1 or 0 from the port pin of a microcontroller or through a push-button switch and battery.

Piezoelectric Vibrator:
Piezoelectric crystals when applied in varying electric voltages at the input generate vibrations.
Piezoelectric Buzzer:



A piezoelectric speaker enables synthesised music tunes and sounds.The appropriately programmed pulses generate the music, sounds, buzzers and alarms when they are the input to the speaker. A microcontroller is used for generating PWM outputs for actions using speakers.
Solenoid:
A solenoid is an actuator consisting of a number of cylindrically wound coils. The flow of current creates a magnetic field in proportion to the number of turns in the solenoid and the current in it.



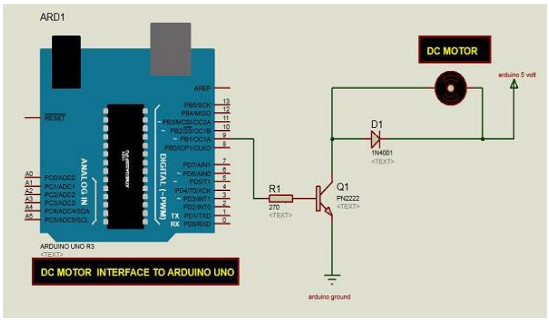
- If a shaft made of iron is placed along the axis, then its motion can be controlled by the input current, pulses and variations of current with time.
- It can create a sharp forward push, backward push and repeated to and fro motion. It can also create rotator motion from linear motion by using a Cam.
- A cam with linear shaft assembly is used in an engine to convert rotatory motion into linear motion and vice versa. A cam is an especially cut mechanical rotating object such that the radius linearly increases (from the centre) between 0° and 180° rotation and decreases between 180° and 360°.

- When a cam assembly rotates, then a linear shaft moves in forward and backward motions in each rotation**.**

DC Motor:

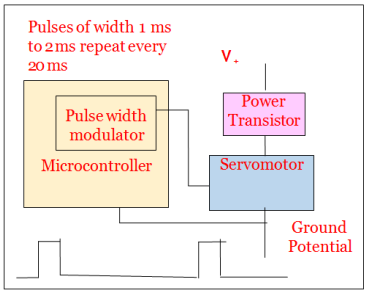
A DC motor (Direct Current motor) is the most common type of motor. DC motors normally have just two leads, one positive and one negative. If you connect these two leads directly to a battery, the motor will rotate. If you switch the leads, the motor will rotate in the opposite direction.

DC Motor interfaced with ARDUINO UNO:



Servomotor:

- Servomotor is a geared DC motor for applications such as robotics. It rotates the shaft of a motor.
- The shaft of the motor can be controlled and positioned or rotated through 180° (+90°) degrees. The shaft's angular position is controlled through 180°, between –90° and +90° degrees.
- A servomotor is conveniently controlled by PWM. The motor has three terminals. Two are for the supply voltage and ground. A position control PWM signal to the motor is given at the third terminal as shown in bellow figure.



Microcontroller electronic circuit for controlling servomotor angular position

- The microcontroller has an internal circuit to generate pulses of different widths as per value, p loaded in the PWM register.
- When the port output PWM pulse is of width 1.5 ms, then it places the shaft at a mid angular position.
- Let us assume that when the pulse width is 1 ms, the angle is –90°.
- When the width is 2 ms, then the angular position is +90°.
- Varying the width, pwms between 1 and 2 ms using the PWM register value will change the angular position,

f = [(pw –1.5) ×180°] When pw = 1.5 ms, then, f = 0° (mid angular position), when 1 ms, then –90°; when 2 ms, then +90°.

