Consumer Electronics

UNIT I:**Consumer Electronics Fundamentals** - History of Electronic Devices- Vacuum Tubes, Transistors, Integrated Circuits- Moorse Law, Semiconductor Devices, Diodes, Rectifiers, Transistors, Logic Gates, Combinational Circuits, ADC, DAC and Microprocessors, Microprocessor Vs Microcontrollers, Microcontrollers in consumer electronics, Energy management, Intelligent Building Perspective.

UNIT II: Entertainment Electronics - Audio systems: Construction and working principle of : Microphone, Loud speaker, AM and FM receiver, stereo, 2.1 home theatre, 5.1 home theatre . Display systems: CRT, LCD, LED and Graphics displays Video Players : DVD and Blue RAY. Recording Systems: Digital Cameras and Camcorders.

UNIT III: Smart Home - Technology involved in Smart home, Home Virtual Assistants- Alexa and Google Home. Home Security Systems - Intruder Detection, Automated blinds, Motion Sensors, Thermal Sensors and Image Sensors, PIR, IR and Water Level Sensors.

UNIT IV: **Home Appliances** - Home Enablement Systems: RFID Home, Lighting control, Automatic Cleaning Robots, Washing Machines, Kitchen Electronics- Microwave, Dishwasher, Induction Stoves, Smart Refrigerators, Smart alarms, Smart toilet, Smart floor, Smart locks.

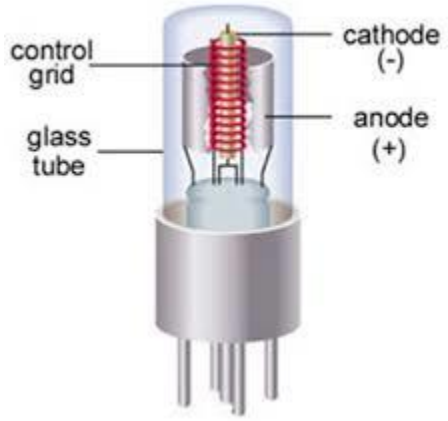
UNIT V: **Communication Systems** - Cordless Telephones, Fax Machines, PDAs- Tablets, Smart Phones and Smart Watches. Introduction to Smart OS- Android and iOS. Video Conferencing Systems- Web/IP Camera, Video security, Internet Enabled Systems, Wi-Fi, IoT, Li-Fi, GPS and Tracking Systems, Contemporary Topics.

TEXT BOOKS:

1. Thomas L Floyd "Electronic Devices" 10th Edition Pearson Education Asia 2018.
2. Philp Hoff "Consumer Electronics for Engineers" - Cambridge University Press.1998.
3. Jordan Frith, " Smartphones as Locative Media ", Wiley. 2014.
4. Dennis C Brewer, " Home Automation", Que Publishing 2013.
5. Thomas M. Coughlin, "Digital Storage in Consumer Electronics", Elsevier and Newness 2012.

Unit 1 Consumer Electronics Fundamentals

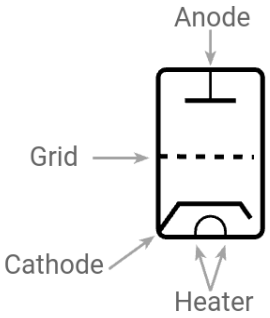
Vacuum tube

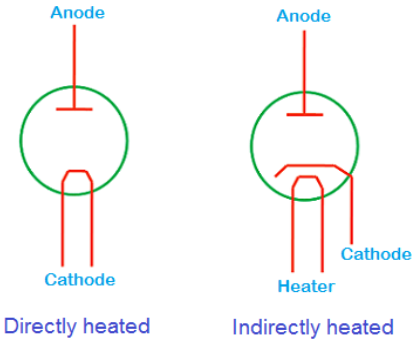


Vacuum tube or thermionic valve technology is based around the basic concept of thermionic emission. The emission of electrons from a metal surface when heat energy is imparted to it is called the thermionic emission. **Thermionic emission** is the thermally induced flow of charge carriers from a surface or over a potential-energy barrier.

Construction

- ***Cathode:*** This is the electrode that is heated and emits the electrons.
- ***Anode:*** This electrode in the vacuum tube or valve has a high potential to attract electrons from the cathode.
- ***Grid:*** This is the valve electrode that has a variable potential and is used to control the flow of electrons between cathode and anode. In some vacuum tubes more grid are used to improve the performance in various ways.
- ***Filament:*** Most valves these days are indirectly heated, i.e. a the filament is not connected to the cathode. The filament heats the cathode which then emits the electrons. Early valves were directly heated and the filament was used to emit the electrons. However this placed limitations on the way in which valves could be used. Having an indirectly heated cathode allows the cathode to operate at a potential higher than ground and also for many filaments to be run in parallel in a single item of equipment.

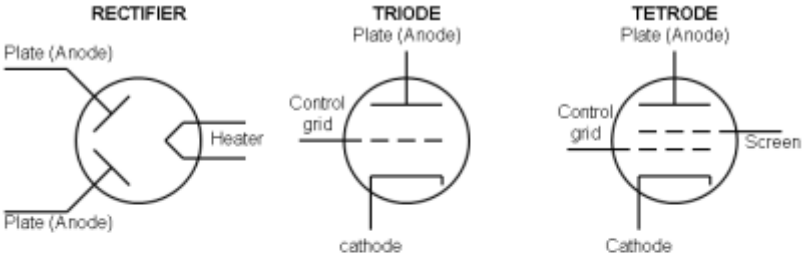




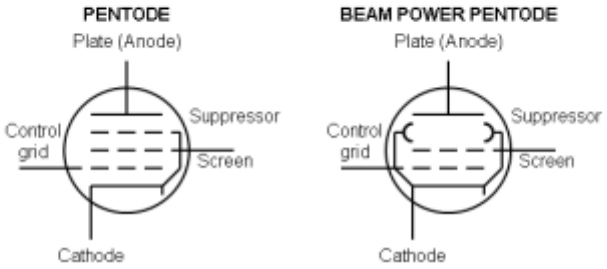
Types of Vacuum Tubes

Diode valve: This is the basic form of thermionic valve / vacuum tube device. It consists of a cathode, anode (and of course the heater or filament). Current can only pass through the diode in one way - electrons flowing from the cathode to the anode - in this way it acts as a rectifier or diode

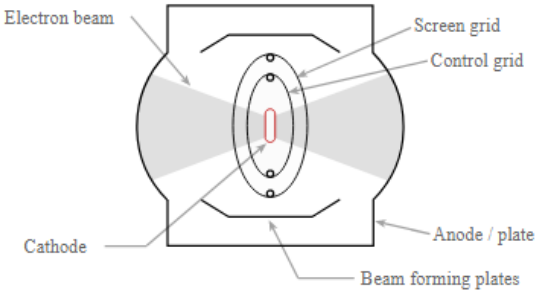
Triode valve: The triode valve has a third electrode added. Called the grid, it is able to control the flow of electrons.



Tetrode: The tetrode has an fourth electrode added. Called a screen grid, it is normally held at a high potential but lower than that of the anode



Beam tetrode: The beam tetrode valve was an enhancement on the basic tetrode valve. It had special beam plates added to the structure between the screen grid and the anode to beam the electrons towards particular areas on the anode. Also as these plates were held at the same potential as the cathode, electrons striking the anode and bouncing off were returned to the anode, and secondary emission was effectively suppressed.



Beam tetrode internal construction

Pentode: The pentode had a fifth electrode added. Called the suppressor grid, it was held at a low potential to suppress secondary emission.

Vacuum Tubes: Advantages

1. Superior sound quality.
2. Highly linear without negative feedback, especially small-signal types.
3. Smooth clipping is widely considered more musical than transistors.
4. Tolerant of large overloads and voltage spikes.
5. Characteristics highly independent of temperature, greatly simplifying biasing.
6. Wider dynamic range than transistors circuits, due to higher operating voltages and overload tolerance.
7. Device capacitances vary only slightly with signal voltages (Miller effect).
8. Capacitive coupling can be done with small, high-quality film capacitors, due to inherently high-impedances of tube circuits.

9. Circuit designs tend to be simpler than transistorized equivalents, which are greatly complicated by the need to linearize intrinsically non-linear transistors.
10. Operation is usually in Class A or Class AB, minimizing crossover notch distortion.
11. Output transformer in power amp protects speaker from DC voltage due to malfunction and protects tubes from shorts and blunts back-emf spikes from speaker.
12. Tubes can be relatively easily replaced by user.

Vacuum Tubes: Disadvantages

1. Bulky, hence less suitable for portable products.
2. Higher operating voltages generally required.
3. High power consumption; needs heater supply that generates waste heat and yields lower efficiency, notably for small-signal circuits.
4. Glass tubes are fragile, compared to metal transistors.
5. High-impedance devices that need impedance matching transformer for low-impedance loads, like speakers; however, the magnetic cushion provided by an output transformer prevents the output tubes from blowing up.
6. Sometimes higher cost than equivalently powered transistors.

Classification of solids

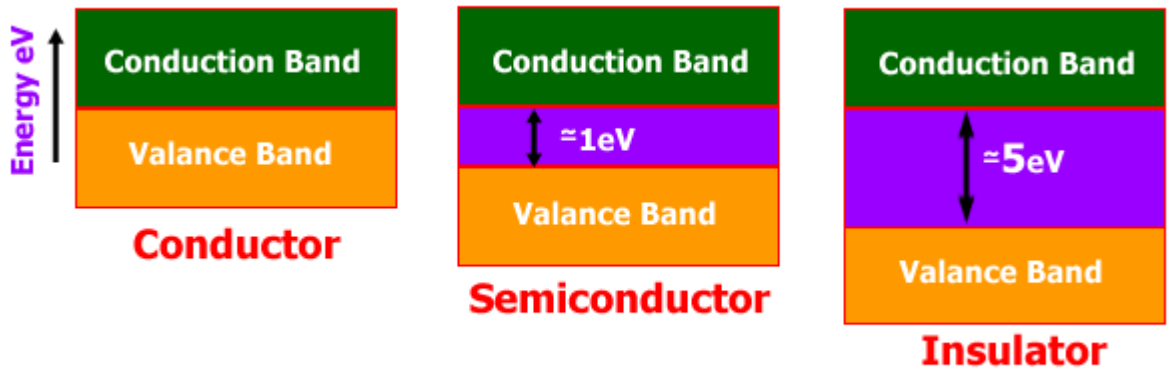


Fig: Classification of Solids on the basis of electricity Conduction

S.No	Conductors	Semiconductors	Insulators
1	Easily conducts the electrical current.	Conducts the electric current less than conductor and greater than insulator.	Does not conduct any current.
2	Has only one valence electron in its outermost orbit.	Has four valence electron in its outermost orbit.	Has eight valence electron in its outermost orbit.
3	Conductor formed using metallic bonding.	Semiconductors are formed due to covalent bonding.	Insulators are formed due to ionic bonding.
4	Valence and conduction bands are overlapped.	Valence and conduction bands are separated by forbidden energy gap of 1.1eV.	Valence and conduction bands are separated by forbidden energy gap of 6 to 10eV.
5	Resistance is very small	Resistance is high	Resistance is very high
6	It has positive temperature coefficient	It has negative temperature coefficient	It has negative temperature coefficient
7	Ex: copper,aluminium,etc	Ex: silicon, germanium, etc	Ex: Mica, Paper, etc

Classification of semiconductor

- Intrinsic Semiconductor
- Extrinsic Semiconductor

Classification of Extrinsic Semiconductor

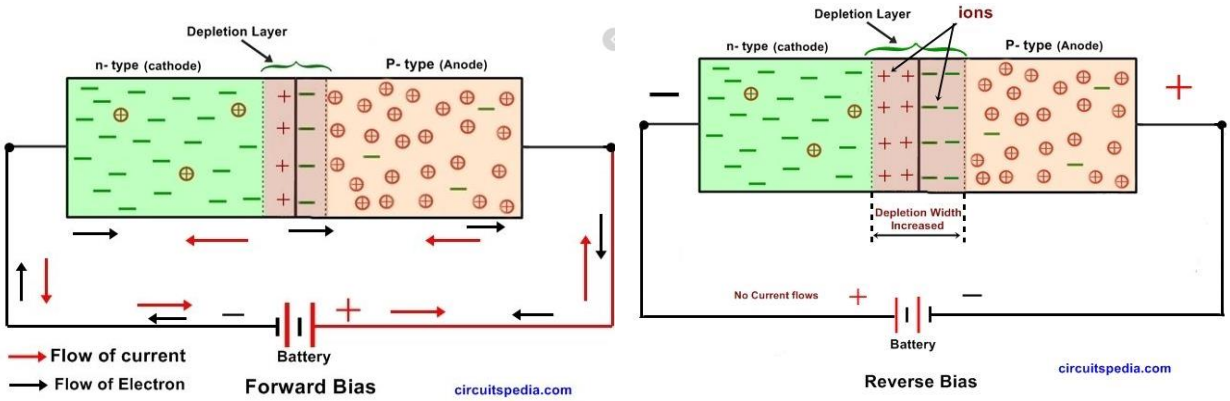
- **In n-type semiconductor:** The doping contributes extra electrons, dramatically increasing the conductivity.(Impurity: phosphorus, arsenic, antimony, bismuth or some other)

- **In p-type semiconductor:** The doping produces extra vacancies or holes, which likewise increase the conductivity.(trivalent Impurity: Boron, gallium , indium aluminum)

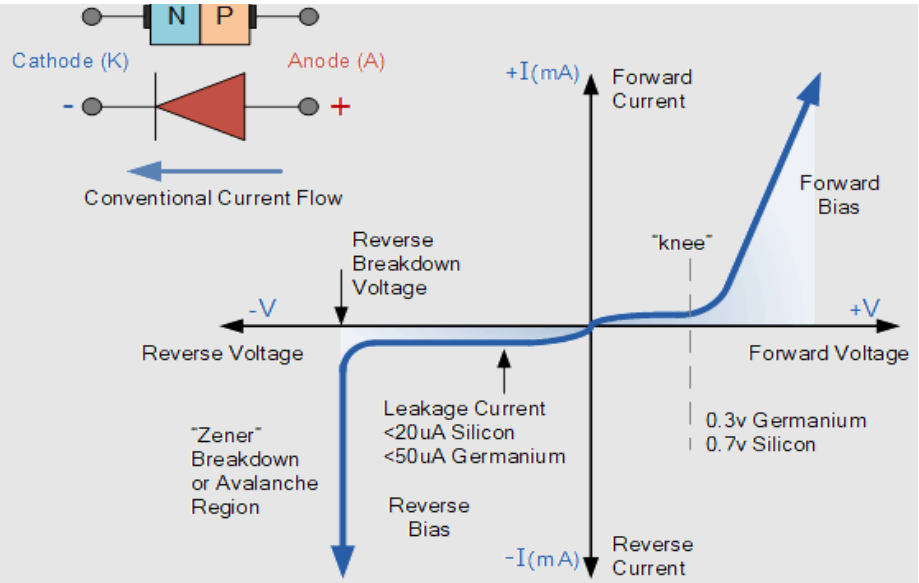
PN Junction diode

A **diode** is defined as a two-terminal electronic component that only conducts current in one direction. Ideal diode will have zero resistance in one direction, and infinite resistance in the reverse direction.

Biasing PN Junction diode



VI Characteristics of PN Junction diode



Junction Diode Summary

The PN junction region of a **Junction Diode** has the following important characteristics:

- Semiconductors contain two types of mobile charge carriers, “Holes” and “Electrons”.
- The holes are positively charged while the electrons negatively charged.
- A semiconductor may be doped with donor impurities such as Antimony (N-type doping), so that it contains mobile charges which are primarily electrons.

- A semiconductor may be doped with acceptor impurities such as Boron (P-type doping), so that it contains mobile charges which are mainly holes.
- The junction region itself has no charge carriers and is known as the depletion region.
- The junction (depletion) region has a physical thickness that varies with the applied voltage.
- When a diode is **Zero Biased** no external energy source is applied and a natural **Potential Barrier** is developed across a depletion layer which is approximately 0.5 to 0.7v for silicon diodes and approximately 0.3 of a volt for germanium diodes.
- When a junction diode is **Forward Biased** the thickness of the depletion region reduces and the diode acts like a short circuit allowing full circuit current to flow.
- When a junction diode is **Reverse Biased** the thickness of the depletion region increases and the diode acts like an open circuit blocking any current flow, (only a very small leakage current will flow).

Application of diode

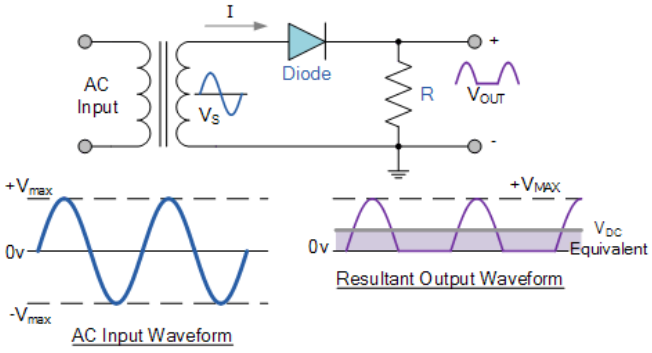
- Rectifiers
- Clipper Circuits
- Clamping Circuits
- Reverse Current Protection Circuits
- In Logic Gates
- Voltage Multipliers.

Rectifier

A rectifier is a circuit which converts the *Alternating Current* (AC) input power into a *Direct Current* (DC) output power.

Types of rectifier: Half wave, full wave and bridge rectifier

Half wave rectifier: The power diode in a half wave rectifier circuit passes just one half of each complete sine wave of the AC supply in order to convert it into a DC supply.



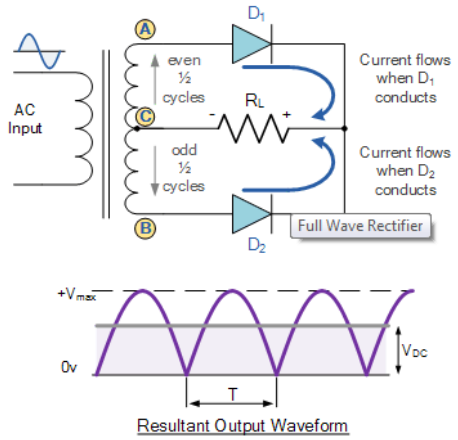
Operation

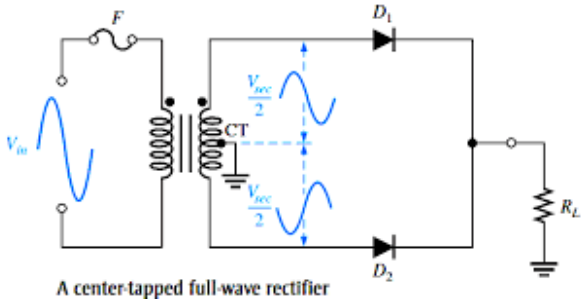
- During each "positive" half cycle of the AC sine wave, the diode is *forward biased* as the anode is positive with respect to the cathode resulting in current flowing through the diode.

- During each "negative" half cycle of the AC sinusoidal input waveform, the diode is *reverse biased* as the anode is negative with respect to the cathode. Therefore, NO current flows through the diode or circuit. Then in the negative half cycle of the supply, no current flows in the load resistor as no voltage appears across it so therefore, Vout = 0.

- The current on the DC side of the circuit flows in one direction only making the circuit **Unidirectional**.

Full wave rectifier



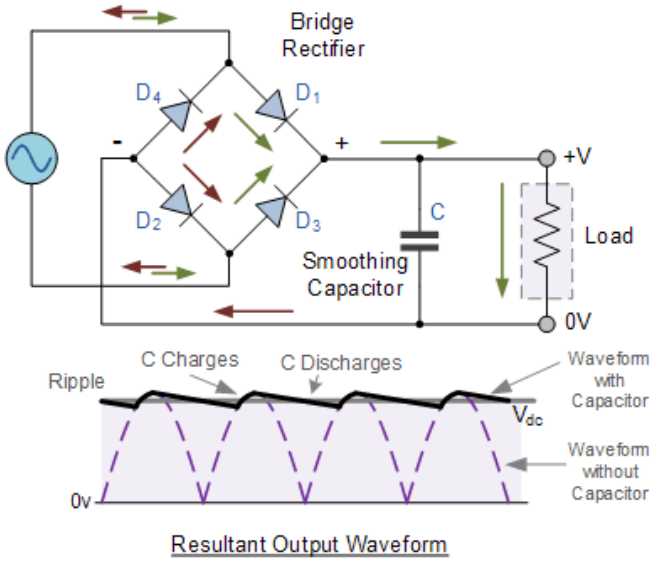


A center-tapped full-wave rectifier

The full wave rectifier circuit consists of two *power diodes* connected to a single load resistance (R_L) with each diode taking it in turn to supply current to the load. When point A of the transformer is positive with respect to point C, diode D_1 conducts in the forward direction as indicated by the arrows.

When point B is positive (in the negative half of the cycle) with respect to point C, diode D_2 conducts in the forward direction and the current flowing through resistor R is in the same direction for both half-cycles. As the output voltage across the resistor R is the phasor sum of the two waveforms combined, this type of full wave rectifier circuit is also known as a "bi-phase" circuit.

Bridge rectifier



Another type of circuit that produces the same output waveform as the full wave rectifier circuit above, is that of the **Full Wave Bridge Rectifier**. This type of single phase rectifier uses four individual rectifying diodes connected in a closed loop "bridge" configuration to produce the desired output.

The main advantage of this bridge circuit is that it does not require a special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.

Operation

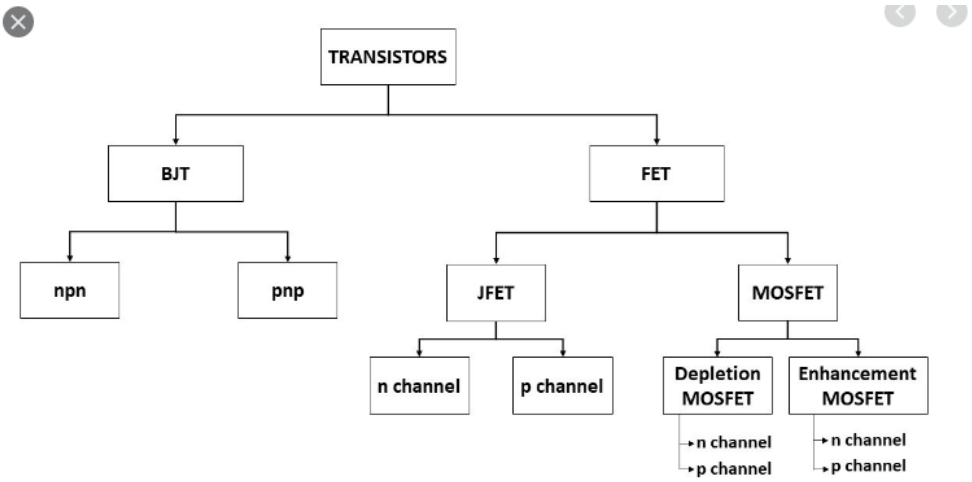
- The four diodes labeled D_1 to D_4 are arranged in "series pairs" with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.

- During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch "OFF" as they are now reverse biased. The current flowing through the load is the same direction as before.

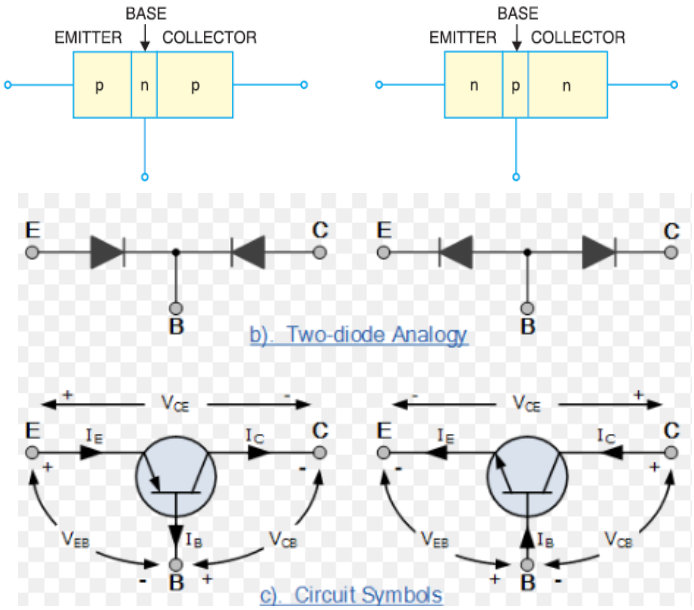
As the current flowing through the load is unidirectional, so the voltage developed across the load is also unidirectional the same as for the previous two diode full-wave rectifier,

Transistor

Transistor is a three terminal electronic device used for amplifier and switching



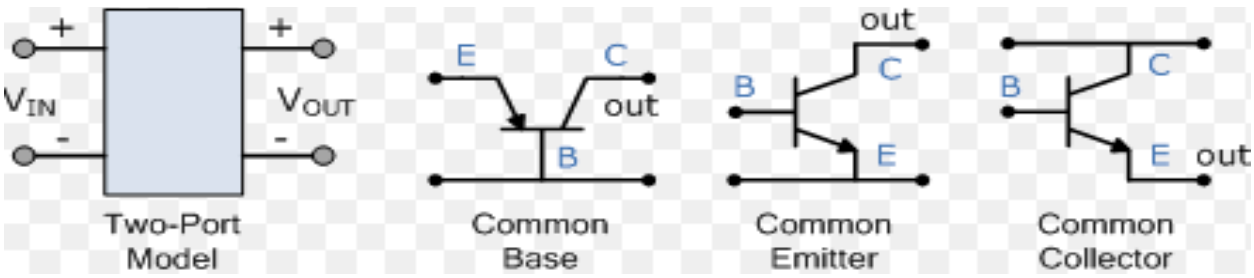
Bipolar Junction Transistor(BJT)



The transistor has three regions, namely ; *emitter*, *base* and *collector*. The base is much thinner than the emitter while collector is wider than both as shown in figure. sake of convenience, it is customary to show emitter and collector to be of equal size.