Electric Linear Actuator:

- An electric linear actuator is a device that converts the rotational motion of a motor into linear motion. This will provide both push and pull movements via the main extending shaft on the Actuator. This pushing and pulling action makes it possible to lift, drop, slide, adjust, tilt, push or pull things, simply by pushing a button.
- Installing a Linear actuator is very simple compared to pneumatic or hydraulic systems because they take up much less space. Electric Linear Actuators have no pumps or hoses, or tanks. They are also cheaper than Hydraulic or Pneumatic Actuators for the same reason.
- An electric linear actuator consists of a DC or AC motor, a series of gear and a Lead screw including a nut. This is in essence what all Linear Actuator consist of, and all that changes from one model to another, are the motor sizes, the gearing ratio inside the gearbox, and the lead-screw style and pitch.

Pneumatic Actuators:

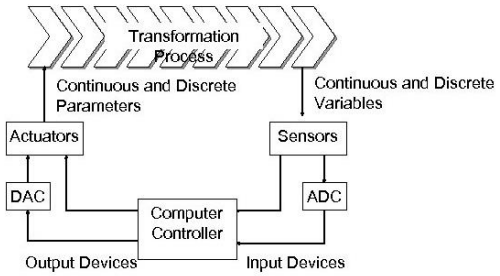
- Pneumatic Actuators move a valve position by converting air pressure into linear or rotary motion.
- Linear motion devices opening close valves such as Gate, Globe, Diaphragm, and others with a sliding stem to control the position up the flow control element.
- Rotary Motion devices typically operates quarter turn type valve such as ball, plug, and butterfly. A quarter turn valve is one which can be opened 100 percent by turning the flow control element just 90 degree.

Hydraulic Actuator:

Hydraulic Actuator is the type of actuator that utilizes the hydraulic pressure as input in order to provide excitation to the plant (controlled process) of the control system. The controller provides the control signal to the actuator that hydraulically applies the equivalent signal to the plant in order to have the desired output in controlled operations.

Computer-Process Interface:

To implement process control, the computer must collect data from(sensors) and transmit signals to the production process(actuators). the bellow figure represents the computer process control system.



Components required to implement the interface:

- Sensors to measure continuous and discrete process variables
- Actuators to drive continuous and discrete process parameters
- Devices for ADC and DAC
- I/O devices for discrete data

RFID:

- Radio Frequency Identification (RFID) is the wireless non-contact use of radio frequency waves to transfer data.

- Tagging items with RFID tags allows users to automatically and uniquely identify and track inventory and assets.
- RFID takes auto-ID technology to the next level by allowing tags to be read without line of sight and, depending on the type of RFID, having a read range between a few centimetres to over 20+ meters.

Within the Electromagnetic Spectrum, there are three primary frequency ranges used for RFID transmissions – Low Frequency, High Frequency, and Ultra-High Frequency.

Low Frequency based RFID:

- Low Frequency Range in electromagnetic spectrum : 30 - 300 kHz
- RFID operating Frequency Range: 125 - 134 kHz
- Read Range: Contact - 10 Centimetres
- Average Cost Per Tag: $0.75 - $5.00
- Applications: Animal Tracking, Access Control, Car Key-Fob, Applications with High Volumes of Liquids and Metals.
- Pros: Works well near Liquids & Metals, Global Standards
- Cons: Very Short Read Range, Limited Quantity of Memory, Low Data Transmission Rate, High Production Cost

High Frequency based RFID:

- High Frequency Range in electromagnetic spectrum :3MHz -30MHz
- Operating Frequency Range: 13.56 MHz
- Read Range: Near Contact - 30 Centimetres to few meters
- Average Cost Per Tag: $0.20 - $10.00
- Applications: DVD Kiosks, Library Books, Personal ID Cards, Poker/Gaming Chips, NFC (Near Field Communication) Applications
- Pros: NFC Global Protocols, Larger Memory Options, Global Standards
- Cons: Short Read Range, Low Data Transmission Rate