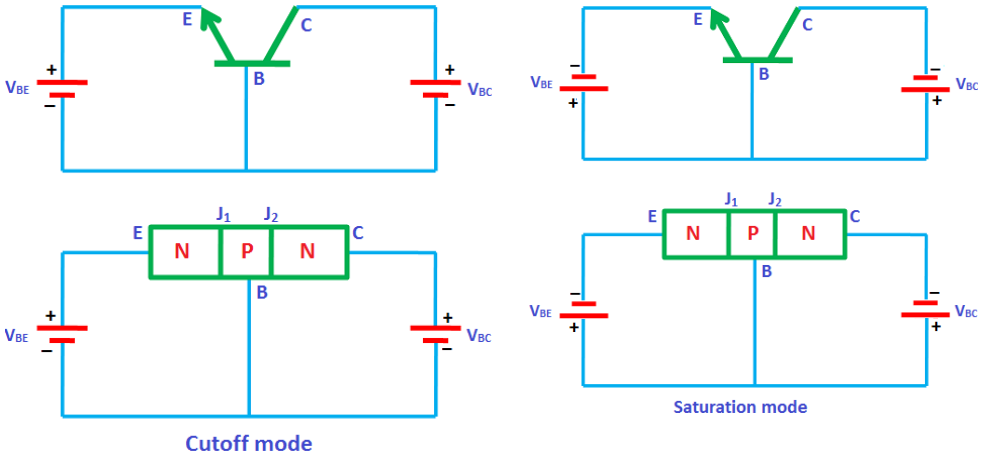
(ii) The emitter is heavily doped so that it can inject a large number of charge carriers (electrons or holes) into the base. The base is lightly doped and very thin; it passes most of the emitter injected charge carriers to the collector. The collector is moderately doped.

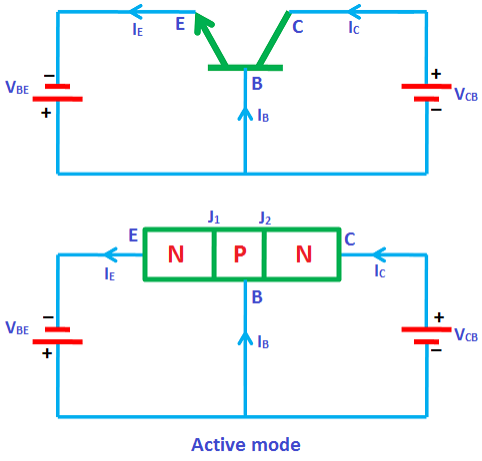
Transistor Circuit Configurations



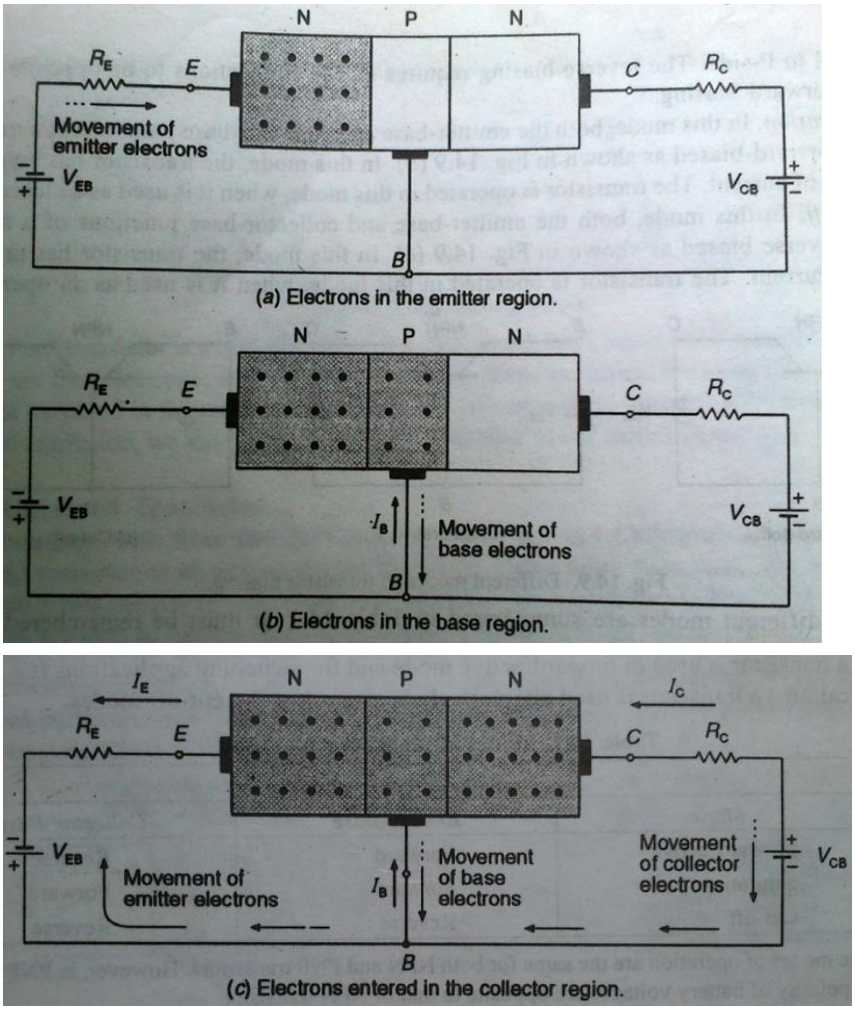
Operating modes of transistor

Modes	EBJ	CBJ	Application
Cutoff	Reverse	Reverse	Switching application in digital circuits
Saturation	Forward	Forward	
Active	Forward	Reverse	Amplifier
Reverse active	Reverse	Forward	Performance degradation





Working principle of NPN Transistor



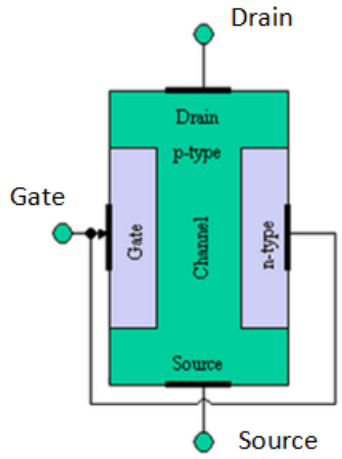
Working of NPN transistor. Figure shows the *npn* transistor with forward bias to emitter base junction and reverse bias to collector-base junction. The forward bias causes the electrons in the *n*-type emitter to flow towards the base. This constitutes the emitter current I_E. As these electrons flow through the *p*-type base, they tend to combine with holes. As the base is lightly doped and very thin, therefore, only a few electrons (less than 5%) combine with holes to constitute base current I_B. The remainder (more than 95%) cross over into the collector region to constitute collector current I_C. In this way, almost the entire emitter current flows in the collector circuit. It is clear that emitter current is the sum of collector and base currents *i.e.* $I_E = I_B + I_C$

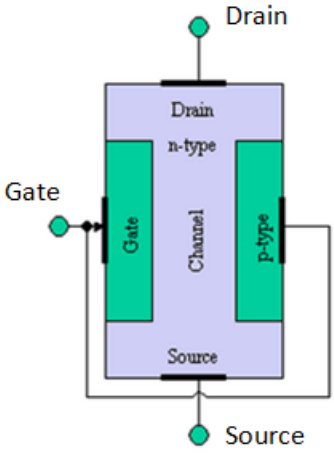
Junction Field Effect Transistor(JFET)

A **junction field effect transistor** is a three terminal semiconductor device in which current conduction is by one type of carrier i.e., electrons or holes.

The JFET was developed about the same time as the transistor but it came into general use only in the late 1960s. In a JFET, the current conduction is either by electrons or holes and is controlled by means of an electric field between the gate electrode and the conducting channel of the device. The JFET has high input impedance and low noise level.

Construction of JFET





- The bar forms the conducting channel for the charge carriers.
- If the bar is of p-type, it is called p-channel JFET as shown in fig.1(i) and if the bar is of n-type, it is called n-channel JFET as shown in fig.1(ii).
- The two PN junctions forming diodes are connected internally and a common terminal called gate is taken out.
- Other terminals are source and drain taken out from the bar as shown in fig.
- Thus a JFET has three terminals such as , gate (G), source (S) and drain (D).

The following points may be noted:

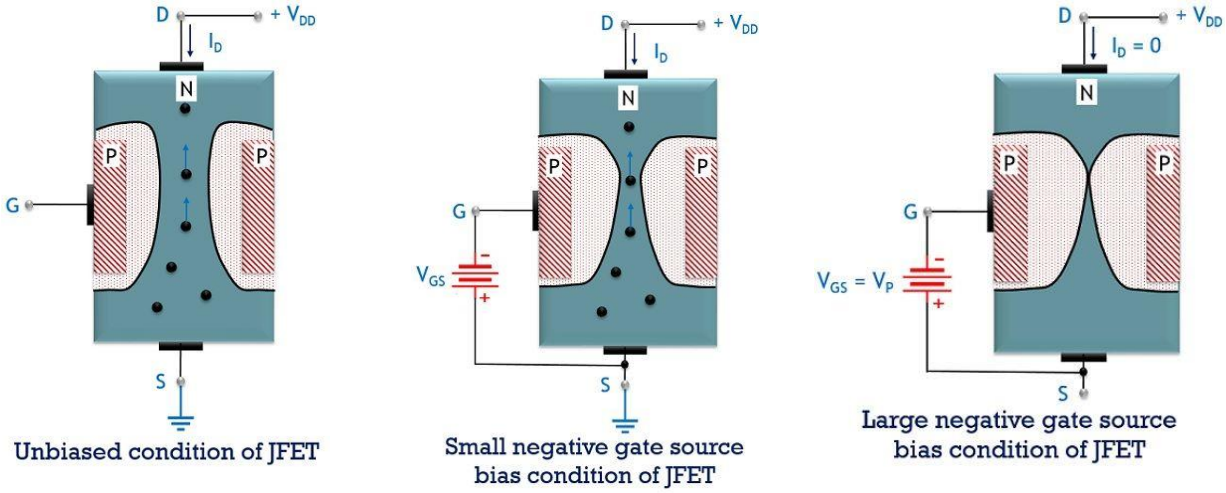
1. The input circuit (i.e. gate to source) of a JFET is reverse biased. This means that the device has high input impedance.
2. The drain is so biased w.r.t. source that drain current I_D flows from the source to drain.
3. In all JFETs, source current I_S is equal to the drain current i.e $I_S = I_D$.

Principle and Working of JFET

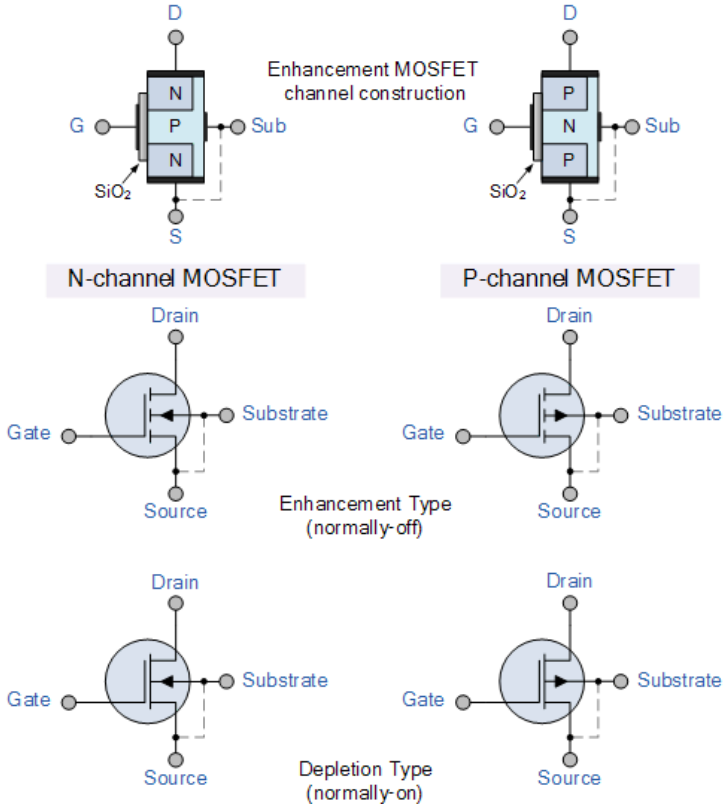
- The two PN junctions at the sides form two depletion layers.
- The current conduction by charge carriers (i.e. electrons) is through the channel between the two depletion layers and out of the drain.
- The width and hence resistance of this channel can be controlled by changing the input voltage V_{GS}.
- The greater the reverse voltage V_{GS}, the wider will be the depletion layer and narrower will be the conducting channel.
- The narrower channel means greater resistance and hence source to drain current decreases.
- Reverse will happen when V_{GS} decreases.
- Thus JFET operates on the principle that width and hence resistance of the conducting channel can be varied by changing the reverse voltage V_{GS}.
- In other word, the magnitude of drain current I_D can be changed by altering V_{GS}.

The working of JFET can be explained as follows:

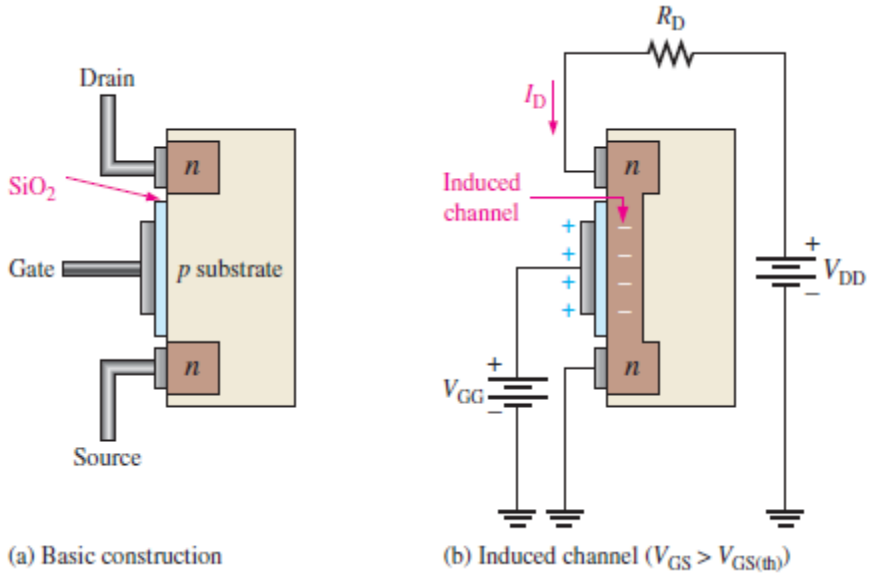
- When a voltage V_{DS} is applied between drain and source terminals and voltage on the gate is zero as shown in fig.(i), the two pn junctions at the sides of the bar establish depletion layers.
- The electrons will flow from source to drain through a channel between the depletion layers.
- The size of the depletion layers determines the width of the channel and hence current conduction through the bar.



Metal oxide semiconductor field effect transistor (MOSFET)



Enhancement type MOSFET (E- MOSFET)



(a) Basic construction (b) Induced channel ($V_{GS} > V_{GS(th)}$)

Working principle of N-Channel MOSFET

The N-Channel MOSFET has an N- channel region located in between the source and drain terminals. It is a four-terminal device having the terminals as gate, drain, source, body. In this type of Field Effect Transistor, the drain and source are heavily doped n region and the substrate or body are of P-type.

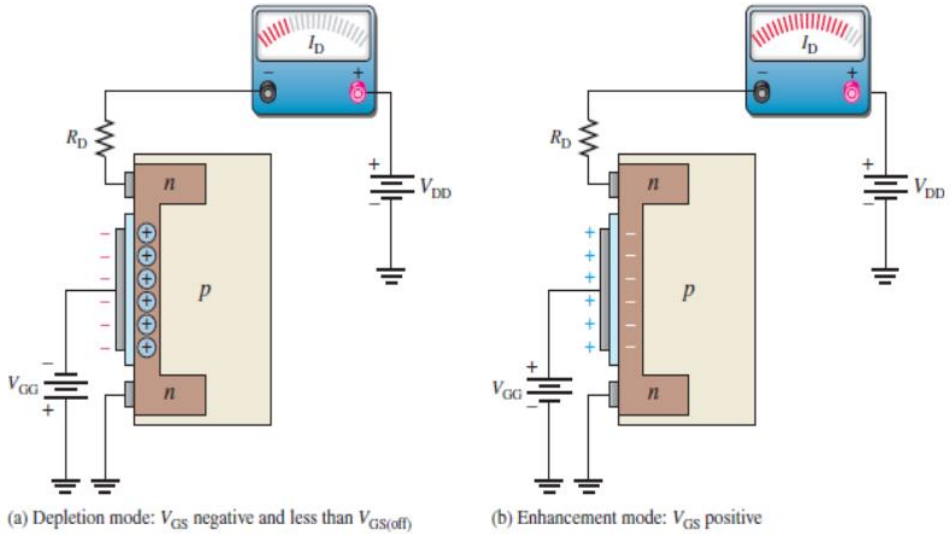
The current flow in this type of MOSFET happens because of negatively charged electrons. When we apply the positive voltage with repulsive force at the gate terminal then the holes present under the oxide layer are pushed downward into the substrate. The depletion region is populated by the bound negative charges which are associated with the acceptor atoms.

Upon the reach of electrons, the channel is formed. The positive voltage also attracts electrons from the n source and drain regions into the channel. Now, if a voltage is applied between the drain and source the current flows freely between the source and drain and the gate voltage controls the electrons in the channel. Instead of positive voltage if we apply negative voltage then a hole channel will be formed under the oxide layer.

Depletion type MOSFET (DE-MOSFET)

The D-MOSFET can be operated in either of two modes—the depletion mode or the enhancement mode and is sometimes called a **depletion/enhancement MOSFET**. Since the gate is insulated from the channel, either a positive or a negative gate voltage can be applied. The *n*-channel MOSFET operates in the **depletion** mode when a negative gate-to-source voltage is applied and in the **enhancement** mode when a positive gate-to-source voltage is applied. These devices are generally operated in the depletion mode.

Depletion Mode Visualize the gate as one plate of a parallel-plate capacitor and the channel as the other plate. The silicon dioxide insulating layer is the dielectric. With a negative gate voltage, the negative charges on the gate repel conduction electrons from the channel, leaving positive ions in their place. Thereby, the *n* channel is depleted of some of its electrons, thus decreasing the channel conductivity. The greater the negative voltage on the gate, the greater the depletion



of *n*-channel electrons. At a sufficiently negative gate to-source voltage, *V*GS(off), the channel is totally depleted and the drain current is zero.

Enhancement Mode With a positive gate voltage, more conduction electrons are attracted into the channel, thus increasing (enhancing) the channel conductivity, as illustrated in Figure

Applications

- MOSFETs are used in digital integrated circuits, such as microprocessors.
- Used in calculators.
- Used in memories and in logic CMOS gates.
- Used as analog switches.
- Used as amplifiers.
- Used in the applications of power electronics and switch mode power supplies.
- MOSFETs are used as oscillators in radio systems.
- Used in automobile sound systems and in sound reinforcement systems.

Advantages of MOSFET :

1. The operational speed of MOSFET is higher than that of JFET.
2. Input impedance is much higher as compared to JFET.
3. It can be easily used in case of high current applications.
4. These devices provide an easy manufacturing process.

Disadvantages of MOSFET :

1. It is a delicate device and is easily destroyable.
2. Excessive application of gate to source voltage V_{GS} may destroy the thin SiO_2 layer.

Difference Between JFET and MOSFET

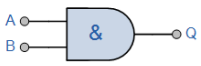
S.No	JFET	MOSFET
1	Operated in depletion mode	Operated in depletion mode and enhancement mode
2	High input impedance(>10MΩ)	Very High input impedance(>10000MΩ)
3	Gate is not insulated from channel	Gate is insulated from channel by a layer of Sio_2
4	Channel exists permanently	Channel exists permanently in depletion type but not in enhancement type.
5	Difficult to fabricate than MOSFET	Easier to fabricate
6	Drain resistance is high	Drain resistance is less
7	Gate is formed as a diode	Gate is formed as a capacitor

Difference Between JFET and BJT

	JFET	BJT
1.	Unipolar device (current conduction is only due to one type of majority carrier either electron or hole).	Bipolar device (current condition, by both types of carriers, i.e., majority and minority-electrons and holes)
2.	The operation depends on the control of a junction depletion width under reverse bias.	The operation depends on the injection of minority carriers across a forward biased junction.
3.	Voltage driven device. The current through the two terminals is controlled by a voltage at the third terminal (gate).	Current driven device. The current through the two terminals is controlled by a current at the third terminal (base).
4.	Low noise level.	High noise level.
5.	High input impedance (due to reverse bias).	Low input impedance (due to forward bias).
6.	Gain is characterised by transconductance.	Gain is characterized by voltage gain.
7.	Better thermal stability.	Less thermal stability.

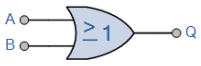
Logic gates

The Logic AND Gate

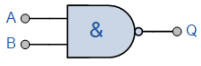
Symbol	Truth Table		
	B	A	Q
	0	0	0
	0	1	0
	1	0	0
	1	1	1
Boolean Expression **Q = A.B**	Read as A **AND** B gives Q		

2-input AND Digital Logic Gate

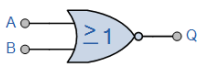
The Logic OR Gate

Symbol	Truth Table		
	B	A	Q
	0	0	0
	0	1	1
	1	0	1
	1	1	1
Boolean Expression Q = A + B	Read as A **OR** B gives Q		

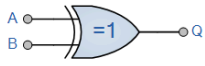
The Logic NAND Gate

Symbol	Truth Table		
	B	A	Q
	0	0	1
	0	1	1
	1	0	1
	1	1	0
Boolean Expression $Q = \overline{A \cdot B}$	Read as A **AND** B gives **NOT** Q		

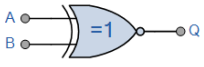
The Logic NOR Gate

Symbol	Truth Table		
	B	A	Q
	0	0	1
	0	1	0
	1	0	0
	1	1	0
Boolean Expression $Q = \overline{A + B}$	Read as A **OR** B gives **NOT** Q		

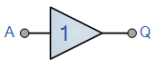
The Logic Exclusive-OR Gate (Ex-OR)

Symbol	Truth Table		
	B	A	Q
	0	0	0
	0	1	1
	1	0	1
	1	1	0
Boolean Expression $Q = A \oplus B$	Read as A **OR** B but not **BOTH** gives Q (odd)		

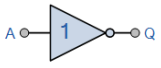
The Logic Exclusive-NOR Gate (Ex-NOR)

Symbol	Truth Table		
	B	A	Q
	0	0	1
	0	1	0
	1	0	0
	1	1	1
Boolean Expression $Q = \overline{A \oplus B}$	Read if A **AND** B the **SAME** gives Q (even)		

The Hex Buffer

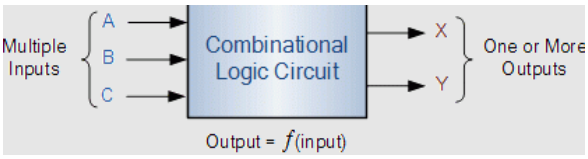
Symbol	Truth Table	
	A	Q
	0	0
	1	1
Boolean Expression Q = A	Read as **A** gives **Q**	

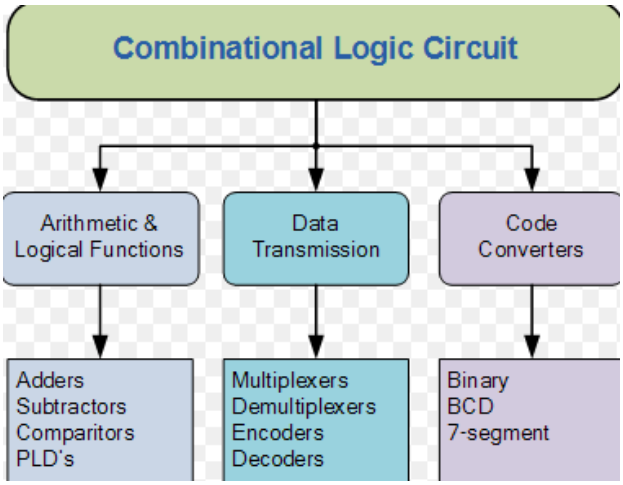
The NOT gate (Inverter)

Symbol	Truth Table	
	A	Q
	0	1
	1	0
Boolean Expression Q = not A or $\overline{A}$	Read as inverse of **A** gives Q	

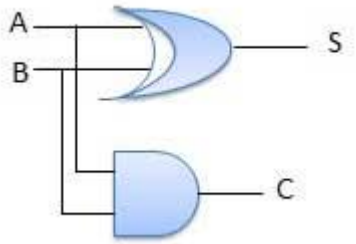
Combinational Logic Circuits

Combinational Logic Circuits are memory less digital logic circuits whose output at any instant in time depends only on the combination of its inputs





Half Adder

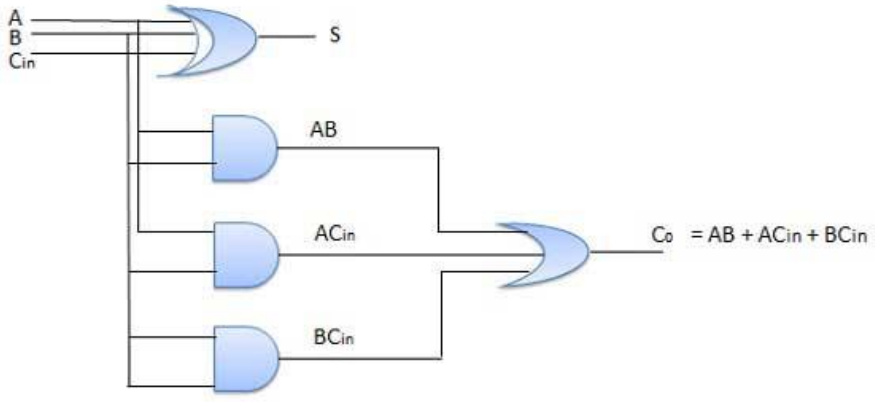


Inputs		Output	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Half adder is a combinational logic circuit with two inputs and two outputs. The half adder circuit is designed to add two single bit binary number A and B. It is the basic building block for addition of two **single** bit numbers. This circuit has two outputs **carry** and **sum**.

Full Adder

Inputs			Output	
A	B	Cin	S	Co
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



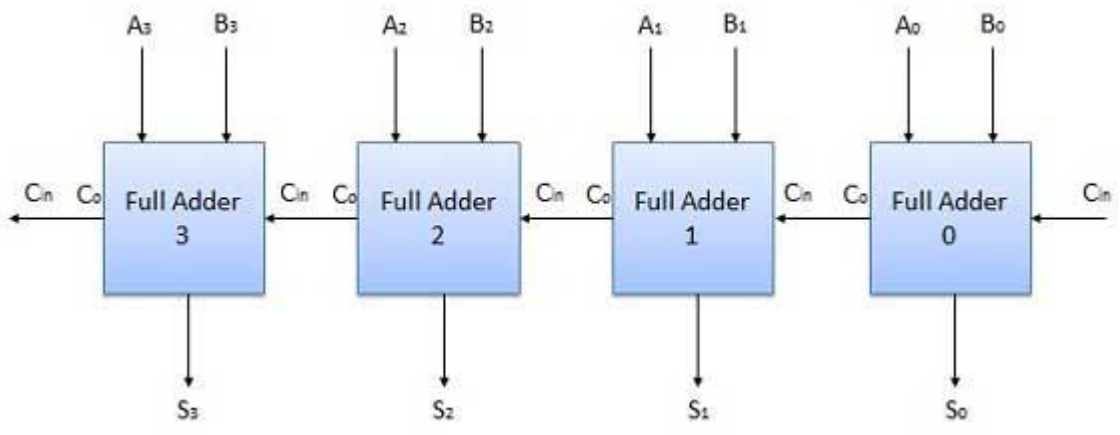
Full adder is developed to overcome the drawback of Half Adder circuit. It can add two one-bit numbers A and B, and carry c. The full adder is a three input and two output combinational circuit.

N-Bit Parallel Adder

The Full Adder is capable of adding only two single digit binary number along with a carry input. But in practical we need to add binary numbers which are much longer than just one bit. To add two n-bit binary numbers we need to use the n-bit parallel adder. It uses a number of full adders in cascade. The carry output of the previous full adder is connected to carry input of the next full adder.

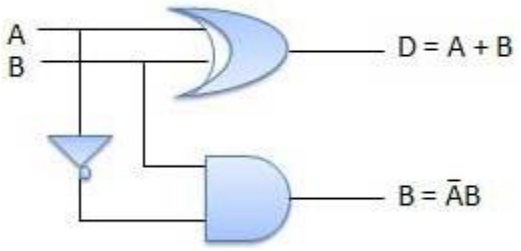
4 Bit Parallel Adder

In the block diagram, A_0 and B_0 represent the LSB of the four bit words A and B. Hence Full Adder-0 is the lowest stage. Hence its C_{in} has been permanently made 0. The rest of the connections are exactly same as those of n-bit parallel adder is shown in fig. The four bit parallel adder is a very common logic circuit.



Half Sub tractors

Inputs		Output	
A	B	(A – B)	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

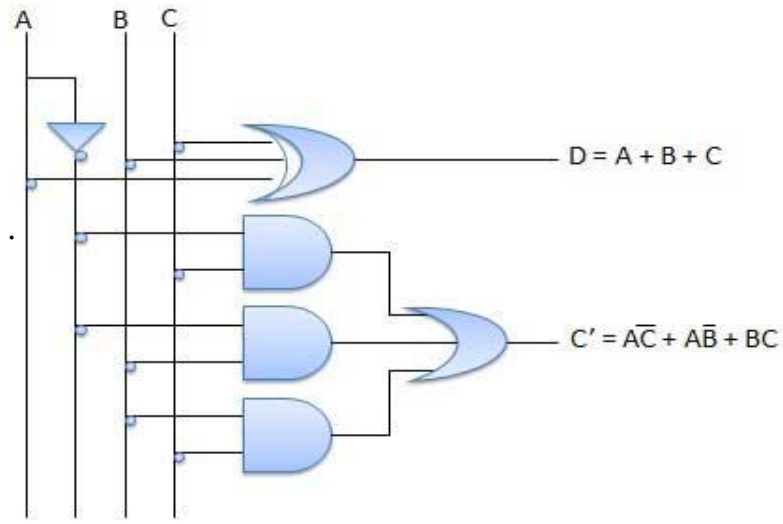


Half subtractor is a combination circuit with two inputs and two outputs (difference and borrow). It produces the difference between the two binary bits at the input and also produces an output (Borrow) to indicate if a 1 has been borrowed. In the subtraction (A-B), A is called as Minuend bit and B is called as Subtrahend bit.

Full Subtractors

The disadvantage of a half subtractor is overcome by full subtractor. The full subtractor is a combinational circuit with three inputs A,B,C and two output D and C'. A is the 'minuend', B is 'subtrahend', C is the 'borrow' produced by the previous stage, D is the difference output and C' is the borrow output

Inputs			Output	
A	B	C	(A-B-C)	C'
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

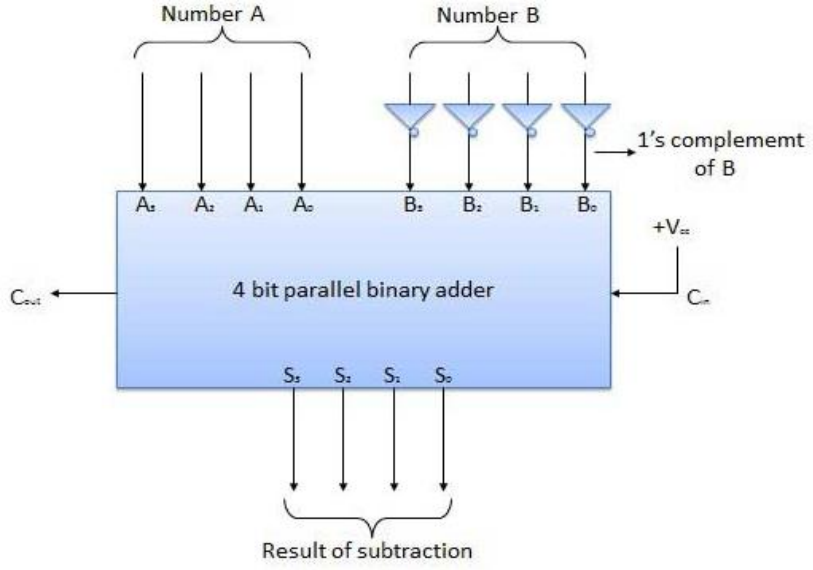


N-Bit Parallel Subtractor

The subtraction can be carried out by taking the 1's or 2's complement of the number to be subtracted. For example we can perform the subtraction (A-B) by adding either 1's or 2's complement of B to A. That means we can use a binary adder to perform the binary subtraction.

4 Bit Parallel Subtractor

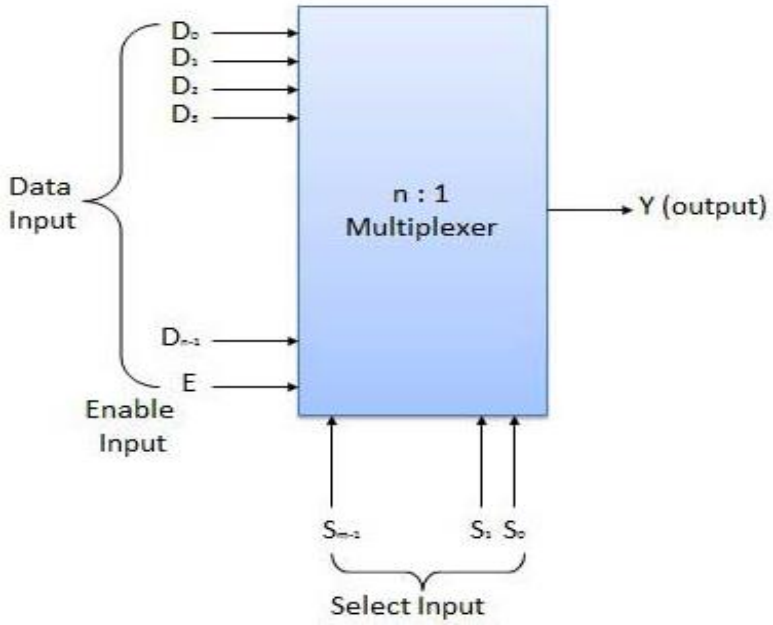
- The number to be subtracted (B) is first passed through inverters to obtain its 1's complement. The 4-bit adder then adds A and 1's complement of B to produce the subtraction.



- S_3 S_2 S_1 S_0 represents the result of binary subtraction (A-B) and carry output C_{out} represents the polarity of the result. If A > B then Cout = 0 and the result of binary form (A-B) then C_{out} = 1 and the result is in the 2's complement form.

Multiplexers

Multiplexer is a special type of combinational circuit. There are n-data inputs, one output and m select inputs with 2m = n. It is a digital circuit which selects one of the n data inputs and routes it to the output. The selection of one of the n inputs is done by the selected inputs.

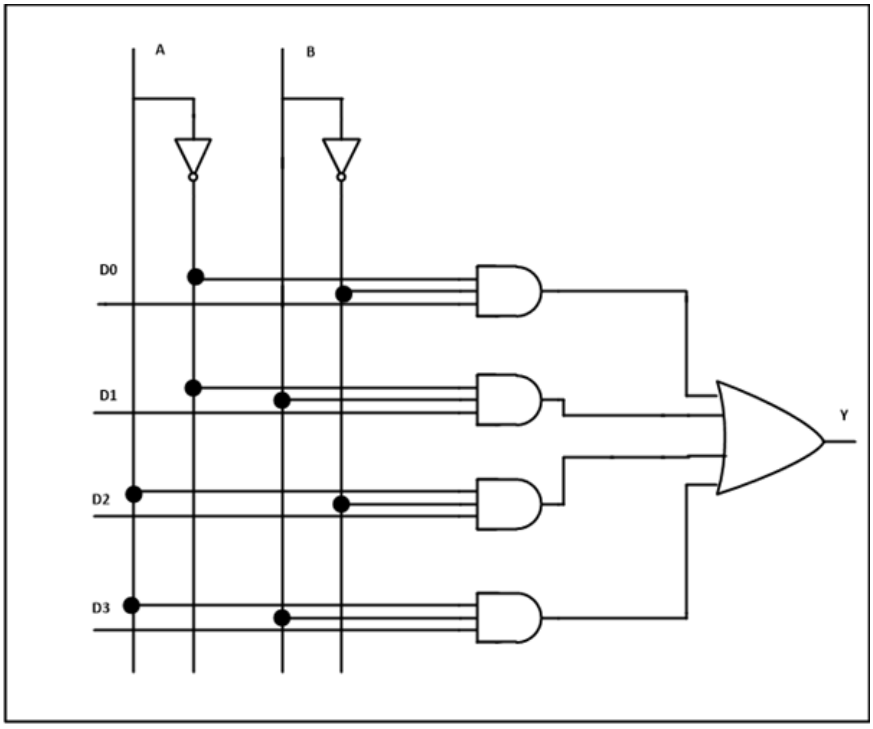


Depending on the digital code applied at the selected inputs, one out of n data sources is selected and transmitted to the single output Y. E is called the strobe or enable input which is useful for the cascading. It is generally an active low terminal that means it will perform the required operation when it is low.

Multiplexers come in multiple variations

2 : 1 multiplexer, 4 : 1 multiplexer, 16 : 1 multiplexer, 32 : 1 multiplexer

Understanding 4-to-1 Multiplexer:



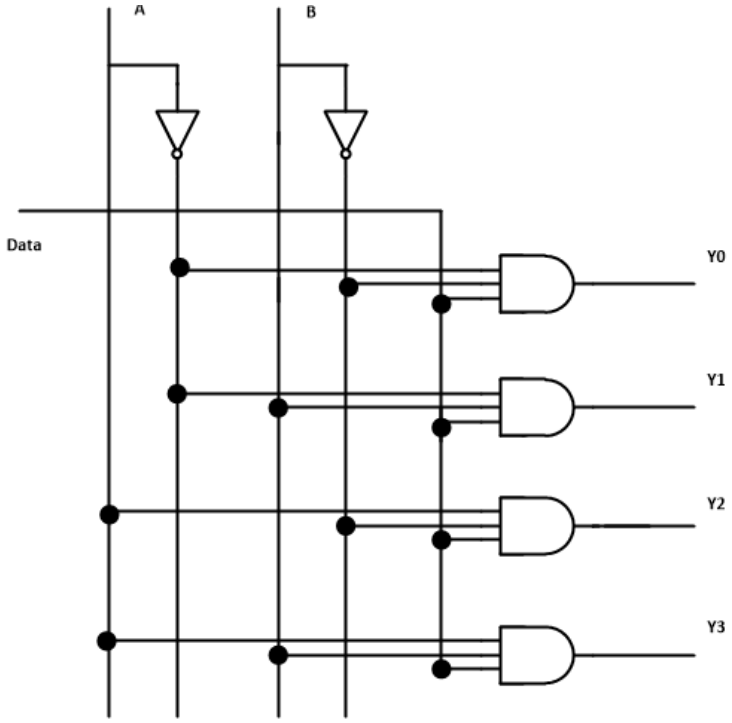
The 4-to-1 multiplexer has 4 input bit, 2 control bits, and 1 output bit. The four input bits are D0,D1,D2 and D3. only one of this is transmitted to the output y. The output depends on the value of AB which is the control input. The control input determines which of the input data bit is transmitted to the output.

For instance, as shown in fig. when AB = 00, the upper AND gate is enabled while all other AND gates are disabled. Therefore, data bit D0 is transmitted to the output, giving Y = Do.

If the control input is changed to AB =11, all gates are disabled except the bottom AND gate. In this case, D3 is transmitted to the output and Y = D3.

- An example of 4-to-1 multiplexer is IC 74153 in which the output is same as the input.
- Another example of 4-to-1 multiplexer is 45352 in which the output is the compliment of the input.
- Example of 16-to-1 line multiplexer is IC74150.

De-multiplexer:



De-multiplexer means one to many. A de-multiplexer is a circuit with one input and many output. By applying control signal, we can steer any input to the output. Few types of de-multiplexer are 1-to 2, 1-to-4, 1-to-8 and 1-to 16 De-multiplexer.

The input bit is labeled as Data D. This data bit is transmitted to the data bit of the output lines. This depends on the value of AB, the control input.

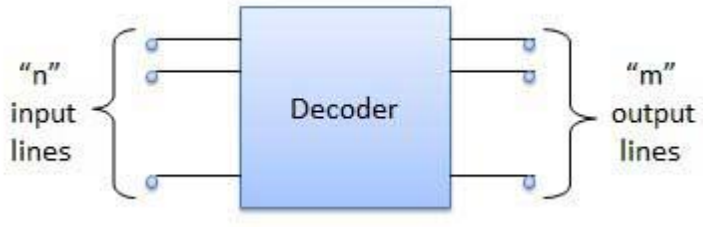
When AB = 01, the upper second AND gate is enabled while other AND gates are disabled. Therefore, only data bit D is transmitted to the output, giving Y1 = Data.

If D is low, Y1 is low. IF D is high,Y1 is high. The value of Y1 depends upon the value of D. All other outputs are in low state.

If the control input is changed to AB = 10, all the gates are disabled except the third AND gate from the top. Then, D is transmitted only to the Y2 output, and Y2 = Data.

Example of 1-to-16 demultiplexer is IC 74154 it has 1 input bit, 4 control bits and 16 output bit.

Decoder



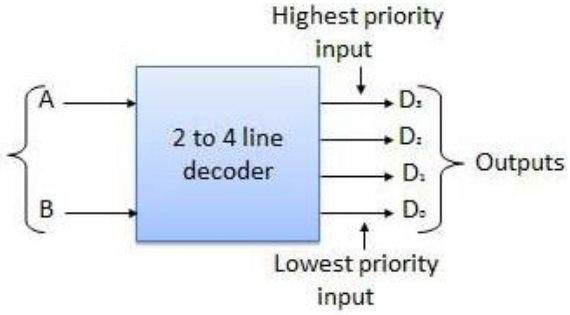
A decoder is a combinational circuit. It has n input and to a maximum m = 2^n outputs. Decoder is identical to a De-multiplexer without any data input. It performs operations which are exactly opposite to those of an encoder.

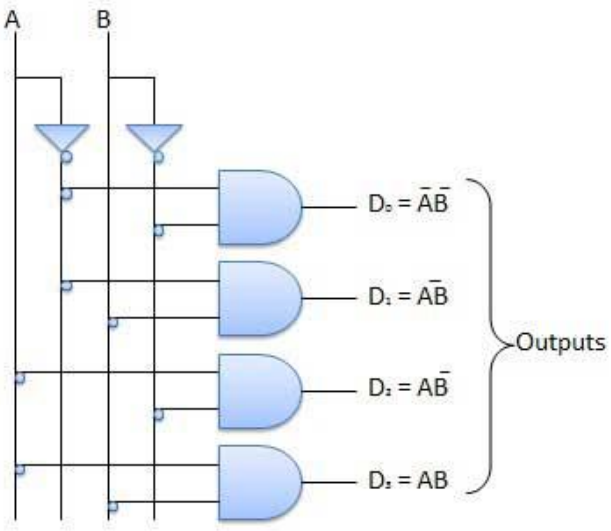
Examples of Decoders are following.

- Code converters
- BCD to seven segment decoders
- Nixie tube decoders
- Relay actuator

2 to 4 Line Decoder

The block diagram of 2 to 4 line decoder is shown in the fig. A and B are the two inputs where D through D are the four outputs. Truth table explains the operations of a decoder. It shows that each output is 1 for only a specific combination of inputs.





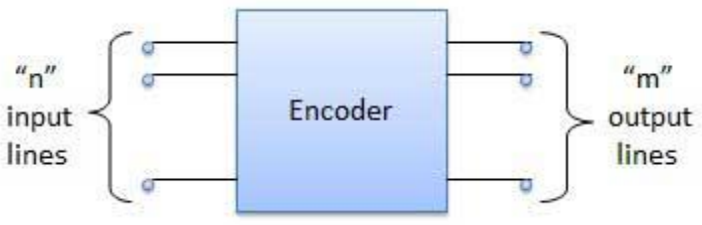
Inputs		Output			
A	B	D_0	D_1	D_2	D_3
0	0	1	0	0	0
0	1	0	1	0	0
0	1	0	0	1	0
1	1	0	0	0	1

Encoder

Encoder is a combinational circuit which is designed to perform the inverse operation of the decoder. An encoder has n number of input lines and m number of output lines. An encoder produces an m bit binary code corresponding to the digital input number. The encoder accepts an n input digital word and converts it into an m bit another digital word.

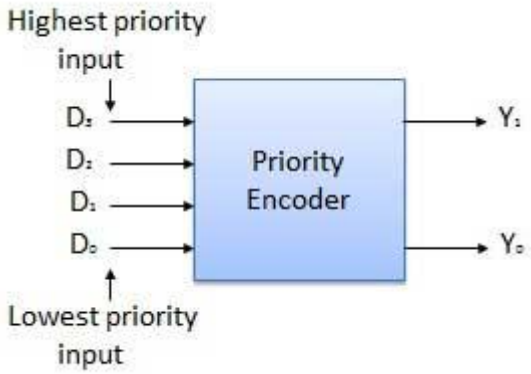
Examples of Encoders are following.

- Priority encoders
- Decimal to BCD encoder
- Octal to binary encoder
- Hexadecimal to binary encoder

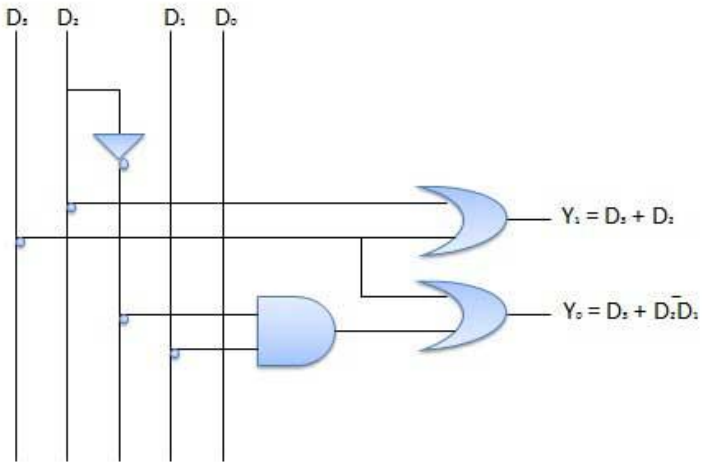


Priority Encoder

This is a special type of encoder. Priority is given to the input lines. If two or more input line are 1 at the same time, then the input line with highest priority will be considered. There are four input D_0, D_1, D_2, D_3 and two output Y_0, Y_1. Out of the four input D_3 has the highest priority and D_0 has the lowest priority. That means if $D_3 = 1$ then $Y_1\ Y_1 = 11$ irrespective of the other inputs. Similarly if $D_3 = 0$ and $D_2 = 1$ then $Y_1\ Y_0 = 10$ irrespective of the other inputs.



Highest	Inputs		Lowest	Outputs	
D_3	D_2	D_1	D_0	Y_0	Y_1
0	0	0	0	x	x
0	0	0	1	0	0
0	0	1	x	0	1
0	1	x	x	1	0
1	x	x	x	1	1



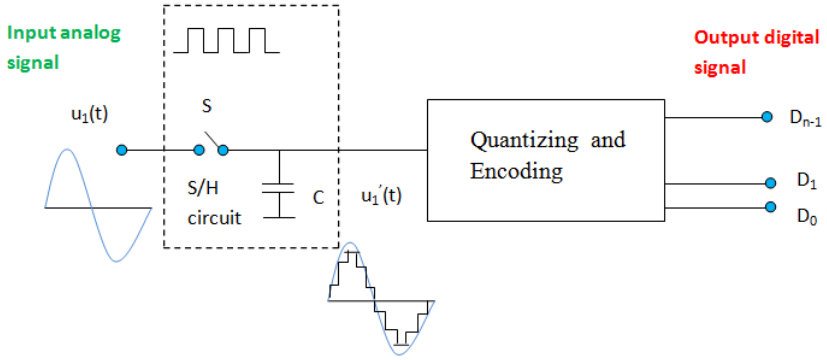
Difference between Multiplexer and De-multiplexer

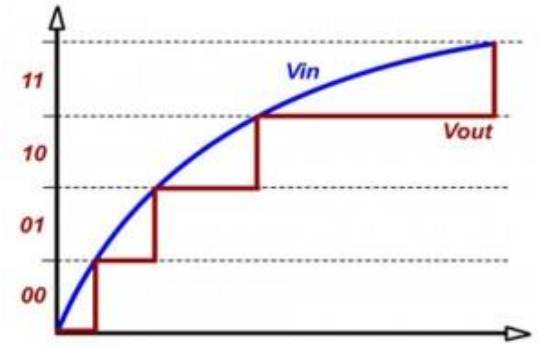
Multiplexer	De-multiplexer
A multiplexer (Mux) is a combinational circuit that uses several data inputs to generate a single output.	A de-multiplexer (Demux) is also a combinational circuit that uses single input that can be directed throughout several outputs.
Multiplexer includes several inputs and the single output	De-multiplexer includes single input and several outputs
A multiplexer is a data selector	The de-multiplexer is a data distributor
It works on the principle of many to one	it works on the principle of one-to-many
The parallel to serial conversion is used in the multiplexer	the serial to parallel conversion is used in De-multiplexer
In Multiplexer, control signals are used to choose the specific input that has to be sent at the output.	De-multiplexer uses the control signal to permit us to include several outputs.
The multiplexer is used to improve the efficiency of the communication system using transmission data like transmission of audio as well as video.	De-multiplexer gets the o/p signals from the Mux & changed them to the unique form at the end of the receiver.

Difference between Encoder and Decoder

ENCODER	DECODER
Encoder circuit basically converts the applied information signal into a coded digital bit stream.	Decoder performs reverse operation and recovers the original information signal from the coded bits
In case of encoder, the applied signal is the active signal input	Decoder accepts coded binary data as its input
The number of inputs accepted by an encoder is 2n.	The number of input accepted by decoder is only n inputs.
The output lines for an encoder is n.	The output lines of an decoder is 2n
The encoder generates coded data bits as its output	The decoder generates an active output signal in response to the coded data bits.
The operation performed is simple.	The operation performed is complex.
The encoder circuit is installed at the transmitting end.	The decoder circuit is installed at the receiving side.
OR gate is the basic logic element used in it.	AND gate along with NOT gate is the basic logic element used in it.
It is used in E-mail, video encoders etc.	It is used in Microprocessors, memory chips etc.

Analog to digital converter (ADC)





Sampling and Holding

In the process of Sample and hold (S/H), the continuous signal will gets sampled and freeze (hold) the value at a steady level for a particular least period of time. It is done to remove variations in input signal which can alter the conversion process and thereby increases the accuracy. The minimum sampling rate has to be two times the maximum data frequency of the input signal.