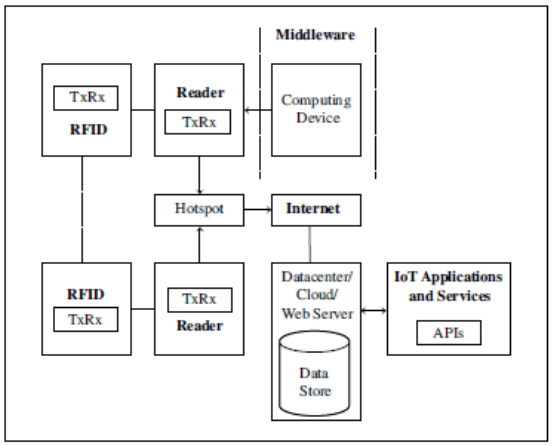
Ultra High Frequency based RFID:

- Ultra High Frequency Range in electromagnetic spectrum: 300 - 3000 MHz
- Operating Frequency Ranges: 433 MHz, 860 - 960 MHz
- Read Range: Near Contact - up to 20 meters

Principle of RFID:

A tag is an electronic circuit which transmits its ID using RF signals. The ID transmits to a reader, then that transmits along with the additional information to a remote server or cloud connected through the Internet. The additional information is as per the application.

Components of RFID:



Components needed in a system for RFID IoT applications and services

the above figure shows the components needed in a system for IoT applications and services.

The components of an RFID system are:

- RFID is a tiny chip which functions as a tag or label onto an object.
- The chip is one of three types—passive, active and battery powered passive (battery switches when reader is nearby).

  Active RFID Tag:
  - Primary Frequency Range: 433 MHz, (Can use 2.45 GHz - under the Extremely High Frequency Range)
  - Read Range: 30 - 100+ Meters
  - Average Cost Per Tag: $25.00 - $50.00
  - Applications: Vehicle Tracking, Auto Manufacturing, Mining, Construction, Asset Tracking
  - Pros: Very Long Read Range, Lower Infrastructure Cost (vs. Passive RFID), Large Memory Capacity, High Data Transmission Rates.
  - Cons: High Per Tag Cost, Shipping Restrictions (due to batteries), Complex Software may be Required, High Interference from Metal and Liquids; Few Global Standards.

  Passive RFID Tag:
  - Primary Frequency Ranges: 860 - 960 MHz
  - Read Range: Near Contact - 25 Meters
  - Average Cost Per Tag: $0.09 - $20.00
  - Applications: Supply Chain Tracking, Manufacturing, Pharmaceuticals, Electronic Tolling, Inventory Tracking, Race Timing, Asset Tracking.

- Pros: Long Read Range, Low Cost Per Tag, Wide Variety of Tag Sizes and Shapes, Global Standards, High Data Transmission Rates.
- Cons: High Equipment Costs, Moderate Memory Capacity, High Interference from Metal and Liquids.

Transceiver :

- A transceiver is in-built at the chip. It communicates in a range 10 cm to 200 m according to the chip. The chip does UART communication to the reader either using RF link or does NFC communication to the reader within 20 cm range; standard frequency range used can be between 120 kHz to 150 kHz, 13.56 MHz, 433 MHz, higher when using UHF and microwave frequencies.
- Transceiver using RF frequencies recommended by Regulator has the data transfer rate of 115 kbps using carrier RF signals from 915 MHz to 868 MHz, 315 MHz or 27 MHz.

RFID Reader:

A nearby RFID reader for receiving ID uses the transceiver within it. It receives the header which consists of 1 start byte, then 10 byte ID and then one end byte when using the UART protocol. Hotspot, mobile or computer with wireless transceiver or Wi-Fi transceiver transmits and receives signals from the RFID tag.

Data processing subsystem:

A reader associates a data processing subsystem which consists of a computing device and a middleware and provides connectivity to the Internet, directly or through a gateway which includes a data adaptation sub layer. The subsystem is a backend system.