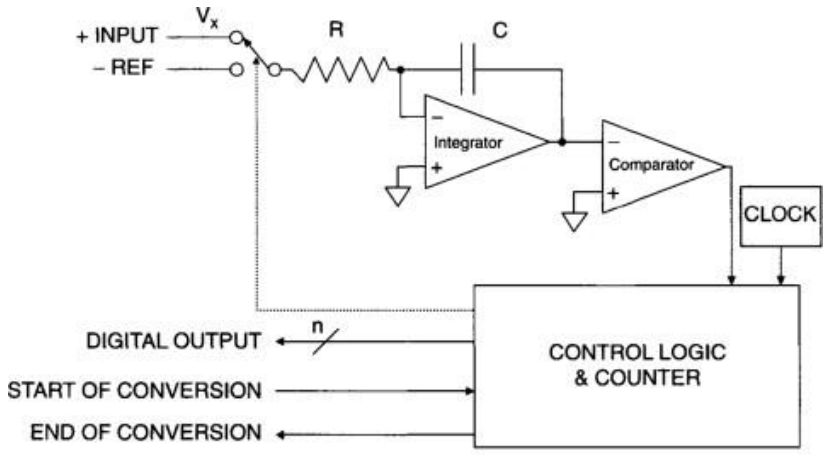
Quantizing: It is the process in which the reference signal is partitioned into several discrete quanta and then the input signal is matched with the correct quantum.

Encoding: Here; for each quantum, a unique digital code will be assigned and after that the input signal is allocated with this digital code.

Types of ADC

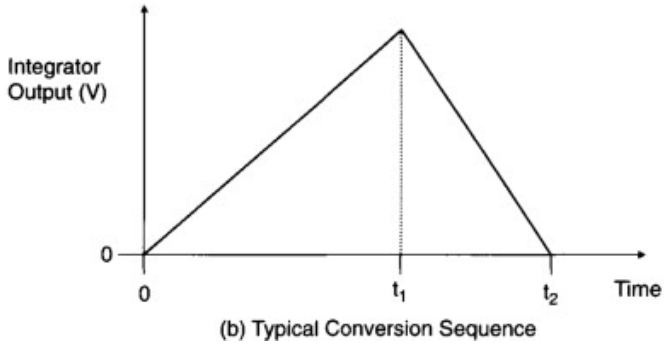
- **Dual Slope ADC:** It have high accuracy but very slow in operation.
- **Flash ADC:** It is the fastest ADC but very expensive.
- **Successive Approximation ADC:** This converter compares the input signal with the output of an internal DAC at each successive step. It is the most expensive type.

Dual Slope ADC



As the name suggests, a **dual slope ADC** produces an equivalent digital output for a corresponding analog input by using two (dual) slope technique.

the dual slope ADC mainly consists of 5 blocks: Integrator, Comparator, Clock signal generator, Control logic and Counter.



(b) Typical Conversion Sequence

The **working** of a dual slope ADC is as follows −

- The **control logic** resets the counter and enables the clock signal generator in order to send the clock pulses to the counter, when it is received the start commanding signal.
- Control logic pushes the switch **sw** to connect to the **external analog input voltage(INPUT)**, when it is received the start commanding signal. This input voltage is applied to an integrator.
- The output of the **integrator** is connected to one of the two inputs of the comparator and the other input of comparator is connected to ground.
- **Comparator** compares the output of the integrator with zero volts (ground) and produces an output, which is applied to the control logic.
- The **counter** gets incremented by one for every clock pulse and its value will be in binary (digital) format. It produces an overflow signal to the control logic, when it is incremented after reaching the maximum count value. At this instant, all the bits of counter will be having zeros only.
- Now, the control logic pushes the switch **sw** to connect to the **negative reference** voltage (-REF).This negative reference voltage is applied to an integrator. It removes the charge stored in the capacitor until it becomes zero.
- At this instant, both the inputs of a comparator are having zero volts. So, comparator sends a signal to the control logic. Now, the control logic disables the clock signal generator and retains (holds) the counter value. The **counter value** is proportional to the external analog input voltage.
- At this instant, the output of the counter will be displayed as the **digital output**. It is almost equivalent to the corresponding external analog input value Vi

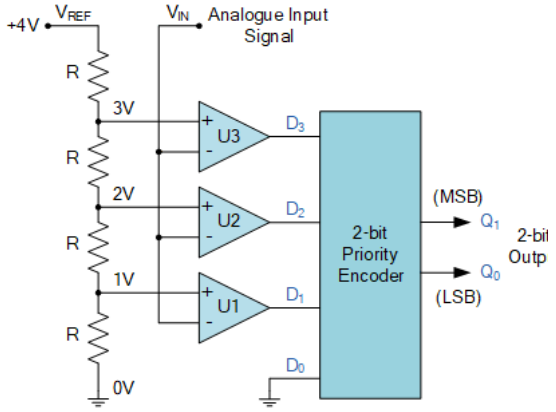
Flash A/D Converter

This ADC converter IC is also called parallel ADC, which is the most widely used efficient ADC in terms of its speed. This flash analog to digital converter circuit consists of a series of comparators where each one compares the input signal with a unique reference voltage. At each comparator, the output will be a high state when the analog input voltage exceeds the reference voltage. This output is further given to the priority encoder for generating binary code based on higher-order input activity by ignoring other active inputs. This flash type is a high-cost and high-speed device.

Here in this simple 2-bit ADC example we have assumed for simplicity that the input voltage V_{IN} is between 0 and 4 volts, so have set V_{REF} and the resistive voltage-divider network to drop 1 volt across each resistor.

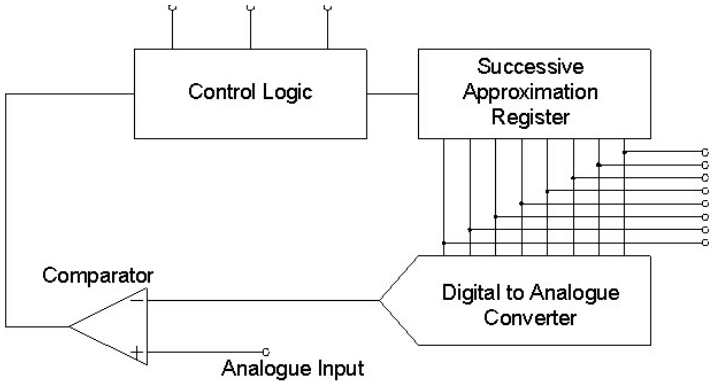
When V_{IN} is between 0 and 1 volt, (<1V) the input on all three comparators will be less than the reference voltage, so their outputs will be LOW and the encoder will output a binary zero (00)

condition on pins Q_0 and Q_1. When V_{IN} increases and exceeds 1 volt but is less than 2 volts, ($1V<V_{IN}<2V$) comparator U1 which has a reference voltage input set at 1 volt, will detect this voltage difference and produce a HIGH output. The priority encoder which is used as the 4-to-2 bit encoding detects the change of input at D_1 and produces a binary output of "1" (01).



Analogue Input Voltage (V_{IN})	Comparator Outputs				Digital Outputs	
	D_3	D_2	D_1	D_0	Q_1	Q_0
0 to 1 V	0	0	0	**0**	0	0
1 to 2 V	0	0	**1**	X	0	1
2 to 3 V	0	**1**	X	X	1	0
3 to 4 V	**1**	X	X	X	1	1

Successive Approximation A/D Converter



The SAR ADC a most modern ADC IC and much faster than dual slope and flash ADCs since it uses a digital logic that converges the analog input voltage to the closest value. This circuit consists of a comparator, output latches, successive approximation register (SAR), and D/A converter.

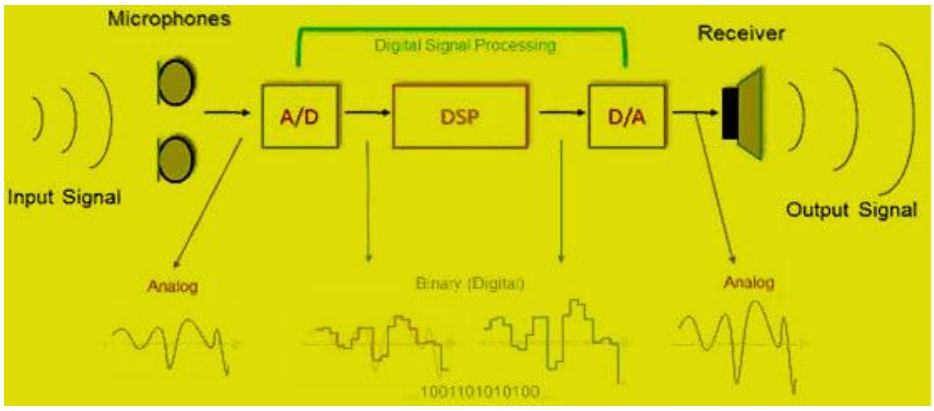
At the start, SAR is reset and as the LOW to HIGH transition is introduced, the MSB of the SAR is set. Then this output is given to the D/A converter that produces an analog equivalent of the MSB, further it is compared with the analog input Vin. If comparator output is LOW, then MSB will be cleared by the SAR, otherwise, the MSB will be set to the next position. This process continues till all the bits are tried and after Q0, the SAR makes the parallel output lines to contain valid data.

Application of ADC

- Used together with the transducer.
- Used in computer to convert the analog signal to digital signal.
- Used in cell phones.
- Used in microcontrollers.
- Used in digital signal processing.
- Used in digital storage oscilloscopes.
- Used in scientific instruments.
- Used in music reproduction technology etc.

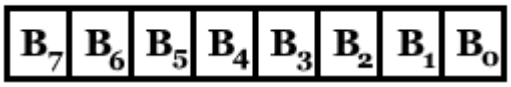
Digital to Analog converter(DAC)

Digital to Analog Converter (DAC) is an integrated circuit that converts digital signal to analog voltage/current which is necessary for further Analog Signal Processing. (OR) Digital to Analog Converter (DAC) basically converts digital code that represents digital value to analog current or voltage.



Working of DAC

The digital binary data exists in the form of bits. Each bit is either 1 or 0 & they represent its weight corresponding to its position. The weight is 2^n where the n is the position of the bit from right hand side & it start from 0.



8-bit Binary Number

Bit Weight = 2^n

Bit weight of 4^{th} bit from left= $2^n = 2^3 = 8$

The bit weight is multiplied by the bit value. Since the bit could be either 0 or 1, it means;

Bit value of 1 x bit weight = 1 x $2^n = 2^n$

Bit value of 0 x bit weight = 0 x $2^{(n-1)} = 0$

Now adding the weights of all the bits with its value in a binary number 10011;

$1\ 0011_2 = (1 \times 2^4) + (0 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0)$

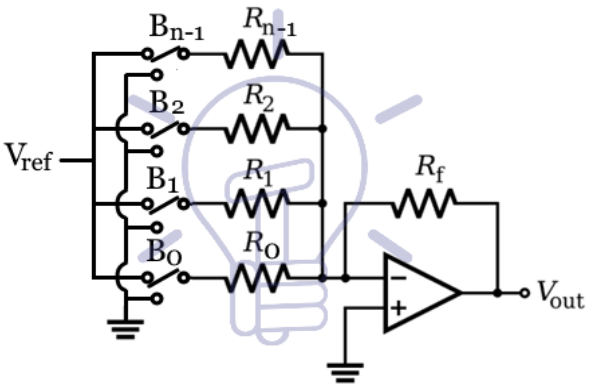
$10011_2 = 16 + 0 + 0 + 2 + 1 = 19$

Types of DAC

Weighted Resistor Method

The weighted resistor method utilizes the summing operational amplifier circuit. The summing amplifier adds the input signals with different gains corresponding to their resistors.

It can be used as a DAC if we assign each resistor a with specific value to scale their gain in the form of 2, 4, 8 ,16 & so on. As we know the V_{ref} (the reference voltage or the maximum analog output voltage) is the only input signal (beside the binary input) so;



$V_{out} = -\{(R_f/R_0)\, V_{ref} + (R_f/R_1)\, V_{ref} + (R_f/R_2)\, V_{ref} + \ldots + (R_f/R_{n-1})\, V_{ref}\}$

$V_{out} = -V_{ref}\{(R_f/R_0) + (R_f/R_1) + (R_f/R_2) + \ldots + (R_f/R_{n-1})\}$

In this circuit, the binary input 1 or 0 is used for switching between the v_{ref} & GND. The input B = 1 means the switch is connected with V_{ref} & B = 0 means the switch is connected with GND. In such case the equation for a binary number B_0, B_1, B_2… B_n ; where B_0 is LSB & B_n is MSB, become

$V_{out} = -V_{ref}\{B_0(R_f/R_0) + B_1(R_f/R_1) + B_2(R_f/R_2) + \ldots + B_{n-1}(R_f/R_{n-1})\}$

The resistor $R_f = R$. while the R_0, R_1, R_2, & R_{n-1} are scaled to provide the necessary gain corresponding to the weight of each bit. The resistors are scaled with the values $2^{(N-1)-n}$, such that;

$R_n = 2^{(N-1)-n} R$ where N is number of bits & n is the bit position So

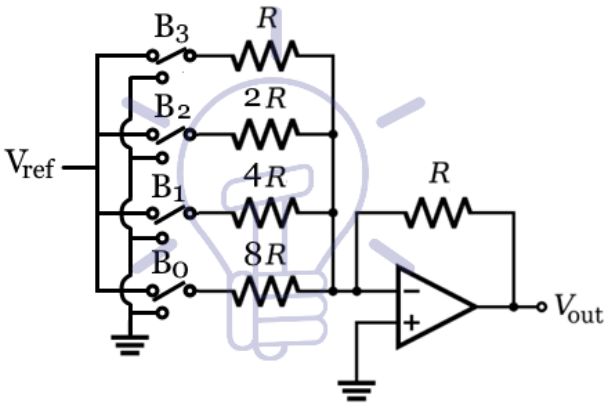
$V_{out} = -V_{ref}\{B_0(R/2^{(N-1)}R) + B_1(R/2^{(N-2)}R) + B_2(R/2^{(N-3)}R) + \ldots + B_{N-2}(R/2^1 R) + B_{N-1}(R/2^0 R)\}$

$V_{out} = -V_{ref}\{B_0(1/2^{(N-1)}) + B_1(1/2^{(N-2)}) + B_2(1/2^{(N-3)}) + \ldots + B_{N-2}(1/2^{(1)}) + B_{N-1}(1/2^0)\}$

The output voltage for a 4 bit binary number would be;

$V_{out} = -V_{ref}\{B_0(1/2^3) + B_1(1/2^{(2)}) + B_2(1/2^{(1)}) + B_3(1/2^0)\}$

$V_{out} = -V_{ref}\{B_0(1/8) + B_1(1/4) + B_2(1/2) + B_3\}$



As you can see, each resistor is scaled to add the bit-weight of each bit of a binary input. Simplified formulae for such circuit would be

$V_{out} = – V_{ref} \{ B_0 (1/2^{(N-1)})) + B_1 (1 /2^{(N-2)}) + B_2 (1/2^{(N-3)})) + B_3 (1/2^{(N-4)}) + B_4 (1/2^{(N-5)} + \ldots\}$
Where the denominator $2^{(N-1)}$ represents the scaling factor of each corresponding resistor.

Example

Let's convert a binary number of 01101 into an analog output where the v_{ref} = 10v.
So the N = 5

$V_{out} = – V_{ref} \{ B_0 (1/2^{(N-1)})) + B_1 (1 /2^{(N-2)}) + B_2 (1/2^{(N-3)})) + B_3 (1/2^{(N-4)}) + B_4 (1/2^{(N-5)} \}$

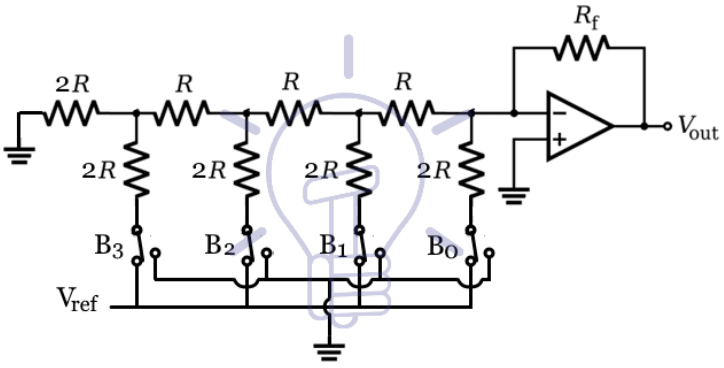
$V_{out} = – V_{ref} \{ B_0 (1/2^4) + B_1 (1 /2^3) + B_2 (1/2^2) + B_3 (1/2^1) + B_4 (1/2^0) \}$

$V_{out} = – (10) \{ 1 (1/2^4) + 0 (1 /2^3) + 1 (1/2^2) + 1 (1/2^1) + 0 (1/2^0)\}$

$V_{out} = – (10) \{ 1/16 + 0 + 1/4 + 1/2 + 0\}$

$V_{out} = – 8.125$

R-2R Ladder Circuit

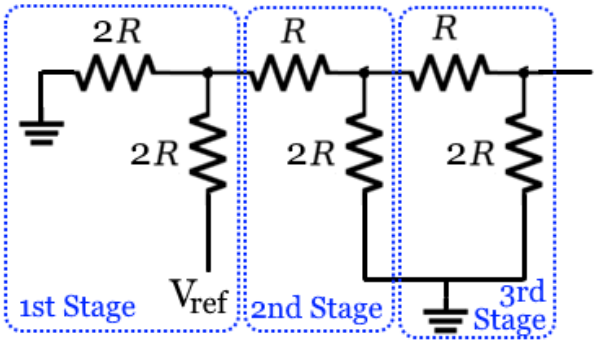


This method is more precise, accurate & easy to design then the weighted resistor method. R-2R ladder circuit is made by adding combination R & 2R resistor in cascaded form as shown in the following figure.

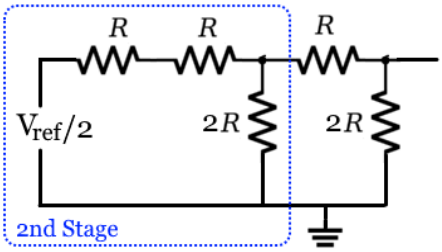
There are only two types of resistors used. Each stage contains R and 2R, is used for a single bit. There is switch between the Vref and GND which is controlled by the binary input. Bit 0 means the GND is connected and bit 1 means the Vref is connected.
Working

Let's assume a 3 bit DAC using R-2R ladder network.

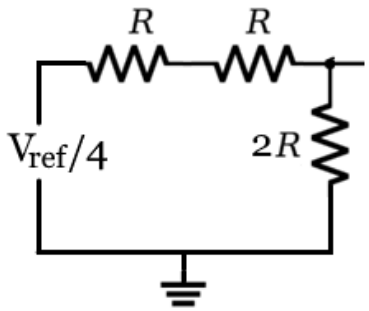
$B_2B_1B_0$ are the 3 bits of the input. When B_2=1, B_1 and B_0 =0. Then the equivalent circuit would be



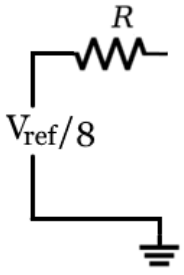
Replacing the 1st stage with its V_{th} & R_{th}; $V_{th} = V_{ref}/2$ & $R_{th} = R$



Now the 2nd stage V_{th} & $R_{th;}$ $V_{th} = V_{ref}/4$ & $R_{th} = R$



Now 3rd stage Vth and Rth $V_{th} = V_{ref}/8$ & $R_{th} = R$



So the output voltage in this case would become $V_{out} = -V_{th}\ (R_f/R) = -(V_{ref}/8)\ (R/R) = -(V_{ref}/8)$

Advantages of R-2R Ladder DAC;

- Uses only two types of resistors
- Easily scalable to any number of bits

- Output impedance is always R

The applications of Digital to Analog Converter include:

- DAC's are used in Digital Signal Processing.
- They are also used in digital power supplies for Micro-controller.
- DAC's are used in digital potentiometers.
- They are used in all digital data acquisition systems.

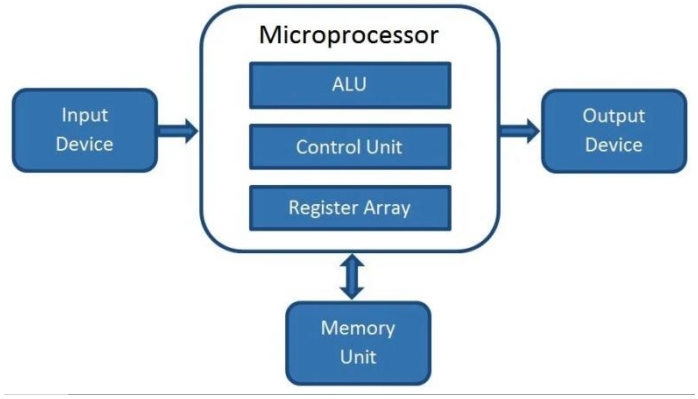
The advantages of Digital to Analog Converter are:

- Weighted Resistor Circuit is the fastest converting circuit compared to other methods.
- High resolution and accuracy can be achieved.
- DAC's are simple to implement.

The disadvantages of DAC are:

- Voltage levels must be exactly the same for all inputs in Weighted Resistors DAC. E.g. 4-bit Converter requires 4 resistors.
- Binary weighted Resistor circuit that require Op-Amps are expensive.
- Power dissipation of Binary weighted Resistors Circuit is very high.
- In R-2R Ladder converters, Delay is caused as the circuit needs switching based on the inputs.
- Gain Error, Offset Error, Non-linearity is commonly caused by Resistors used in the circuit.

Microprocessor



A microprocessor is an integrated circuit (IC) which incorporates core functions of a computer's central processing unit (CPU). It is a programmable multipurpose silicon chip, clock driven, register based, accepts binary data as input and provides output after processing it as per the instructions stored in the memory.

A processor is the brain of a computer which basically consists of Arithmetical and Logical Unit (ALU), Control Unit and Register Array. As the name indicates ALU performs all arithmetic and logical operations on the data received from input devices or memory. Register array consists of a series of registers like accumulator (A), B, C, D, E, H and L etc, which acts as temporary fast access memory locations for processing data. As the name indicates, control unit controls the flow of instructions and data throughout the system.

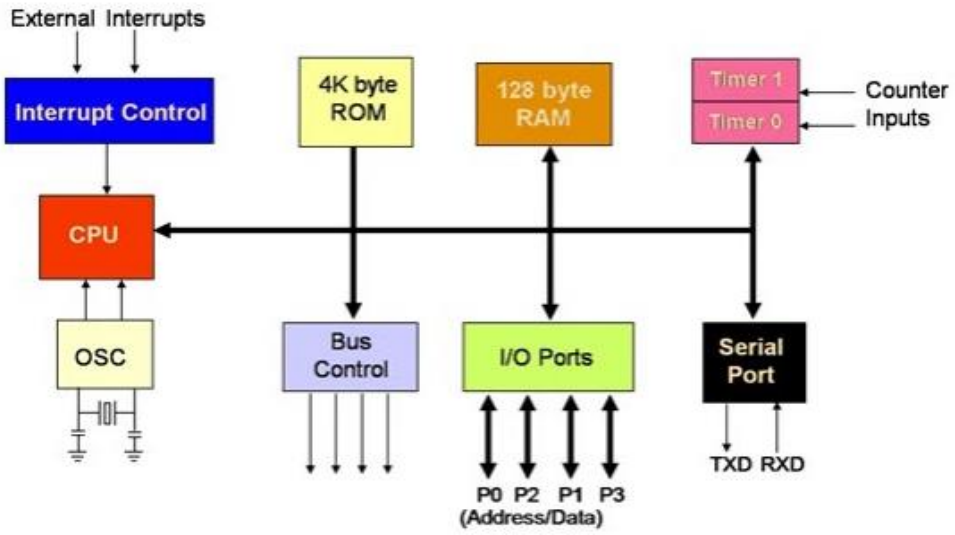
So basically a microprocessor takes input from input devices, process it as per instructions given in the memory and produces output.

Advantages of a Microprocessor

- **Low Cost:** available at low cost due to integrated circuit technology.
- **High Speed:** can work at very high speed due to the technology involved in it. It is capable of executing millions of instructions per second.
- **Small Size:** Due to very large scale and ultra large scale integration technology, a microprocessor is fabricated in a very less footprint. This will reduce the size of the entire computer system.
- **Versatile: T**he same chip can be used for a number of applications by simply changing the program (instructions stored in the memory).
- **Low Power Consumption: m**anufactured using metal oxide semiconductor technology, in which MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) are working in saturation and cut off modes. So the power consumption is very low compared to others.
- **Less Heat Generation:** Compared to vacuum tube devices, semiconductor devices won't emit that much heat.
- **Reliable :**Microprocessors are very reliable, failure rate is very less as semiconductor technology is used.
- **Portable:** Devices or computer system made with microprocessors can be made portable due to the small size and low power consumption.

Microcontroller

The difference between a Microprocessor and a Microcontroller is the availability of the on – chip peripherals like Memory (both RAM and ROM), I/O Ports, Timers/Counters, Communication Interfaces (like Serial Port), etc.



Basic block of Microcontroller

CPU (Central Processing Unit)

It is the heart of the Microcontroller that mainly comprises of an Arithmetic Logic Unit (ALU) and a Control Unit (CU) and other important components. The CPU is the primary device in communicating with peripheral devices like Memory, Input and Output.

ALU or Arithmetic Logic Unit, as the name suggests, performs the Arithmetical and Logical Operations. CU or Control Unit is responsible for timing of the communication process between the CPU and its peripherals.

Program Memory

The instructions of the CPU are stored in the Program Memory. It is usually implemented as Read Only Memory or ROM, where the Program written in to it will be retained even when the power is down or the system is reset.

Modern Program Memory Modules are generally made up of EEPROM (Electrically Erasable Programmable Read – only Memory), which is a type of non – volatile memory.
In this type of memory, the data can be erased and reprogrammed using special programming signals.

When the microcontroller is powered on or manually reset, the processor executes a set of instructions from a pre-defined memory location (address) in the Program Memory.

Data Memory

Data Memory in a Microcontroller is responsible for storing values of variables, temporary data, intermediate results and other data for proper operation of the program.

Data Memory is often called as RAM (Random Access Memory), which is a type of volatile memory. It is generally organized as registers and includes both Special Function Registers (SFRs) and user accessible memory locations.

Input and Output Ports

I/O Ports or Input / Output Ports provide the microcontroller, a physical connection to the outside world. Input Ports provide a gateway for passing on the data from the outside world with the help of sensors.

The data from the input ports is manipulated (depending on the application) and will determine the data on the output port.

Output Ports allow microcontroller to control external devices (like motors and LEDs). Generally, all ports in microcontrollers have dual functionality i.e. they can act as both input and output port (not at the same time though).

Clock Generator (Oscillator)

A clock signal allows the operations inside the microcontroller and other parts to be synchronous. A Clock Generator is an integral part of the Microcontroller's Architecture and the user has to provide an additional Timing Circuit in the form of a Crystal.

Advantage

1. The low time required for performing an operation
2. The processor chips are very small and flexible.
3. Due to their higher integration, the cost and size of the system are reduced
4. The microcontroller is easy to interface additional RAM, ROM and I/O ports.
5. Once microcontrollers are programmed then they cannot be reprogrammed.
6. At the same time, many tasks can be performed so human effects can save.
7. It is easy to use, troubleshooting and systems maintenance is simple.

Disadvantage

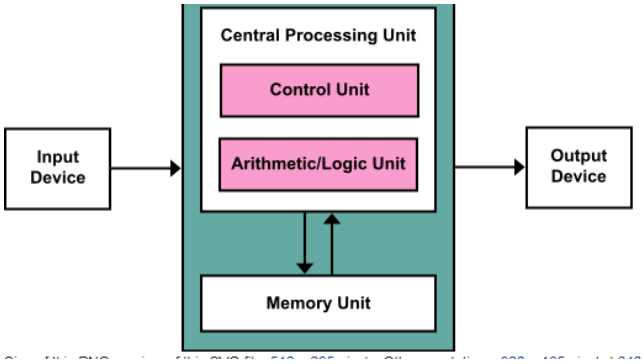
1. The microcontroller cannot interface high power devices directly
2. It has a more complex structure as compared to the microprocessor.
3. It only performed a restricted number of executions simultaneously.
4. It is generally used in micro equipment

Difference between Microprocessor and Microcontroller

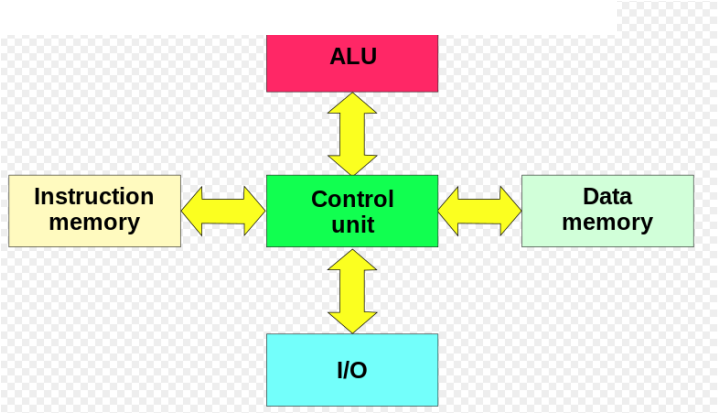
Microprocessor	**Microcontroller**
Microprocessor is the heart of Computer system.	Micro Controller is the heart of an embedded system.
It is only a processor, so memory and I/O	Micro Controller has a processor along with

components need to be connected externally	internal memory and I/O components.
Memory and I/O has to be connected externally, so the circuit becomes large.	Memory and I/O are already present, and the internal circuit is small.
can't use it in compact systems	can use it in compact systems.
Cost of the entire system is high	Cost of the entire system is low
Due to external components, the total power consumption is high. Therefore, it is not ideal for the devices running on stored power like batteries.	As external components are low, total power consumption is less. So it can be used with devices running on stored power like batteries.
Most of the microprocessors do not have power saving features.	Most of the microcontrollers offer power-saving mode.
It is mainly used in personal computers.	It is used mainly in a washing machine, MP3 players, and embedded systems.
Microprocessor has a smaller number of registers, so more operations are memory-based.	Microcontroller has more register. Hence the programs are easier to write.
Microprocessors are based on Von Neumann model	Micro controllers arc based on Harvard architecture
It is a central processing unit on a single silicon-based integrated chip.	It is a byproduct of the development of microprocessors with a CPU along with other peripherals.
It has no RAM, ROM, Input-Output units, timers, and other peripherals on the chip.	It has a CPU along with RAM, ROM, and other peripherals embedded on a single chip.
It uses an external bus to interface to RAM, ROM, and other peripherals.	It uses an internal controlling bus.
Microprocessor-based systems can run at a very high speed because of the technology involved.	Microcontroller based systems run up to 200MHz or more depending on the architecture.
It's used for general purpose applications that allow you to handle loads of data.	It's used for application-specific systems.
It's complex and expensive, with a large number of instructions to process.	It's simple and inexpensive with less number of instructions to process.

Von Neumann model



Harvard architecture



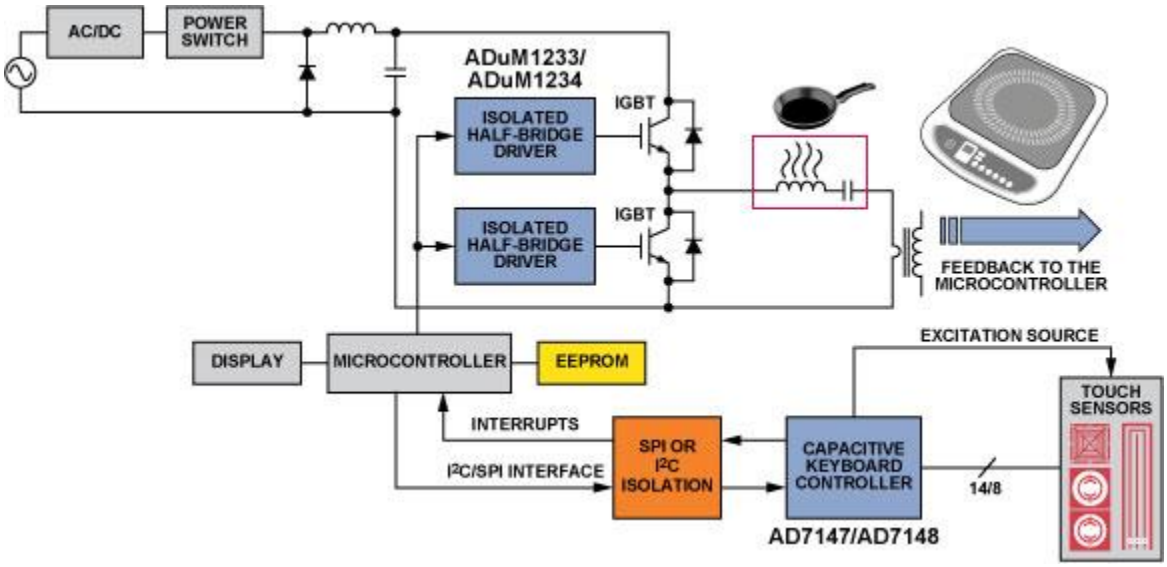
Applications of Microprocessor

- Calculators
- Accounting system
- Games machine
- Complex industrial controllers
- Traffic light
- Control data
- Military applications
- Defense systems
- Computation systems

Application of Microcontroller.

- Mobile phones
- Automobiles
- CD/DVD players
- Washing machines
- Cameras
- Security alarms
- Keyboard controllers
- Microwave oven
- Watches
- Mp3 players

Application of Microcontroller in consumer Electronics



Description of the System

As with a transformer, the inductive element generates a magnetic field. When a metal pan is placed in the field, eddy currents are generated. Their energy is dissipated as heat, causing the pan and, by conduction, its contents to become hot. From an electrical point of view, the inductive element drives a lossy LC resonant circuit, and the losses produce heat. Figure 1 shows the elements of an inductive heating system.

The inductor current waveform is created by a high-efficiency switched dc power supply and a pair of IGBT switches. The switches are driven by a microcontroller, which responds to a feedback loop that forces conditions monitored by sensors to correspond to settings established by the user—and to remain within safe limits.

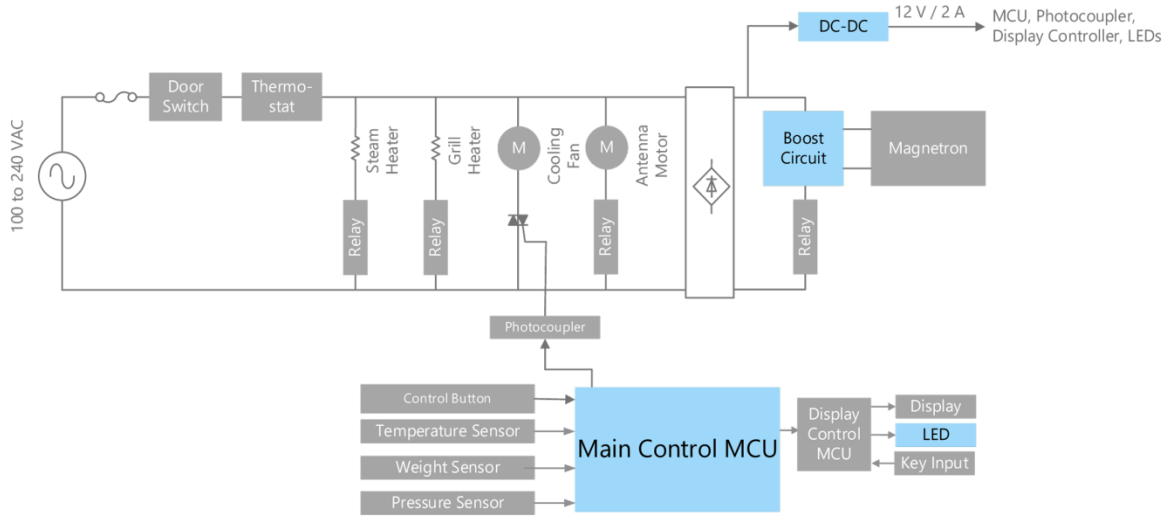
The main sensor, a transformer in series with the inductive plate, monitors the value of the current through the inductive plate in order to maintain the appropriate current value for the selected cooking level. This prevents damage to the power stage—the inductive plate and IGBTs—by decreasing the current level as necessary to avoid an over current condition.

Pan Detection

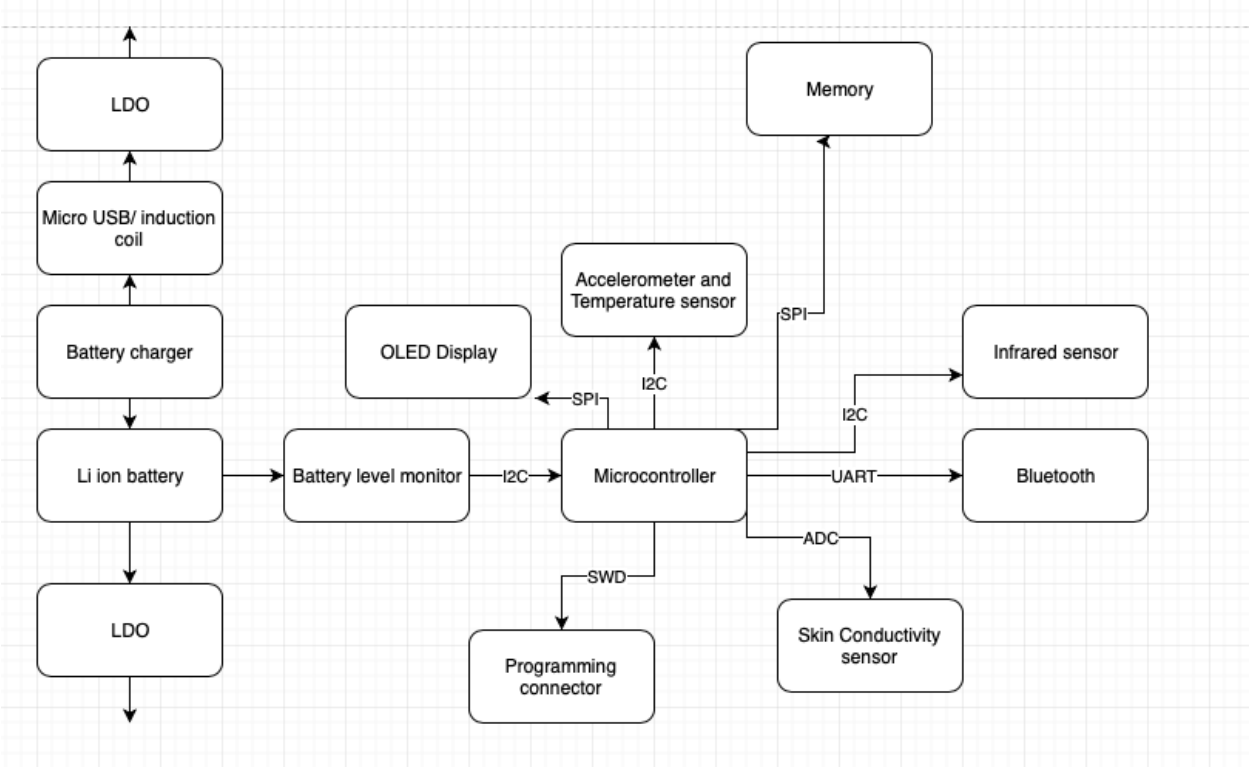
It is important to detect the presence of the pan on the inductive hob. The IGBTs have to manage high voltage rails that are connected to their collector (+HV). By sampling these voltages with resistive dividers, a signal representing them can be sent to the microcontroller to detect any variation of the voltage at the collector of the IGBT. If a user chooses a heating level and places a pan on the inductive hob, the resultant energy transfer and current spike will produce a voltage variation at the collector, and thus at the resistive-divider output. When the pan is removed from the inductive hob, the change will be in the opposite direction. Thus, by comparing the voltage variation with a fixed threshold, using a comparator from the ADCMP3xx family, for example, the pan's presence on the inductive hob can be detected. If no pan is detected, an interrupt is sent

to the microcontroller, which will adjust the PWM frequency until the IGBTs stop providing current to the inductive element. This provides extra safety in case the user forgets to switch off the inductive

Block diagram of Microwave oven



Smart watch



Energy Management

The three primary purposes of building energy management are

- The reduction/management of building energy use
- The reduction of electricity bills while increasing occupant comfort and productivity
- The improvement of environmental stewardship without adversely affecting standards of living.

Lighting and HVAC (Heat, ventilation and Air condition) account for 50% of commercial and 40% of residential building electricity expenditure respectively, indicating that efficiency improvements in these two areas can significantly reduce energy expenditure. These savings can be made through two avenues:

- The use of energy-efficient lighting and HVAC systems
- The deployment of energy management systems which utilize real time price information to schedule loads to minimize energy bills. The latter scheme requires an intelligent power grid or smart grid which can provide bidirectional data flows between customers and utility companies.

The smart grid is characterized by the incorporation of intelligence and bidirectional flows of information and electricity throughout the power grid. These enhancements promise to revolutionize the grid by enabling customers to not only consume but also supply power. Utilities will be able to provide customers with real time pricing (RTP) information and enable their active participation in demand response (DR) programs to reduce peak electricity demand. The smart grid will also facilitate greater incorporation of renewable energy sources such as wind and solar energy, resulting in a cleaner power grid.

The extension of the smart grid into the home via smart meters, home automation networks (HAN's) and advanced metering infrastructure (AMI) enables the provision of real-time pricing information and other services to consumers. This facilitates services such as residential DR. DR is the modification of user electricity consumption patterns due to price variations or incentives from the utility, and its objective is to reward behavior which reduces energy utilization during peak pricing periods. Smart grid DR provides a means of stretching current power infrastructure and delaying the need to build new power plants. It also reduces the rate of greenhouse gas emission by limiting the need for costly and dirty coal-fired peaked plants.

Intelligent Building

The Intelligent Building Institute defines an intelligent building as: " one that provides a productive and cost-effective environment through optimization of its four basic elements – structure, systems, services and management – and the interrelationships between them. Intelligent buildings help building owners, property managers and occupants realize their goals in the area of cost, energy management, comfort, convenience, safety, long term flexibility and marketability."

These buildings are characterized by three features

- Automated control
- The incorporation of occupant preferences and feedback
- Learning ability (performance adjustment based on environmental and occupant changes)

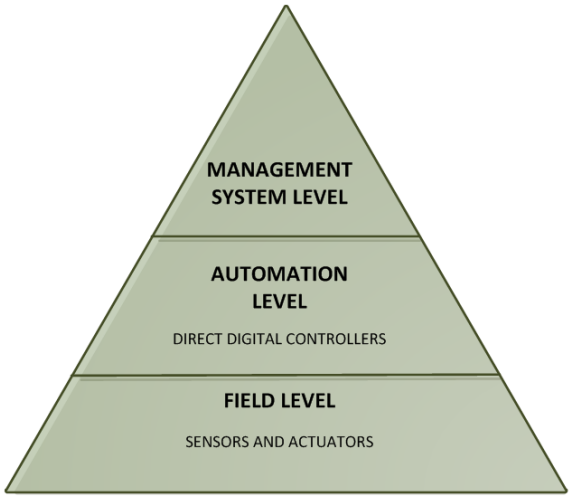
Such environments are distinguished by a tight coupling of HVAC, security, lighting, and fire protection systems. They are sensor rich and produce large amounts of data which can be analyzed to predict occupant behavior and detect equipment faults.

The intelligence and sensing capabilities required to support such environments are provided by wireless sensor and actuator networks (WSAN's). WSANs consist of large numbers of tiny, networked sensor or actuator-equipped, power-constrained wireless devices with limited amount of memory and processing power. These devices are the building blocks for the modern day building and home automation networks

Building automation and home automation networks

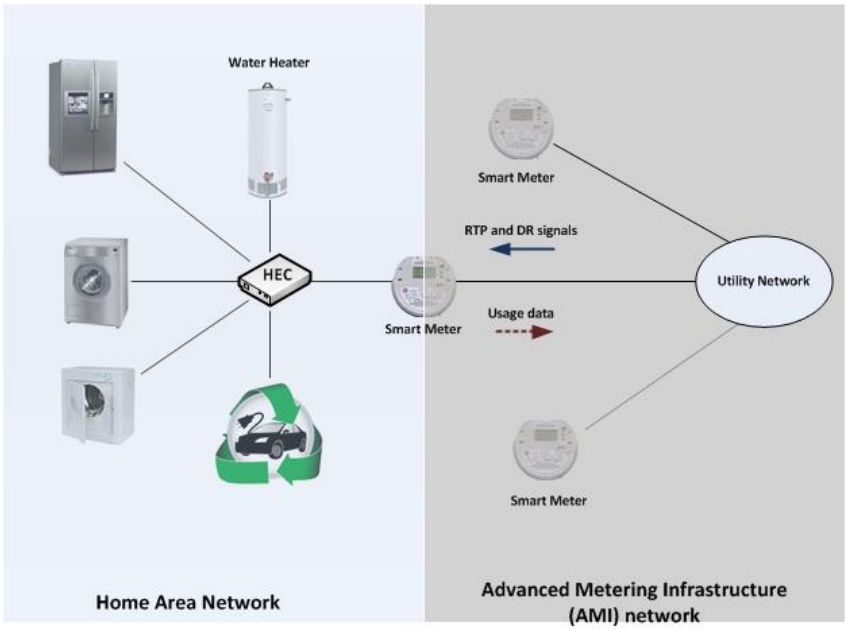
- Building automation systems provide centralized management of climate control, lighting, and security systems in order to improve energy efficiency and occupant comfort. These systems reduce energy waste and costs, while boosting occupant productivity
- They also facilitate or remote building management as well as improved occupant safety and security

Building automation systems have a hierarchical structure consisting of field, automation and management layers



- The field layer comprises of temperature, humidity, light level, and room occupancy sensors. The actuators are made up of automated blinds, light switches, flow valves etc.
- The automation layer consists of direct digital controllers (DDC's) which provide precise automated control of building processes using digital devices.
- The management layer provides centralized management of the entire system. It provides a view of the whole building, facilitating centralized control, data collection and analysis.

Home automation networks



HAN's comprise of smart appliances which can communicate with one another or a Home Energy Controller (HEC) to enable residents to automatically monitor and control home lighting, safety and security systems, and manage home energy usage. The widespread availability of low-cost wireless technologies such as Zigbee has accelerated the deployment of HAN's by facilitating the addition of communication capabilities to household appliances.

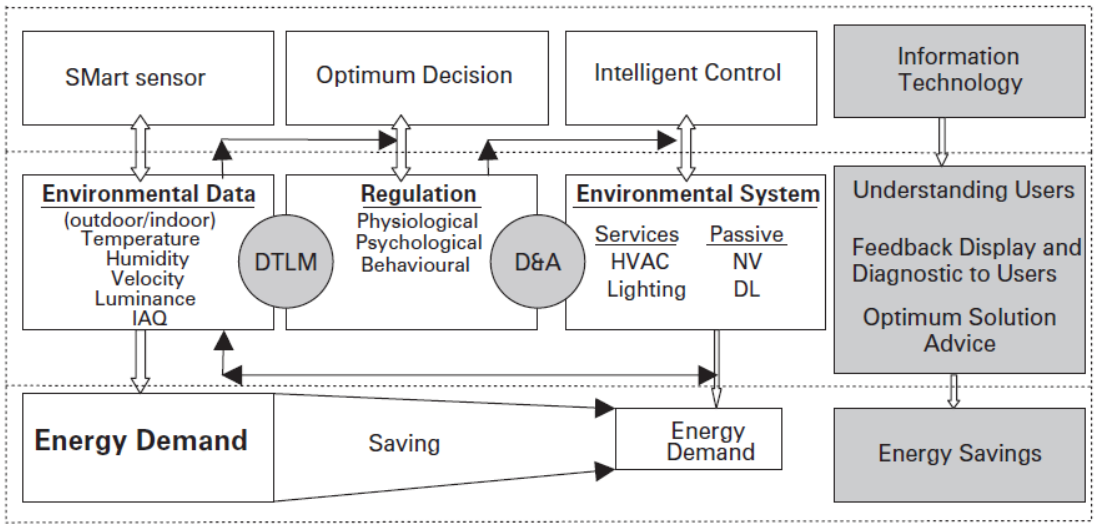


FIGURE 1 Framework of the SMODIC system

The holistic building energy management model includes smart sensors, optimum decision and intelligent control (SMODIC). This model will be able to monitor occupants' perception of the environment and supply diagnostics and advice about regulation thereby performing intelligent control in order to achieve energy savings without compromising comfort satisfaction. Figure 1 shows the framework of this model.

The smart sensor system is designed to monitor the indoor environment and occupants' thermal/visual sensation using a wireless platform. The collected data can be used to develop a dynamic thermal comfort and lighting model (DTLM) which takes into account physiological, psychological and behavioral responses. Based on the DTLM, the multiple-criteria decision-making (MCDM) method will be applied to develop an optimum decision model which takes into account the uncertain factors of the system such as whether or not windows are open, blinds on or off, thermostat up or down, etc. The information from the smart sensor system will flow into the optimum decision system which will supply diagnostics for the existing indoor environment and advise on actions (diagnostics and advice [D&A]). The D&A will be transformed into an intelligent control system. An SMODIC system therefore can be produced which will be integrated into the existing building energy management system, if one exists. The proposed SMODIC system will be able to achieve minimum energy consumption while maximizing users' satisfaction in buildings because this system is responsive to feedback about the users' expectations and their response to the indoor environment. The SMODIC system will also be able to provide the optimum decision for users in terms of behavioral control, and intelligent control algorithms to the services systems

THE SMART SENSOR SYSTEM

A lot of factors affect indoor environments, which include various low-concentration pollutants and climate-related parameters. Therefore it is important to select key parameters for the sensor system. The key parameters include air temperature, radiant temperature, air velocity, humidity,

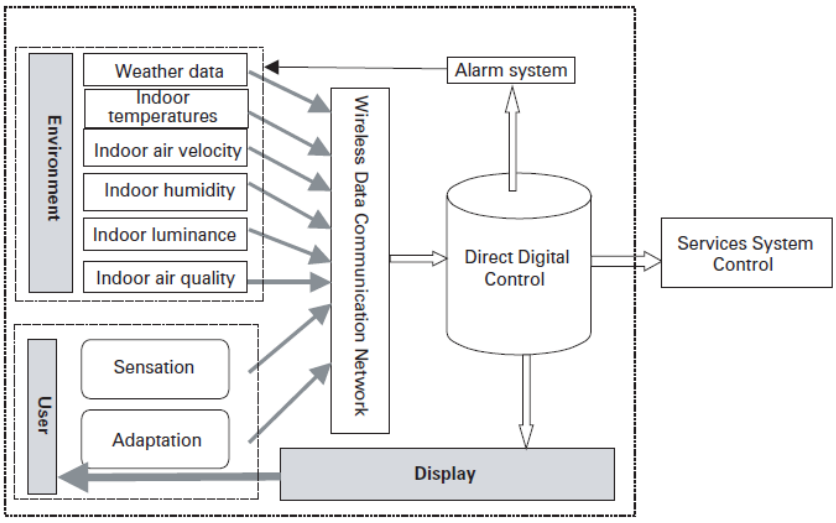


FIGURE 2 Smart sensor system

air pressure and air quality. In this model, a standard communication interface has been applied in the sensor system which is composed of wireless sensor networks that will be used to collect information about individual occupants' preferences and the existing indoor environment status of the temperature, humidity, lighting and acoustics as well as CO2 concentration levels. The smart sensor system turns the information-imitating signals into digital signals using an analogue to digital (A/D) converter and then transfers them to a direct digital controller (DDC), which has an independent ability to control the various programmes. Through the data bus, the DDC receives information from the sensor systems, performs optimising calculations and outputs control signals to the intelligent control system, which contains various actuators. This system works flexibly by using the control interface provided in the system software to detect errors and adjust or reset parameter sensors. In addition, the system can auto-reduce the number of parameter sensors and collect data according to users' requirements. The actuators, including valve actuators, damper actuators and inverters, etc., can adjust mechanical operations according to the control signal from the DDC. The system is able to provide a rapid response to the indoor environment along with the functions of playback and multiple real-time data display, printing.