A reader circuit may send data directly or through a computer, mobile or tablet to the Internet. The computations for transmission (of the contents information of tagged device) are usually little. **Middleware:** Middleware are software components used at the reader, read manager, data store for the transaction data store and APIs of the applications. Applications and services and other associated applications software use the data store at the cloud or web server.

Applications:

- Livestock Tagging
- Wild Animal Tracking
- Electronic Article Surveillance (EAS)
- Automated Toll Collection
- Animal Husbandry
- Smart Grocery Store
- Smart Kitchen

Issues:

Design issue: Designing a unique ID system needs a standard global framework.

Security issue: A tag is read only. It can thus interact with any reader and thus allows automated external monitoring. A tag can thus be tracked without authority. A privacy

issue arises when a tag and reader need not to be authenticated before their use.
Cost issue: RFID tag and reader become costly with data processing and security enhancing technology.
Protection issue: The tag needs protection from the adverse weather condition which may damage the tag.
Recycling issue: Recycling of the tags can be an environmental concern.
Active life issue: Active RFID, which consists of battery, has limited life of up to 2 to 4 years.

Technological Challenges

RFID technology challenges are as follows:

- **Interference**: When an organisation uses a number of wireless systems, since RFID hotspot also requires wireless installation, the frequencies may interfere among the systems. The systems require effective mitigation from interference.
- Need of low cost tags and RFID technology.
- Design robustness
- Data security

Security Challenges:

The issues associated with RFID security are:

- Discovery of foreign attacks (intrusions) and maintain overall data integrity
- Unauthorised disabling of a tag by a reader which is external, thus making the tag
- useless
- Unauthorised tag manipulation by a reader which is external, thus making the tag
- useless
- Cloning of the tag by an unauthorized entity

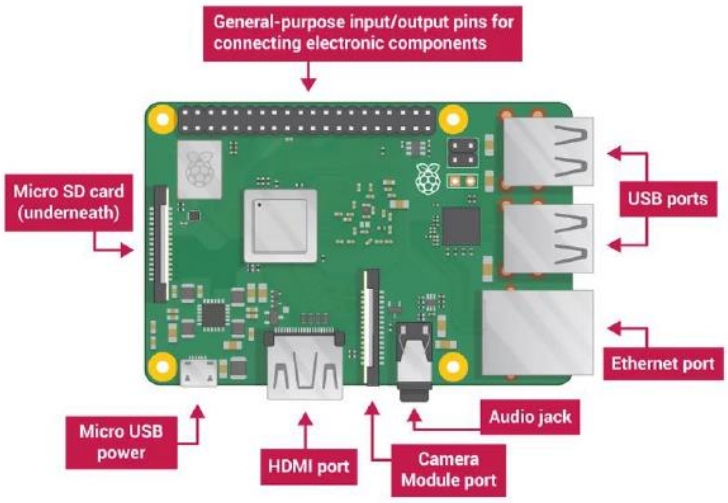
Introduction to Embedded devices for IOT- Raspberry Pi:

Raspberry Pi B+ Model:

It is a four layered ARM11 architecture based Broad com BCM2835 RISC microprocessor which is designed to provide a cost-effective, low-power capabilities, high performance Application Processor solution for mobile phones and general applications.