Moore's Law

Moore's Law refers to Moore's perception that the number of transistors on a microchip doubles every two years, though the cost of computers is halved. Moore's Law states that we can expect the speed and capability of our computers to increase every couple of years, and we will pay less for them. Another tenet of Moore's Law asserts that this growth is exponential.

Unit II Entertainment Electronics

UNIT II: Entertainment Electronics - Audio systems: Construction and working principle of : Microphone, Loud speaker, AM and FM receiver, stereo, 2.1 home theatre, 5.1 home theatre. Display systems: CRT, LCD, LED and Graphics displays Video Players : DVD and Blue RAY. Recording Systems: Digital Cameras and Camcorders.

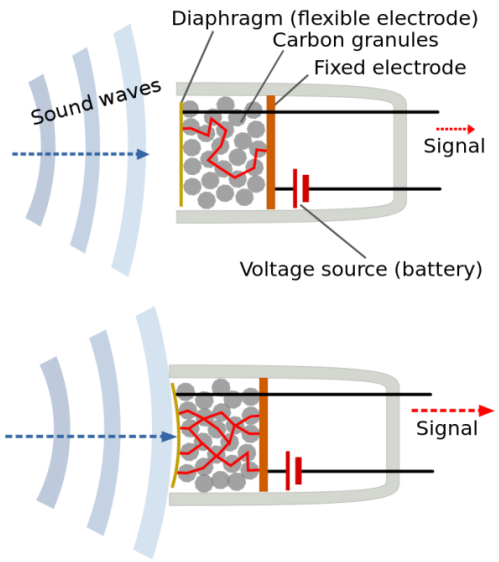
Microphones

Microphones are a type of *transducer* - a device which converts energy from one form to another. Microphones convert acoustical energy (sound waves) into electrical energy (the audio signal).

Different types of microphone have different ways of converting energy but they all share one thing in common: The *diaphragm*. This is a thin piece of material (such as paper, plastic or aluminium) which vibrates when it is struck by sound waves. In a typical hand-held mic like the one below, the diaphragm is located in the head of the microphone. When the diaphragm vibrates, it causes other components in the microphone to vibrate. These vibrations are converted into an electrical current which becomes the audio signal.

CARBON MICROPHONE

For a *telephone system* important requirements are *(i)* the microphone shall be of convenient size; *(ii)* capable of mass production at low cost while possessing high sensitivity to operate from a simple battery; *(iii)* its performance must be stable and adequate to provide intelligible speech and articulation and; *(iv)* it need not necessarily include the higher harmonic frequencies for reproducing.



The **carbon microphone**, also known as **carbon button microphone**, **button microphone**, or **carbon transmitter**, It consists of two metal plates separated by granules of carbon. One plate is very thin and faces outward, acting as a diaphragm. When sound waves strike this plate, the pressure on the granules changes, which in turn changes the electrical resistance between the plates. Higher pressure lowers the resistance as the granules are pushed closer together. As a steady direct current is passed between the plates, the varying resistance results in a modulation of the current at the same frequency of the impinging sound waves. In telephony, this signal is directly passed through a telephone

system to the central office, or it is electronically amplified in other sound systems, such as a public address system or a recording device. The frequency response of the carbon microphone, however, is limited to a narrow range, and the device produces significant electrical noise.

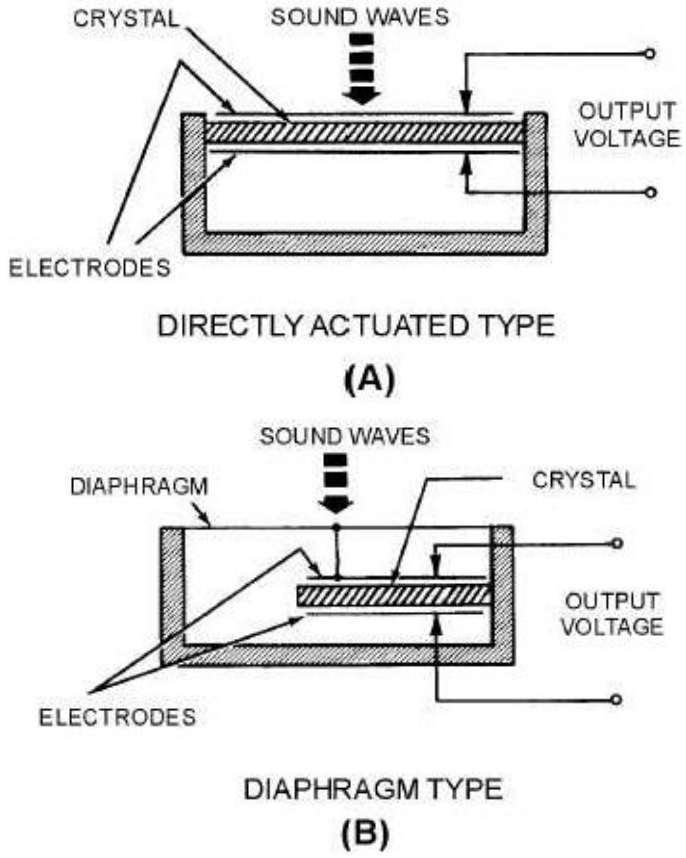
Advantages of Carbon Microphone

1. It delivers high output signal
2. It is simple in construction and rugged in design
3. It's working principle is simple
4. It is cheaper in cost and simple to manufacture.
5. It tolerates extremely high sound pressure levels.

Disadvantages of Carbon Microphone

1. It has high background noise and it will often produce cracking sound. It is not possible to eliminate this "carbon hiss".
2. It has poor frequency response.
3. It requires battery or other supply for its operation.
4. The carbon granules get damaged and sometimes fused together.
5. As shown it requires amplifier to amplify the signal to be reproduced at the speaker end.
6. Its bandwidth is extremely limited.

Crystal Microphone



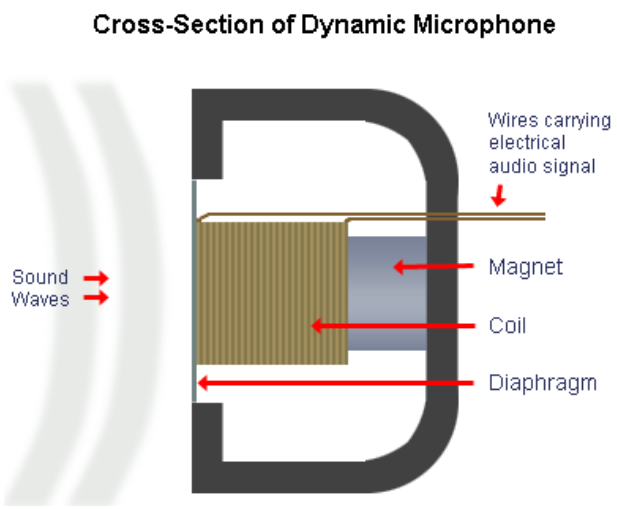
The crystal microphone uses the PIEZOELECTRICEFFECT of Rochelle salt, quartz, or other crystalline materials. This means that when mechanical stress is placed upon the material, a voltage electromagnetic force (EMF) is generated. Since Rochelle salt has the largest voltage output for a given mechanical stress, it is the most commonly used crystal in microphones. In figure A the crystal is mounted so that the sound waves strike it directly. In figure B a diaphragm that is mechanically linked to the crystal so that the sound waves are indirectly coupled to the crystal.

This microphone will have high output in the order of 10 to 100 mV. The **crystal microphone** is omni-directional and is cheaper. The disadvantage of crystal microphone is that it is easily damaged by moisture or heat. This type of microphone is used in cassette recorders. The impedance is very high usually in the order of 1 to 5 Mega Ohm.

Dynamic Microphone or Moving coil

Dynamic microphones are versatile and ideal for general-purpose use. They use a simple design with few moving parts. They are relatively strong and flexible to rough handling. They are also better suited to handling high volume levels, such as from certain musical instruments or amplifiers. They have no internal amplifier and do not require batteries or external power.

Working Principle



The dynamic or moving coil microphone relies on the fact that if a wire held within a magnetic field is moved then an electric current is induced. This is the same effect as seen in an electric generator and many other items. The dynamic microphone consists of a magnet, and a diaphragm to which a coil is attached. The assembly is held in place by an outer casing and the coil can move freely over the magnet.

As sound waves hit the diaphragm, this causes the coil to move backwards and forwards within the magnetic field and as a result an electric current is induced in line with the incoming sound vibrations. This EMF is proportional to the velocity of motion (v) of the conductor in the air-gap: if the microphone is to have the same sensitivity at all frequencies it is necessary for the velocity of motion of the coil, due to a sound of given intensity, to be independent of the pitch of the sound.

In order to respond to transients and high frequency sound waves it is necessary to keep the mass of the cone and its coil as small as possible. For this reason, *the coil is usually wound with aluminium wire of very fine gauge and the number of turns is limited.* This means that the generated voltage is also limited, and so *the natural impedance of the instrument is low*. The average is around

30 ohm, but many models have a transformer incorporated in the instrument itself to give an output at a higher impedance.

Advantages of Dynamic Microphone or moving coil microphone

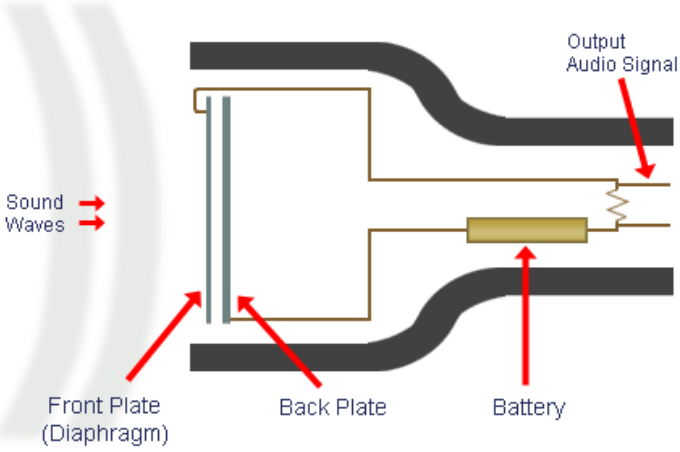
1. It is one of the good quality microphone with omni-directional properties
2. It is available at affordable cost.
3. It is rugged in construction (almost 100% mechanical) and can handle high pressure levels.
4. It does not require any battery or power source to run.
5. It can convert sound waves over entire audible range to electric current (or voltage) for further use.
6. It is durable which can withstand lot of volume.
7. It colors the sound in the range between 5 to 10 KHz which adds clarity, presence and understandability to many vocal and instrument sounds

Disadvantages of Dynamic Microphone or moving coil microphone

1. It has poor high frequency response due to inertia of coil, tube & diaphragm and force required to overcome interaction between coil and magnet. Hence it is not suitable for recording instruments with higher frequencies and harmonics compare to condenser microphone.
2. This microphone type miss many sounds as it requires lot of sound pressure to move the coil.
3. It is not as accurate (or sensitive) as condenser microphone. Hence it cannot be used for in-studio film productions

Condenser Microphones

Condenser or *capacitor*, an electronic component which stores energy in the form of an electrostatic field. The use of *condenser* micro phone is to convert acoustical energy into electrical energy. Condenser microphones require power from a battery or external source. The resulting audio signal is stronger signal than that from a dynamic. Condensers also tend to be more sensitive and responsive than dynamics, making them well-suited to capturing subtle nuances in a sound. They are not ideal for high-volume work, as their sensitivity makes them prone to distort.



A capacitor has two plates with a voltage between them. In the condenser mic, one of these plates is made of very light material and acts as the diaphragm. The diaphragm vibrates when struck by sound waves, changing the distance between the two plates and therefore changing the capacitance. Specifically, when the

plates are closer together, capacitance increases and a charge current occurs. When the plates are further apart, capacitance decreases and a discharge current occurs.

A voltage is required across the capacitor for this to work. This voltage is supplied either by a battery in the mic or by external phantom power.

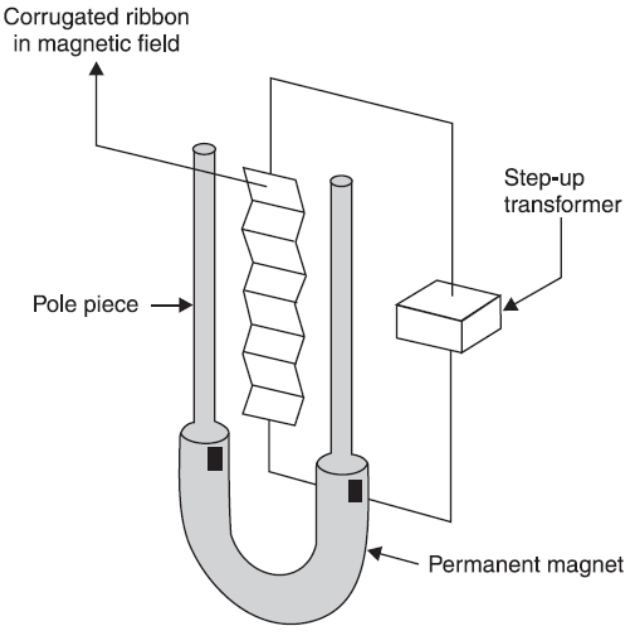
Advantages of Condenser Microphone

1. It is smaller in size, with flat frequency response.
2. It is light in weight compare to dynamic microphone due to lighter diaphragm assembly.
3. It supports high range of frequencies due to fast moving diaphragm.
4. It offers high sensitivity and it is more suitable to capture sounds of audio instruments and vocals.

Disadvantages of Condenser Microphone

1. It requires voltage (i.e. power) to operate.
2. It can handle certain maximum input signal level.
3. It is more complex compare to dynamic microphone.
4. It is more affected due to extreme temperature and humidity conditions compare to dynamic microphone.
5. It is more expensive compare to dynamic microphone.
6. Cheaper condenser microphone generates small magnitude of noise.

RIBBON (VELOCITY) MICROPHONES



While ribbon microphones technically fall under the umbrella of dynamic mics, as they also transduce acoustic energy through electromagnetic induction, they are a very different animal than their rugged, moving-coil counterparts. In ribbon microphones, A ribbon of aluminium foil is suspended between the poles of a magnet and generates a current when it vibrates within the magnetic field. There is no multiplication of induced EMFs by the successive turns of a coil, the ribbon can be regarded as a coil with but a single turn. As a result, the output voltage is very low and so also is the impedance, something of the order of 0.1Ω. All ribbon microphones, therefore, have a built-in transformer to step-up the impedance and voltage to a usable level.

The ribbon serves as both the diaphragm and the transducer element itself, giving you much greater sensitivity and transient response in comparison to standard dynamic mics. However, the trade-off for this increased responsiveness is much greater fragility, as ribbon elements tend to be only a few microns thick and thus are easily damaged if not cared for properly. Strong gusts of wind and blunt force impact from drops and falls can all put your average ribbon mic out of commission.

- The ribbon microphone is bidirectional.
- It is more directional than the crystal and dynamic microphones, the overall response of the ribbon microphone falls off as the angle of sound reaching it varies from 90 degrees to the faces of the ribbon.

- The ribbon microphone is quite sensitive to the movement of the air surrounding it, and *it must be carefully protected from puffs of wind when used outdoors.* A ribbon microphone should be placed at least 18 inches from the source of the sound.

WIRELESS MICROPHONE:

A wireless microphone, as the name implies, is a microphone without a physical cable connecting it directly to the sound recording or amplifying equipment with which it is associated. Also known as a radio microphone, it has a small, battery-powered radio transmitter in the microphone body, which transmits the audio signal from the microphone by radio waves to a nearby receiver unit, which recovers the audio. The other audio equipment is connected to the receiver unit by cable. Wireless microphones are widely used in the entertainment industry, television broadcasting, and public speaking to allow public speakers, interviewers, performers, and entertainers to move about freely while using a microphone to amplify their voices.

There are many different standards, frequencies and transmission technologies used to replace the microphone's cable connection and make it into a wireless microphone. They can transmit, for example, in radio waves using UHF or VHF frequencies, FM, AM, or various digital modulation schemes. Some low cost models use infrared light. Infrared microphones require a direct line of sight between the microphone and the receiver, while costlier radio frequency models do not.

The advantages are:

- Greater freedom of movement for the artist or speaker.
- Avoidance of cabling problems common with wired microphones, caused by constant moving and stressing the cables.

- Reduction of cable "trip hazards" in the performance space

The disadvantages are:

- Sometimes limited range (a wired balanced XLR microphone can run up to 300 ft or 100 meters). Some wireless systems have a shorter range, while more expensive models can exceed that distance.
- Possible interference with or, more often, from other radio equipment or other radio microphones, though models with many frequency-synthesized switch-selectable channels are now plentiful and cost effective.
- Operation time is limited relative to battery life; it is shorter than a normal condenser microphone due to greater drain on batteries from transmitting circuitry, and from circuitry giving extra features, if present.
- Noise or dead spots.
- Limited number of operating microphones at the same time and place, due to the limited number of radio channels.

Characteristics of Microphones

There are many types of microphones available. Each has certain advantages and disadvantages. Hence the selection of microphones depends upon the certain characteristics as below:

(1) Output level; (2) Frequency response; (3) Output impedance and (4) Directivity.

(1) *Output level*: -

The output level of a microphone governs the amount of amplification that must be available for use with the microphone. The output level of microphone is usually given in dB preceded by a minus sign. The minus sign means that the output level is so many dB below the reference level of 1milliwatt for a specified sound pressure.

(2) *Frequency response*: -

The frequency response of a microphone is a rating of the fidelity of relative output voltage which results from sound waves of different frequencies. The simplest way to find a complete picture of the frequency response characteristics of a microphone is to plot a curve of its output voltage v/s input frequency. Since good microphones are relatively flat over their range, it is often considered sufficient to specify the range over which their output does not vary more than ±1-2 dB.

(3) *Output impedance*: -

A microphone, like any other component with electrical i/p of o/p, has a value of impedance. When a microphone is connected to an amplifier, a complete circuit is formed and electric current flows whenever a sound causes the microphone to generate an electrical voltage.

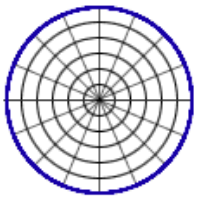
For most high quality microphones impedance is low, a few ohms ranging upto a hundred ohms or so. The importance of microphone impedance is not a matter of the precise value but of the ability of the microphone and the recorder to be matched together. High impedance microphones must be connected must be connected into a recorder with high impedance input, otherwise both the signal amplitude and the frequency range will be adversely affected.

Directional Properties

Every microphone has a property known as *directionality*. This describes the microphone's sensitivity to sound from various directions. Some microphones pick up sound equally from all directions, others pick up sound only from one direction or a particular combination of directions. The types of directionality are divided into three main categories:

1. **Omnidirectional**

   Picks up sound evenly from all directions (omni means "all" or "every").



Captures sound equally from all directions.

Uses: Capturing ambient noise; Situations where sound is coming from many directions; Situations where the mic position must remain fixed while the sound source is moving.

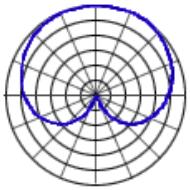
Notes:

- Although omni-directional mics are very useful in the right situation, picking up sound from every direction is not usually what you need. Omni sound is very general and unfocused - if you are trying to capture sound from a particular subject or area it is likely to be over whelmed by other noise.

2. **Unidirectional**

   Picks up sound predominantly from one direction. This includes cardioid and hypercardioid microphones (see below).

Cardioid



Cardioid means "heart-shaped", which is the type of pick-up pattern these mics use. Sound is picked up mostly from the front, but to a lesser extent the sides as well.

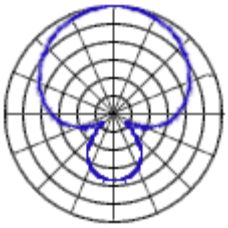
Uses: Emphasizing sound from the direction the mic is pointed whilst leaving

some latitude for mic movement and ambient noise.

Notes:

- The cardioid is a very versatile microphone, ideal for general use. Handheld mics are usually cardioid.
- There are many variations of the cardioid pattern (such as the hyper cardioid below).

Hypercardioid



This is exaggerated version of the cardioid pattern. It is very directional and eliminates most sound from the sides and rear. Due to the long thin design of hyper cardioids, they are often referred to as shotgun microphones.

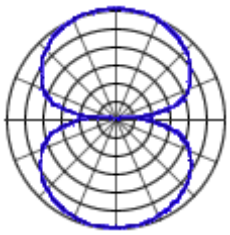
Uses: Isolating the sound from a subject or direction when there is a lot of ambient noise; Picking up sound from a subject at a distance.

Notes:

- By removing all the ambient noise, unidirectional sound can sometimes be a little unnatural. It may help to add a discreet audio bed from another mic (i.e. constant background noise at a low level).
- You need to be careful to keep the sound consistent. If the mic doesn't stay pointed at the subject you will lose the audio.
- Shotguns can have an area of increased sensitivity directly to the rear.

3. **Bidirectional**

   Picks up sound from two opposite directions.



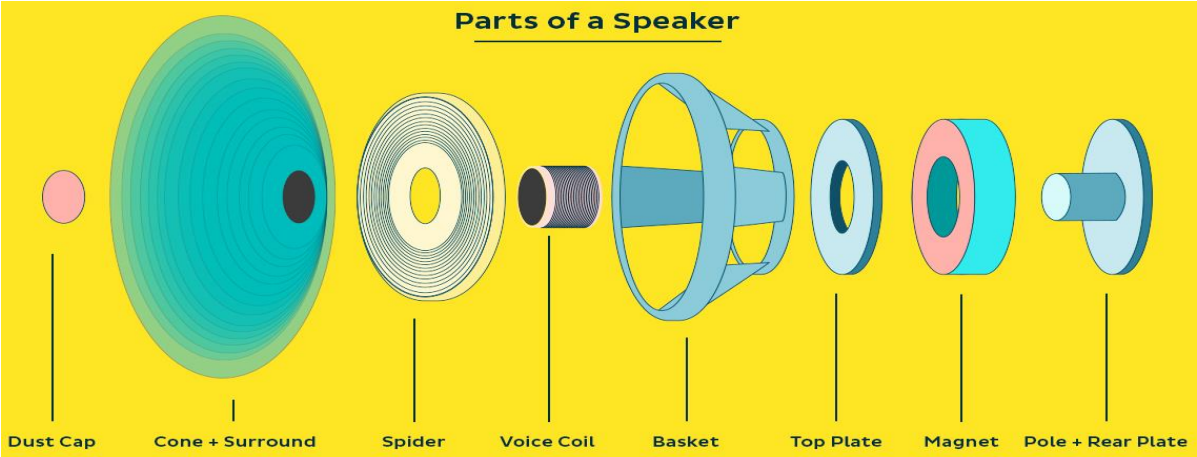
Uses a figure-of-eight pattern and picks up sound equally from two opposite directions.

Uses: As you can imagine, there aren't a lot of situations which require this polar pattern. One possibility would be an interview with two people facing each other (with the mic between them).

Loud speaker

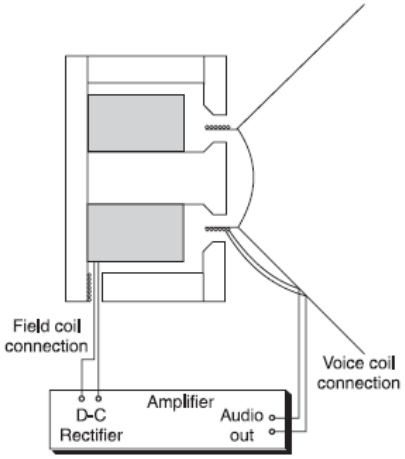
Loud speaker is a transducer which converts electrical signal into sound signal. There are two types of dynamic speaker: electro dynamic and permanent magnet speaker

Parts of loud speaker



- **Cone:** The cone is connected to the voice coil and moves air to create sound waves. Most modern tweeters move air with a dome rather than a cone.
- **Voice coil:** The electromagnet that drives the cone and is alternately charged positively and negatively
- **Magnet:** The non-changing magnetic field that allows the voice coil's alternating magnetic force to be attracted or repelled.
- **Top plate, back plate and pole piece:** The magnetically conductive parts that efficiently concentrate the magnet's energy around the voice coil.
- **Spider:** A springy cloth disc that keeps the voice coil and bottom of the cone from moving off to the side and focuses the coils motion in a forward and backward motion.
- **Surround:** A flexible ring that keeps the cone from moving side to side while allowing it to push forward and backwards. Together with the spider, a suspension system is formed for the parts that move, the moving parts being the cone and voice coil.
- **Flex wires and wire terminals:** These components move the electrical current from the amplifier to the voice coil.
- **Dust cap:** Covers the middle section of the cone and keeps debris from getting into the gap between the magnet and the pole piece where the voice coil resides.
- **Frame (or basket):** Holds the entire speaker assembly together and attaches it to the cabinet

DYNAMIC LOUDSPEAKERS



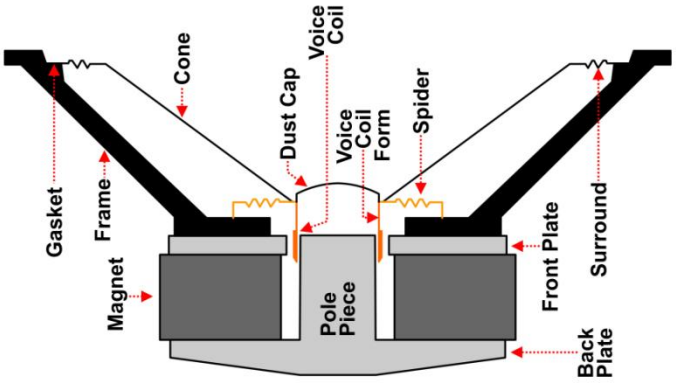
There are two varieties of dynamic loudspeakers : Electro-dynamic and permanent magnet (PM) speakers. Both work in exactly the same way, the difference is in their construction.

The electro-dynamic speaker has a *soft iron* magnetic circuit, non-retentive of magnetism, around whose centre leg, a large, multilayer field coil is wound, as shown in Fig. When dc flows through this field coil, it magnetizes the iron core. *A magnetic flux field directly proportional to the strength of the current through the coil is thus set up across the air-gap. The iron core is*

not permanently magnetized, it stays magnetizedonly as long as current flows through the field coil.

Improvements in permanent magnet materials have made the electro-dynamic speaker *practically obsolete*, but some still exist in vintage radios. Note that these use the field coil as part of a choke filter in the power supply, a good example of killing two birds with one stone. The electro-dynamic speaker has disappeared completely, so far as hi-fi is concerned, the permanent magnet speaker reigns supreme.

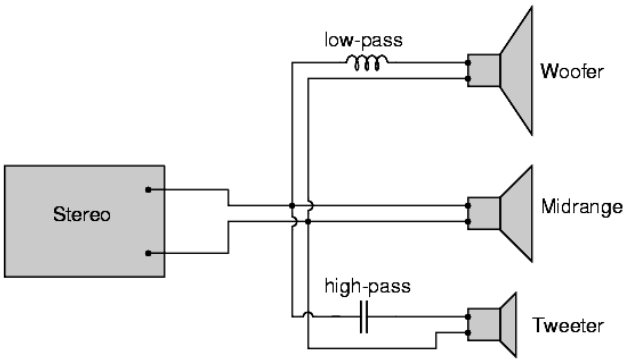
Permanent magnet Dynamic loud speaker



The most popular type of loudspeaker today is the permanent magnet dynamic type. Because of its comparative simplicity of construction and design, the precision that may be built into it, the ease with which it is interfaced with other equipment, its easy adaptability to many different applications, and its comparative freedom from electrical trouble, the *dynamic loudspeaker* has found acceptance in all kinds of reproducing systems. It is found in the smallest pocket radios and is a major component of the most elaborate theatre systems.

The PM speaker contains a very light coil of wire affixed to the diaphragm and located concentrically around, within, or in front of the centre of the permanent magnet. The coil (voice coil) is free to move in the field of the magnet. Electrical impulses, varying at an audio rate, are applied to the *voice coil* by the amplifier. Because these impulses are constantly changing in amplitude and direction, a changing magnetic field is set up in the voice coil. This field *reacts* with the constant field of the permanent magnet. The result is that the voice coil moves further into the gap when the fields are opposite and attract, and farther out of the gap when they are alike and repel. This causes an *in-and-out movement of the diaphragm*; consequently, we obtain sound waves from electrical impulses. The speed at which the coil and diaphragm vibrate depends upon the *frequency* of the impulses. The distance that the diaphragm moves in and out depends on their *amplitude.*

Woofers



Woofer is the term commonly used for a loudspeaker driver designed to produce low frequency sounds, typically from around 40 hertz up to about a kilohertz or higher. There are two types of low frequency speaker, the commonly known woofer, and the more recent addition the subwoofer. The latter is used for the reproduction of frequencies below those produced by the woofer and it is generally purchased as an add-on to an existing system.

The low frequencies speaker provides the bass of any hi-fi system. Its sole purpose is to reduce the low frequency notes of the program source. The prime requisite for low frequency reproduction is a large *diaphragm* the larger the better. In addition to large size, the diaphragm must *be of fairly heavy construction* Light diaphragms just can't hold up under the vibrations encountered under the lower audio ranges.

A woofer must be able to vibrate back and forth very easily *i.e* have *high compliance.* One way to accomplish this is to have the diaphragm loosely connected to the frame. The gasketing that holds the periphery of diaphragm to the frame basket is fastened so that it barely keeps the diaphragm from slipping loose.

Rather than the loose suspension system, the cone is supported by a very flexible material so that it can be moved very easily by the voice coil. *The suspension is tight hut the sine wave at the diaphragm edge is made very flexible.*

The large speakers have more extended lows, the smaller ones more extended highs.

A woofer must also have a *large voice coil* to handle considerable heat. The larger the voice coil, the more the current *produced* by the amplifier output circuit and, therefore, the more the power the woofer can handle. Finally, a *strong magnet* can be *of* great help to move the heavy voice coil and cone assembly too well. The better the woofer, the heavier the magnet assembly (unless it's ceramic).

Tweeters

A **tweeter** is a loudspeaker designed to produce high audio frequencies, typically from around 2,000 Hz to 20,000 Hz. Nearly all tweeters are electro-dynamic drivers, using a voice coil suspended within a fixed magnetic field.

There are two main types of high frequency speakers; the well-known *tweeter* and the more recent *super tweeter*. Super tweeters can be add-ons or they can be *integral with the system.* Six basic high-frequency speakers (tweeters) exist.

(i) The *cone* is a physically disincentive version of the woofer.

(ii) The *dome*, so called because of its dome-shaped diaphragm.

(iii) The *horn*, so named because it is a horn.

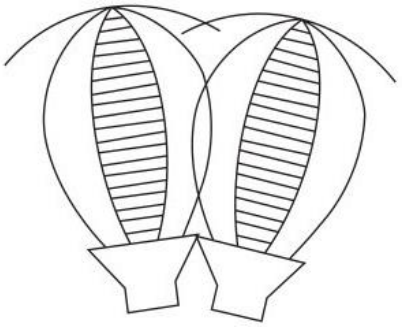
(iv) The *Heil air-motion transformer* which uses the principle of lever in its operation, named after its inventor, Dr. Oskar Heil.

(v) *High polymer molecular-film* tweeter, uses the piezoelectric effect for its principle of operation (used exclusively by Pioneer).

(vi) The *electrostatic* tweeter works on the principle of attraction or repulsion between two metal plates.

Types of tweeters

Cone tweeter



Cone tweeters have the same basic design and form as a woofer with optimizations to operate at higher frequencies. The optimizations usually are:

- a very small and light cone so it can move rapidly;
- cone materials chosen for stiffness (e.g., ceramic cones in one manufacturer's line), or good damping properties (e.g., silk or coated fabric) or both;
- the suspension (or spider) is stiffer than for other drivers less flexibility is needed for high frequency reproduction;
- small voice coils (3/4 inch is typical) and light (thin) wire, which also helps the tweeter cone move rapidly.

Cone tweeters are relatively cheap, but do not have the dispersion characteristics of domes. Thus they are routinely seen in low cost applications such as factory car speakers, shelf stereo systems, and boom boxes. Cone tweeters can also be found in older stereo hi-fi system speakers designed and manufactured before the advent of the dome tweeter. They are now a rare sight in modern hi-fi usage.

Dome tweeters

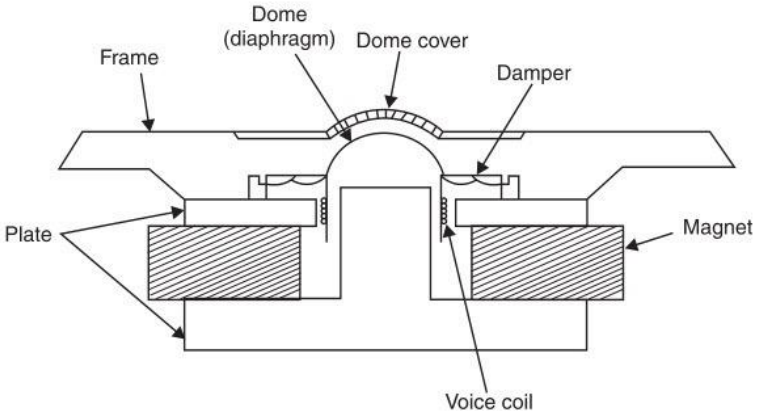


Fig. 4.27 *Dome-type tweeter*

A dome tweeter is constructed by attaching a voice coil to a dome, which is attached to the magnet or the top plate via a low compliance suspension. These tweeters typically do not have a frame or basket, but a simple front plate attached to the magnet assembly. Dome tweeters are categorized by their voice coil diameter. The majority of dome tweeters presently used in hi-fi speakers are 25 mm (1 in) in diameter. A variation is the ring radiator in which the 'suspension' of the cone or dome becomes the major radiating element. These tweeters have different directivity characteristics when compared to standard dome tweeters.

Horn tweeters

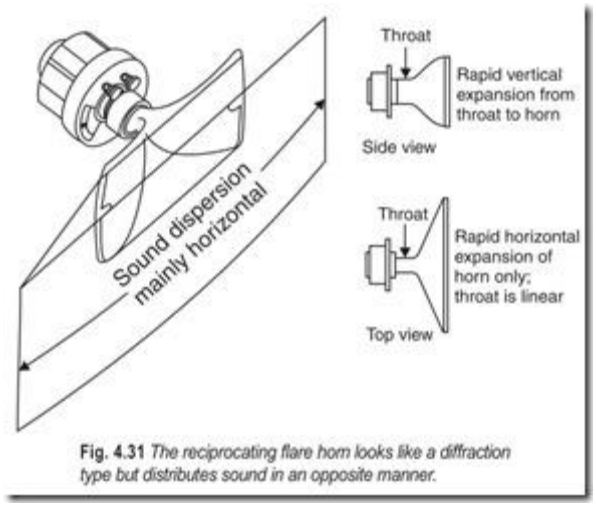
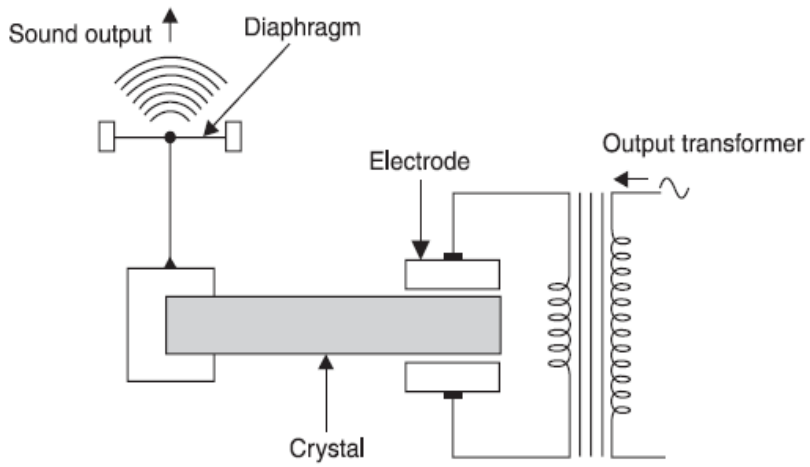


Fig. 4.31 *The reciprocating flare horn looks like a diffraction type but distributes sound in an opposite manner.*

A *horn* is a tube so flared (tapered) that the diameter increases from a small value at one end called the *throat* to a large value at the other end called the *mouth.* Horns, have been used for centuries for increasing the radiation of the human voice and musical instruments. Horn couples the small voice coil area to a large area of air. In this way, the horn acts as an *acoustic transformer* and converts the relatively high impedance at the throat and driver.

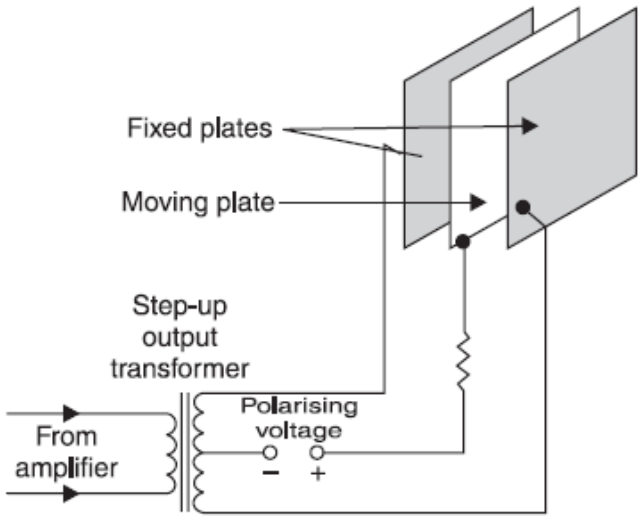
CRYSTAL LOUDSPEAKERS

Rochelle-salt crystals have the property of becoming *physically distorted* when a voltage is applied across two of their surfaces. This property is the basis of the crystal type of speaker driver, illustrated in Fig. The crystal is clamped between two electrodes across which the audio frequency



output voltage is applied. The crystal is also mechanically connected to a diaphragm. The deformations of the crystal caused by the audio frequency signal across the electrodes cause the diaphragm to vibrate and thus to produce sound output. Crystal speakers have been impractical for reproduction of the full audio-frequency range because *the input impedance is almost completely capacitive.* Thus it is difficult to couple power into them. At high audio frequencies, the reactance becomes lower ($Xc = 1/2fC$) and the relative amount of power smaller. In the bass range, stresses on the crystals are very great, and crystals have been known to crack under stresses. Consequently, crystal units have found some use in *tweeters* (the high-frequency portion of dual speaker units) and rarely even in this application because *their response is not linear*.

Electrostatic (Condenser/Capacitor) speaker

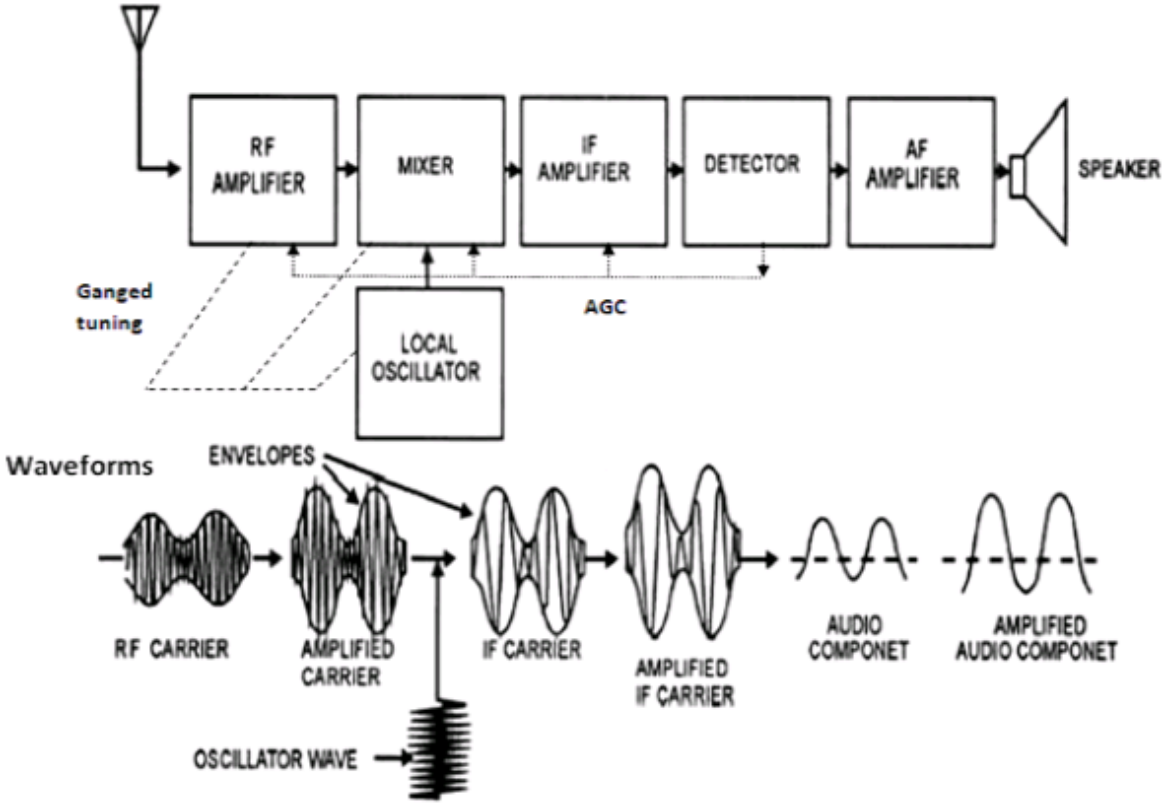


A detailed view of a modern electrostatic speaker is shown in Fig. The practical speaker of today uses push-pull, with a built-in step-up transformer to work from the ordinary 8 ohm amplifier output tap. The polarizing voltage is applied to the centre or movable plate through a resistor that keeps the voltage *stable* during variations in the signal voltage. The signal voltage is applied to the two outside plates. Because the diaphragm is centered between the two plates that attract it equally, there is no bending when there is no signal. Also, *because of the push pull action the diaphragm can move twice as far in response to signal voltages for the same amount of compression of the dielectric material.*

The major weakness of the electrostatic speaker requires the dc bias is that it to be much larger than the applied audio signal. In practical speakers, 1,000 to 1,200 volts may be used. Further, when we get into the bass frequency ranges, a great deal of power would be required to get enough output. To produce such power, the speaker area would have to be very large. So, even though full range electrostatic speakers have been constructed, *in practical use electrostatic speakers have been mostly confined to frequencies above 1,000 Hz.*

The step-up transformer and the high voltage polarizing supply is usually built right into the modern electrostatic. Often the electrostatic unit and its matching woofer are sold together as a complete system. **Some high class systems use electrostatics to reproduce the high frequencies.** Koss uses electrostatics on some of their stereo headphones

AM Receiver



Super heterodyne is basically a process of designing and constructing wireless communications such as radio receivers by mixing two frequencies together in order to produce a difference frequency component called as intermediate frequency (IF), so as to reduce signal frequency prior to processing.

A super heterodyne receiver usually consists of an antenna, RF amplifier, mixer, local oscillator, IF amplifier, detector, AF amplifier and a speaker.

The working of a super heterodyne receiver is explained with the help of the block diagram given below in Fig1 along with the waveforms at the output of each block.

- The super heterodyne receiver, the incoming signal through the antenna is filtered to reject the image frequency and then amplified by the RF amplifier.
- RF amplifier can be tuned to select and amplify a particular carrier frequency within the AM broadcast range. Only the selected frequency and it two sidebands are allowed to pass through the amplifier.
- The carrier of the received signal is called radio frequency carrier and its frequency is radio frequency f_{RF} and the local oscillator signal operates at f_{OSC}. The amplified RF frequency is then mixed with the local oscillator frequency.
- The combining of these two signals is done at the mixer which produces sum and difference frequency signals of the incoming carrier signal and local oscillator signal,
- The sum frequency is rejected by the filter and the remaining difference frequency signal which is a down converted frequency signal is called as intermediate frequency (IF) carrier

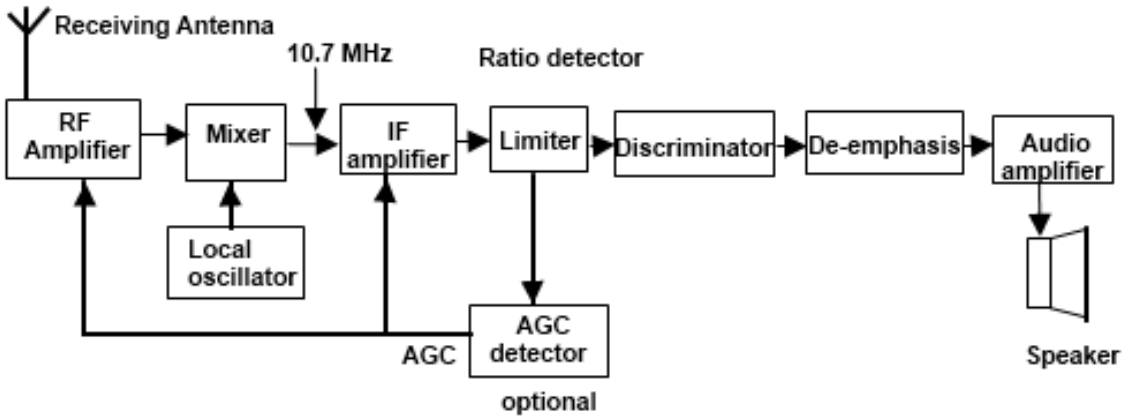
- The frequency of local oscillator is not same as the frequency to which RF amplifier is tuned. Local oscillator is tuned to a frequency that may be either higher or lower than the incoming frequency by an amount equal to the IF frequency.

- Thus idea of the super heterodyne receiver is to reduce the high frequency radio components of the incoming carrier to a fairly low, fixed value such as to be processed at the different stages of the receiver, and also to provide good stability, gain and proper selectivity and fidelity.
- The modulation of the IF carrier signal is same as that of the original carrier signal and it has a fixed frequency of 455kHz which is amplified by one or more stages of amplification.
- The IF signal is amplified with the help of IF amplifier which raises its level for the information extraction process. Also the IF amplifier fulfills most of the gain and bandwidth requirements of the receiver.
- IF amplifier operations are independent to the frequency at which receiver is tuned, maintaining the selectivity and sensitivity of the super heterodyne receiver considerably constant throughout the tuning range of the receiver.
- This amplified IF signal is applied to the detector to detect the information signal component from 455 kHz IF, to reproduce the original information data, which is generally in the form of audio signal.
- The detector stage eliminates one of the sidebands which is still present and separates the RF from the audio components of the other sideband.
- The RF component is filtered out and audio is supplied to the audio stages for amplification.
- The generated audio signal is then applied to the AF amplifier to increase the audio frequency level of the signal and to provide enough gain to drive the speaker or headphones.
- A speaker is connected to the AF amplifier to play the audio information signal.
- An important part of superheterodyne receiver is Automatic gain control (AGC) which is given to the RF, IF and mixer stages in order to generate constant output irrespective of the varying input signal.
- Superheterodyne radio receiver in spite of being more complicated than some of the other receivers offers many advantages in terms of performance, most importantly the selectivity. It is more efficiently able to remove unwanted and distorting signals than other forms like TRF and regenerative receivers.

- Due to the enormous advantages provided by the super heterodyne receivers compared to the other radio receivers, they are widely used in all broadcast radio receivers, commercial radios as well as televisions operate on the basis of the super heterodyne principle.

FM Receiver

The block diagram of an FM receiver is shown in figure. The RF amplifier amplifies the received signal intercepted by the antenna. The amplified signal is then applied to the mixer stage. The second input of the mixer comes from the local oscillator. The two input frequencies of the mixer generate an IF signal of 10.7 MHz. this signal is then amplified by the IF amplifier.



Superheterodyne FM Receiver Block Diagram

The output of the IF amplifier is applied to the limiter circuit. The limiter removes the noise in the received signal and gives a constant amplitude signal. This circuit is required when a phase discriminator is used to demodulate an FM signal.

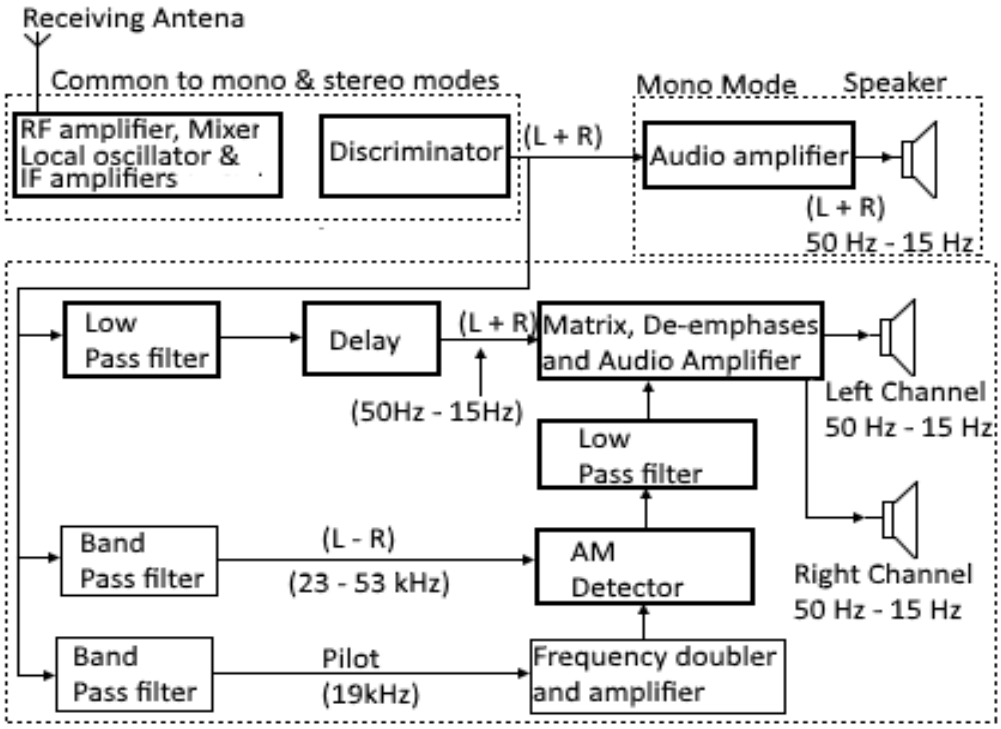
The output of the limiter is now applied to the FM discriminator, which recovers the modulation signal. However, this signal is still no the original modulating signal. Before applying it to the audio amplifier stages, it is de-emphasized. De-emphasizing attenuates the higher frequencies to bring them back to their original amplitudes as these are boosted or emphasized before transmission. The output of the de-emphasized stage is the audio signal, which is then applied to the audio stages and finally to the speaker. It should be noted that a limiter circuit is required with the FM discriminators. If the demodulator stage uses a ratio detector instead of the discriminator, then a limiter is not required. This is because the ratio detector limits the amplitude of the received signal. In figure a dotted block that covers the limiter and the discriminator is marked as the ratio detector.