Raspberry Pi Hardware

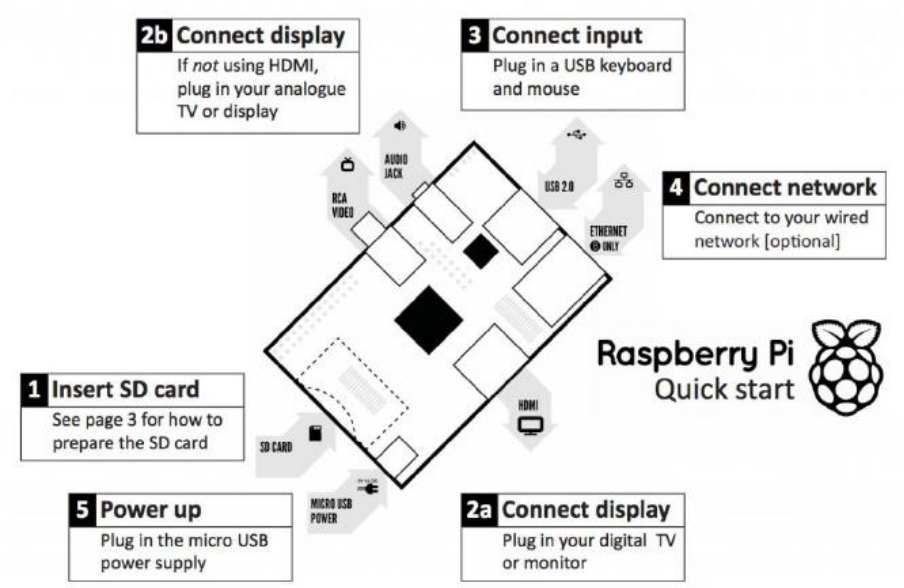
The Raspberry Pi is a credit-card sized computer that plugs into your TV and a keyboard. It is a little computer which can be used in electronics projects. It is a device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything that a computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

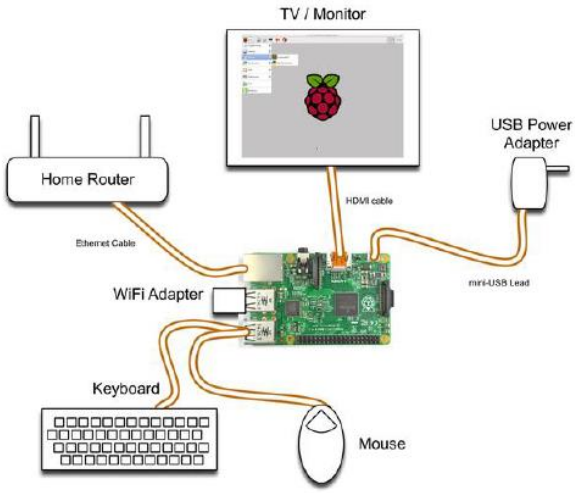


Raspberry pi requires less additional hardware compare with a personal computer. The following are more or less essential,

1. Raspberry Pi board
2. Prepared micro SD Card for storing Operating System
3. USB keyboard
4. Display (with HDMI, DVI, Composite or SCART input)
5. Powered USB Hub
6. USB mouse
7. Cables

Raspberry pi setup:





Micro SD Card

A micro SD (Secure Digital) card is a storage device that has many useful features depending on how and where it's used. SD card is added to a small device like mobile phone, to extend the storage space available for ringtones, texts, apps, music and other data. It does not include a built in hard disk, but uses an SD card for booting and persistent storage. There is no internal storage in Raspberry pi so it uses a micro SD card to store the operating system (Linux).

Keyboard & Mouse

Most standard USB keyboards and mice will work with the Raspberry Pi. Wireless keyboard/mice should also function, and only a single USB port is required for an RF dongle. In order to use a Bluetooth keyboard or mouse it would need to use a Bluetooth dongle, which again uses a single port. Remember that the Model A has a single USB port and the Model B+ has four USB ports (typically a keyboard and mouse will use a USB port each).

Display

Raspberry pi b+ model supports different types of displays**.** that are

- HD TVs and most LCD Monitors are connected by using male HDMI cable and with an inexpensive adaptor if DVI is used. Audio and Video output of raspberry pi is taken by using HDMI port or headphone or it will be connected to an amplifier or your TV, desktop monitor also.
- Older TVs can be connected using Composite (a yellow-to-yellow cable) or via SCART (using a Composite to SCART adaptor).It supports PAL and NTSC TVs.
- In Raspberry pi b+ model a VGA port is present. So we can directly connect processor to the monitor.
- There are currently four Raspberry Pi models. They are
- Model A
- Model B
- Model B+
- Compute Module.

All models use the same CPU, the BCM2835, but they had different hardware features.

Features:

The features of Raspberry-Pi (BCM-2835) RISC Microprocessor include:

- Basic size, 85mm x 56mm
- Broadcom Processor, SoC running at 700MHz (can be over clocked)
- RAM, 512MB soldered on top of the Broadcom chip
- Dual step-down (buck) power supply for 3.3V and 1.8V
- 5V supply has polarity protection, 2A fuse and hot-swap protection
- New USB/Ethernet controller chip
- 4 USB ports instead of 2 ports
- HDMI port
- 40 GPIO pins instead of 26. The top/first 26 pins (Raspberry pi B model)match the original layout, 9 additional GPIO
- 2 EEPROM Plate identification pins
- Micro SD card socket instead of full size SD
- Audio part of the A/V jack
- Camera and DSI Display connector
- Composite (NTSC/PAL) video now integrated into 4-pole 3.5mm 'headphone' jack
- It supports following languages

The Raspberry Pi Foundation recommends Python
Any language which will compile for ARMv6 can be usedInstalled by default on the Raspberry Pi: C, C++, Java, Ruby.

Raspberry Pi B+ model GPIO pins:

	Pin No.		
3.3V	1	2	5V
GPIO2	3	4	5V
GPIO3	5	6	GND
GPIO4	7	8	GPIO14
GND	9	10	GPIO15
GPIO17	11	12	GPIO18
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
GPIO10	19	20	GND
GPIO9	21	22	GPIO25
GPIO11	23	24	GPIO8
GND	25	26	GPIO7
DNC	27	28	DNC
GPIO5	29	30	GND
GPIO6	31	32	GPIO12
GPIO13	33	34	GND
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
GND	39	40	GPIO21

A powerful feature of the Raspberry Pi is the row of GPIO (general-purpose input/output) pins along the top edge of the board. A 40-pin GPIO header is found on all current Raspberry Pi boards (unpopulated on Pi Zero and Pi Zero W). Prior to the Pi 1 Model B+ (2014), boards comprised a shorter 26-pin header.
Any of the GPIO pins can be designated (in software) as an input or output pin and used for a wide range of purposes.

Voltages:
Two 5V pins and two 3V3 pins are present on the board, as well as a number of ground pins (0V), which are unconfigurable. The remaining pins are all general purpose 3V3 pins, meaning outputs are set to 3V3 and inputs are 3V3-tolerant.

Outputs
A GPIO pin designated as an output pin can be set to high (3V3) or low (0V).

Inputs
A GPIO pin designated as an input pin can be read as high (3V3) or low (0V). This is made easier with the use of internal pull-up or pull-down resistors. Pins GPIO2 and GPIO3 have fixed pull-up resistors, but for other pins this can be configured in software.
As well as simple input and output devices, the GPIO pins can be used with a variety of alternative functions, some are available on all pins, others on specific pins.

- PWM (pulse-width modulation)
    - Software PWM available on all pins
    - Hardware PWM available on GPIO12, GPIO13, GPIO18, GPIO19

- SPI
  - SPI0: MOSI (GPIO10); MISO (GPIO9); SCLK (GPIO11); CE0 (GPIO8), CE1 (GPIO7)
  - SPI1: MOSI (GPIO20); MISO (GPIO19); SCLK (GPIO21); CE0 (GPIO18); CE1 (GPIO17); CE2 (GPIO16)
- I2C
  - Data: (GPIO2); Clock (GPIO3)
  - EEPROM Data: (GPIO0); EEPROM Clock (GPIO1)
- Serial
  - TX (GPIO14); RX (GPIO15)

The Raspberry pi boards are used in many applications like Media streamer, Arcade machine, Tablet computer, Home automation, Carputer, Internet radio, Controlling robots, Cosmic Computer, Hunting for meteorites, Coffee and also in raspberry pi based projects.