In FM receivers, generally, AGC is not required b because the amplitude of the carrier is kept constant by the limiter circuit. Therefore, the input to the audio stages controls amplitudes and there are no erratic changes the volume level. However, AGC may be provided using an AGC detector. This generates a DC voltage to control the gains of the RF and IF amplifier.

A stereo FM receiver has three major sections

Mono mode, stereophonic mode, section common to both mono and stereo modes

The section that is common to both mono and stereo modes is a standard FM receiver that recovers the modulating signal. The output section is routed to the remaining two sections. The output consists of both the left and right channel marked as (L+R) in fig. this output is applied to the mono section and the speaker produce audio signals monophonic mode.



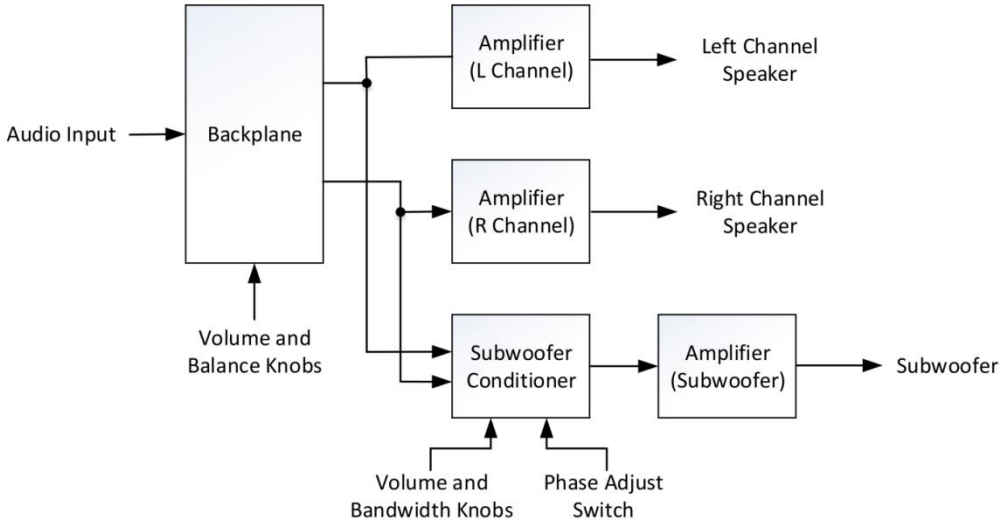
The stereo section is more complicated. It uses three filters to extract(L+R) and (L-R) signals and the pilot carrier from the discriminator output. The (L+R) signal is obtained from the low pass filter, which contains frequencies between 50hz and 15 KHz. This signal delayed for a fixed time before applying it to the matrix and the de-emphasis network. This is done to simultaneously get the (L+R) and (L-R) signals at the matrix. The matrix network separates the left(L) and right® channels. These are then de-emphasized and amplified by the audio amplifier and are given to their respective speakers.

A band pass filter is used to extract the (L-R) signal varying between 23-53 KHz. It is a double-side band(DSB) signal. This signal is applied to an AM detector to demodulate. The transmitter uses a 38 KHz carrier signal to get a DSB-SC signal from the (L-R) signal. Thus , at the receiver a carrier of 38 KHz is required to demodulate the received (L-R) signal.

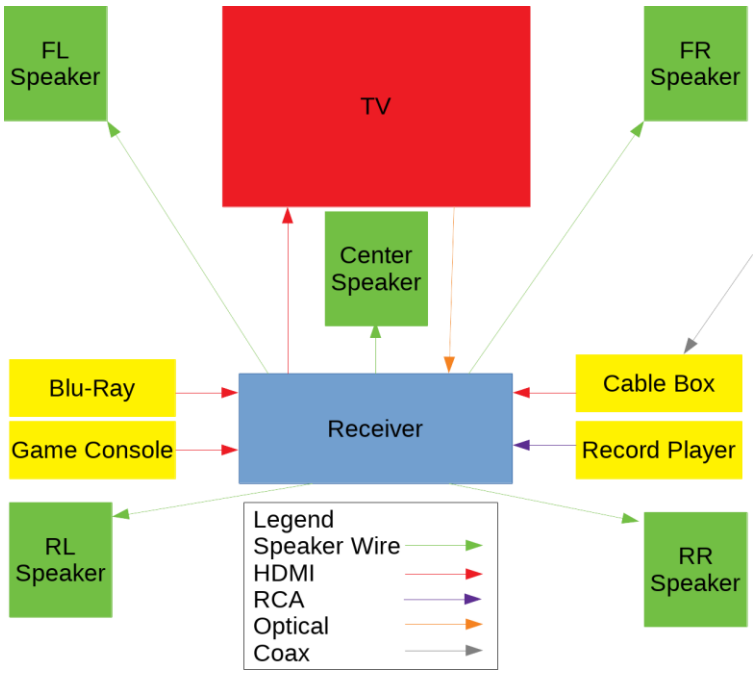
The pilot carrier of 19 KHz is extracted using another band pass filter, this pilot carrier is given to the frequency doublers, which doubles its frequency to 38 KHz. After amplification of this the AM detector detects the(L-R) signal, which is carrier, it is applied to the AM detector matrix. As some

time is taken for the (L-R) signal to demodulate, the (L+R) signal is delayed so that both (L+R) and (L-R) reach the matrix at the same time.

2.1 Audio System



5.1 Home Theater



5.1 Surround sound systems are one of the widely used surround sound setup in home theater systems. Usually- Dolby Digital and DTS encoded in a DVD are 5.1 channel audio formats. 5.1 surround sound technologies produces five channels of sound in the left, right, center, left-surround and right-surround positions. These five channels are the minimum required to produce 5.1 surround sounds. The dot decimal (.1) represents the channel for LFE (low frequency effects), which is usually sent to a subwoofer. Other 5 units are capable for handling the frequency range except low frequency(*Usually they are capable of handling the frequency range from 100Hz to 22Khz and no need for any other higher frequency component like tweeter*). These five units are usually called satellite units.

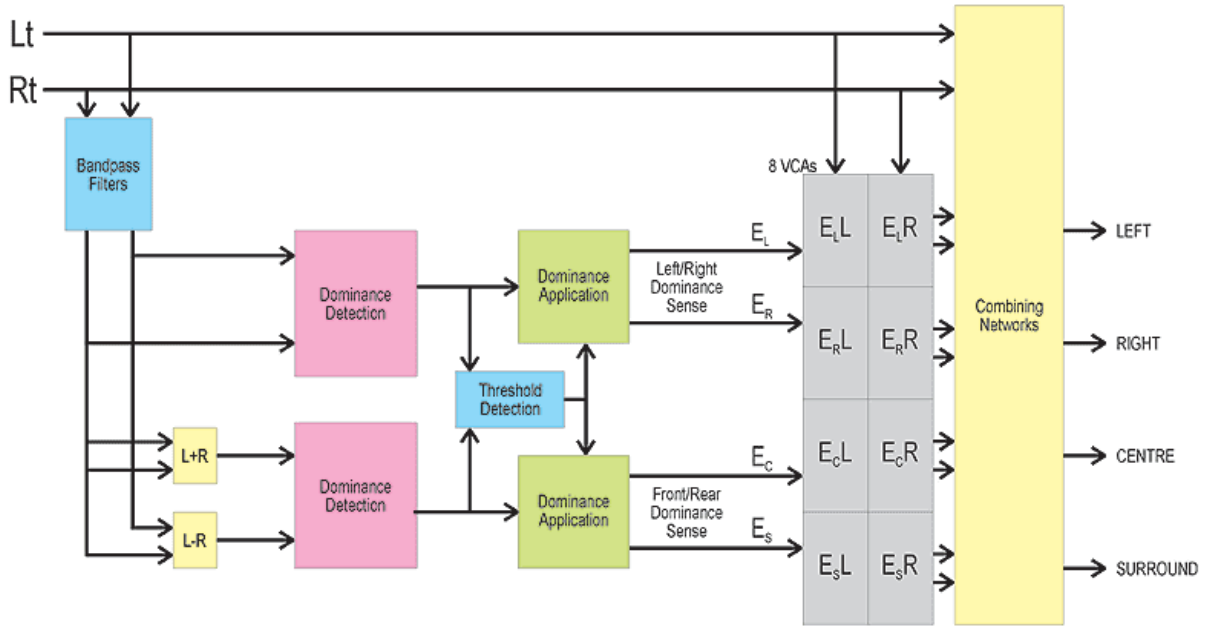


Figure shows the structure of the decoder, with the Lt and Rt input signals being passed straight to a combining network from which the decoded outputs are obtained. The inputs are also routed through a band-pass filter to simple passive sum-and-difference decoders. The filtering removes low frequencies which carry no useful directional information, and high frequencies which could be distorted by amplitude or phase errors in the recording medium.

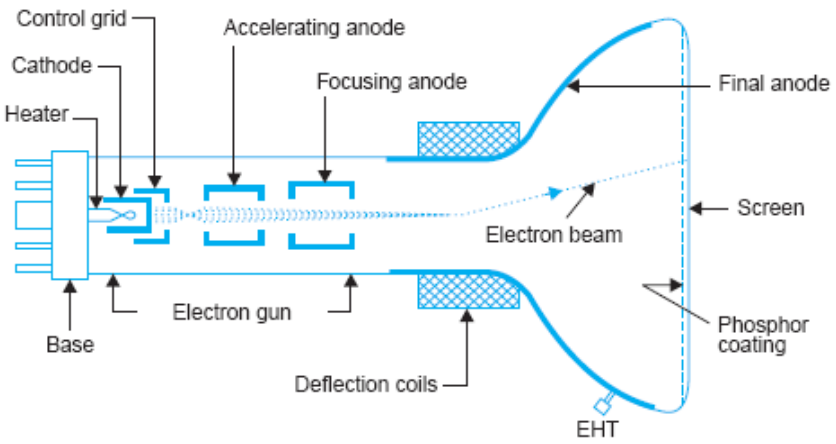
The left-right and centre-surround channel pairs derived from the passive decoders are analyzed independently to detect dominant signals. Four control voltages are generated (EL, ER, EC, and ES) corresponding to the relative strength of the dominant signal in the left, right, centre and surround channels. If a certain threshold is exceeded, they are used to adjust the gain of eight VCAs — four working on the level of the Lt signal and four affecting the Rt signal. This octet of gain-adjusted signals is then inverted and combined with the original Lt and Rt signals to produce the four 'directionally enhanced' output signals — L, C, R, and S.

Display system

CRT (Cathode Ray Tube)

The picture tube shown in Fig is very similar to the cathode-ray tube used in an oscilloscope. The glass envelope contains an electron gun structure that produces a beam of electrons aimed at the fluorescent screen. When the electron beam strikes the screen, light is emitted. The beam is deflected by a pair of deflecting coils mounted on the neck of the picture tube in the same way and rate as the beam scans the target in the camera tube. The amplitudes of the currents in the horizontal

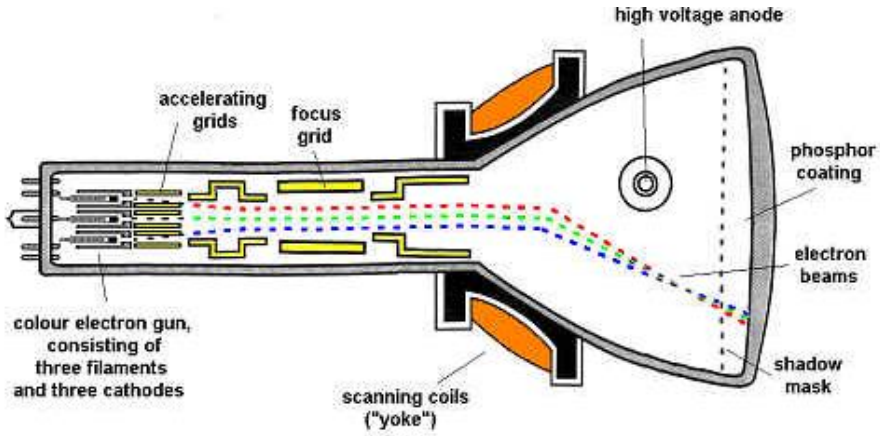
and vertical deflecting coils are so adjusted that the entire screen, called raster, gets illuminated because of the fast rate of scanning.



The video signal is fed to the grid or cathode of the picture tube. When the varying signal voltage makes the control grid less negative, the beam current is increased, making the spot of light on the screen brighter. More negative grid voltage reduces the brightness. if the grid voltages is negative enough to cut-off the electron beam current at the picture tube there will be no light. This state corresponds to black. Thus the video signal illuminates the fluorescent screen from white to black through various shades of grey depending on its amplitude at any instant. This corresponds to the brightness changes encountered by the electron beam of the camera tube while scanning the picture details element by element. The rate at which the spot of light moves is so fast that the eye is unable to follow it and so a complete picture is seen because of the storage capability of the human eye.

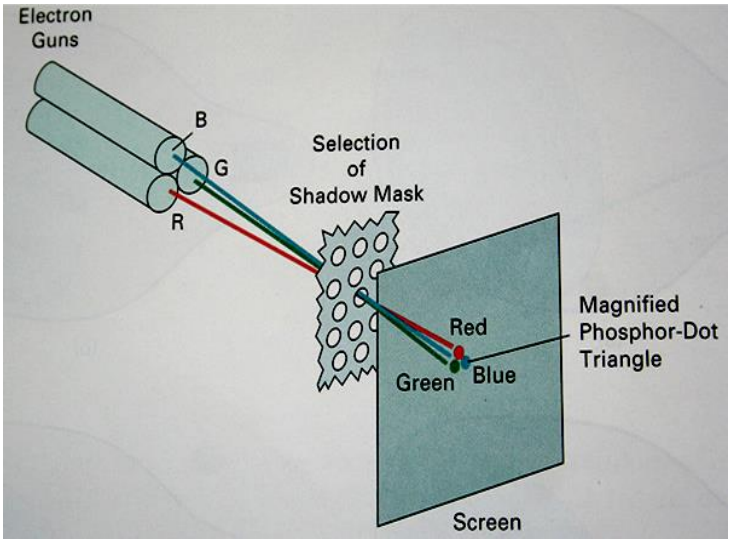
Colour picture tube

The colour television camera separates the primary hues from the televised scene and the colour picture tube recombines them. The colour picture tube consists of three electron guns(red, blue and green gun) in one picture tube envelope. The three guns are placed in the neck of the tube in a triangle(delta). The combinations of these primary colours produce all the other colours, including white.

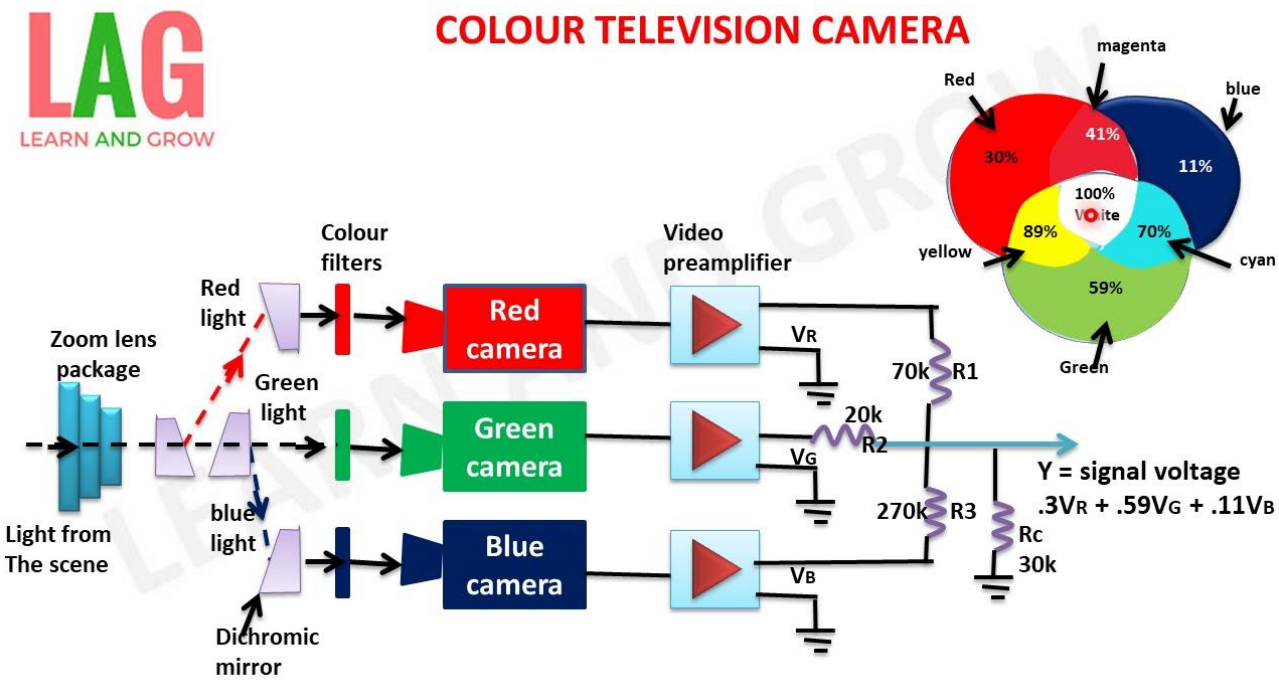


The phosphor on the screen or face plate is considerably different from the phosphor of monochrome picture tubes. Instead of a solid coating of one phosphor on the

screen, each of three phosphors is placed in dots along a horizontal axis in a triangle fashion. The colour tube called the trigun tricolor tube also has a shadow mask. It ensures that the beams from the three electron guns hit their respective phosphor dots.



The colour tube is scanned in the same way as a black and white picture tube. If the picture being received is a black and white picture all the three guns will be operating. If however, the picture being televised is in colour, the red gun will operate for red objects, green for green objects in the picture and so on. If some other colour is required, then the proper guns will operate to mix the basic colours and produce the desired colour. The quantity of electrons hitting the phosphor dots is controlled by their respective control grids so as to produce any desired colour.



LCD(liquid Crystal Display)

A Liquid crystal display is a passive device, which means it doesn't produce any light to display characters, images, video and animations. But it simply alters the light travelling through it. The internal construction of LCD describes how the light altered when it passes through it in order to produce any characters, images, etc

Consider a single pixel area in LCD, in which there are two polarization filters oriented at 90 degree angle to each other as shown in figure 1.1. These filters are used to polarize the unpolarized light. The first filter (Vertical polarized filter in figure 1.1) polarizes the light with one polarization plane (Vertical). When the vertically polarized light passes through the second filter (Horizontal polarized filter) no light output will produce.

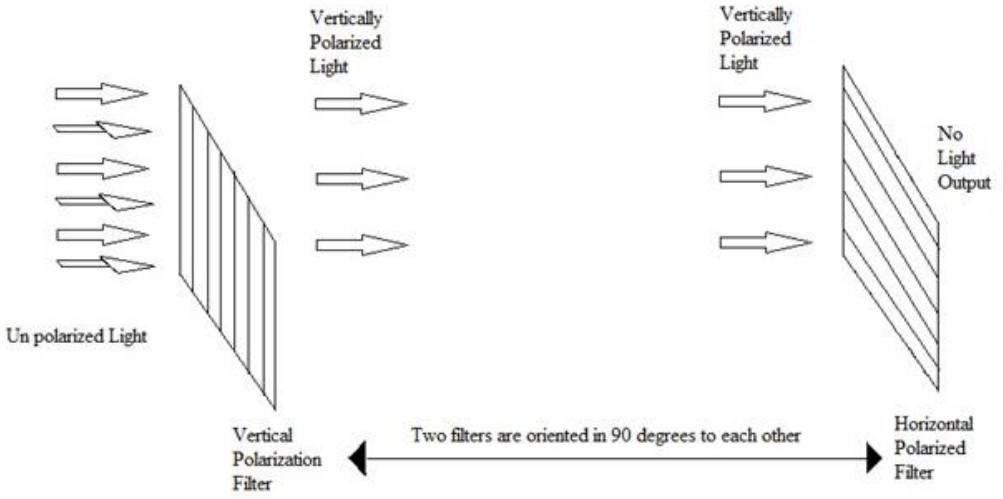
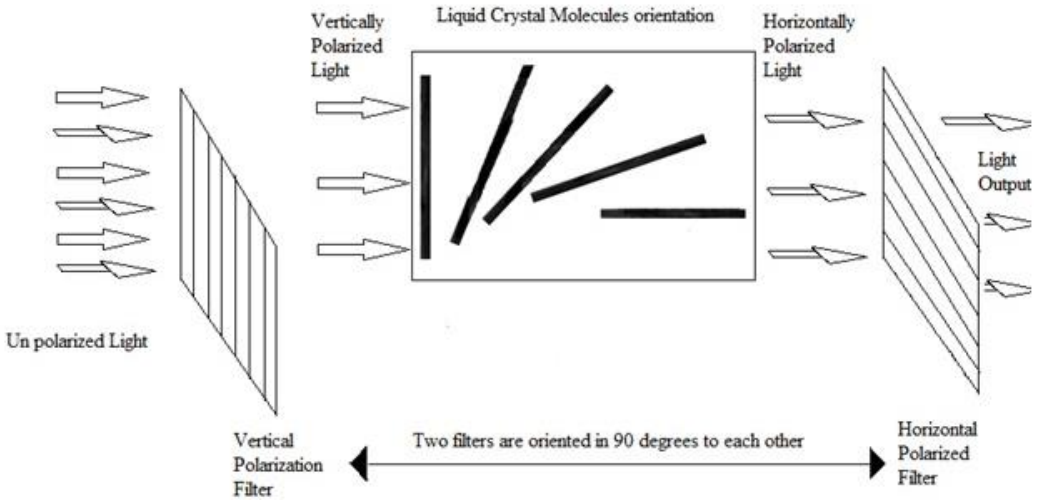
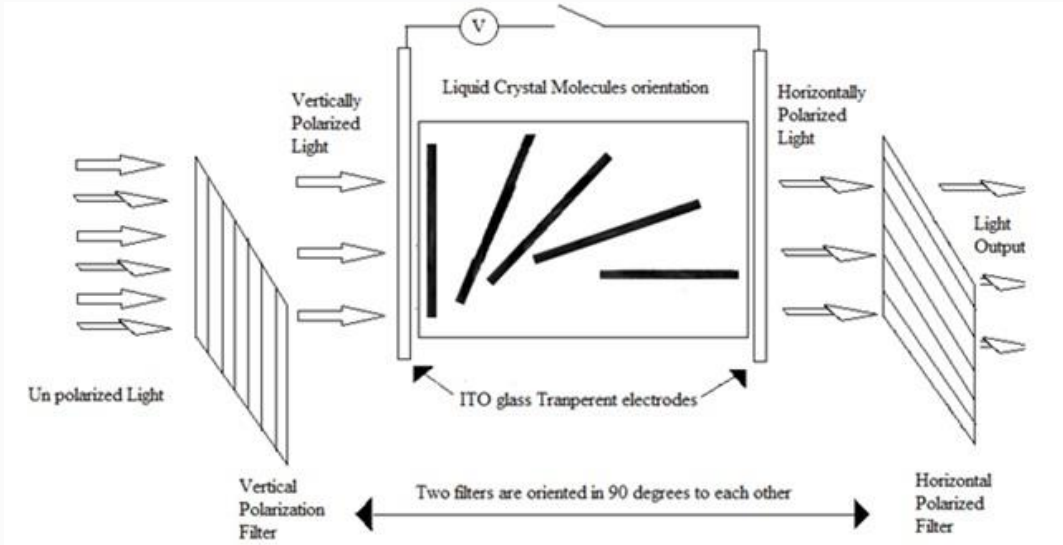


Figure 1.1 Orientation of two polarization filters in LCD

The vertically polarized light should rotate 90 degrees in order to pass through the horizontal polarized light. This can be achieving by embedding liquid crystal layer between two polarization filters. The liquid crystal layer consists of rod shaped tiny molecules and ordering of these molecules creates directional orientation property. These molecules in the liquid crystal are twisted 90 degrees as shown in the figure 1.2. The vertically polarized light passes through rotation of the molecules and twisted to 90 degrees. When the orientation of light matches with the outer polarization filter light will pass it and brightens the screen.

If the Liquid crystal molecules are twisted 90 degrees more precisely, then more light will pass through it. Two glass transparent electrodes are aligned front and back of the liquid crystal in order to change the orientation of the crystal molecules by applying voltage between them as shown in figure 1.3 and figure 1.4. If there is no voltage applied between the electrodes, the orientation of


Vertically
Polarized
Light
Liquid Crystal Molecules orientation
Horizontally
Polarized
Light
Light
Output
Un polarized Light
Vertical
Polarization
Filter
Two filters are oriented in 90 degrees to each other
Horizontal
Polarized
Filter


V
Liquid Crystal Molecules orientation
Vertically
Polarized
Light
Horizontally
Polarized
Light
Light
Output
Un polarized Light
ITO glass Tranperent electrodes
Vertical
Polarization
Filter
Two filters are oriented in 90 degrees to each other
Horizontal
Polarized
Filter

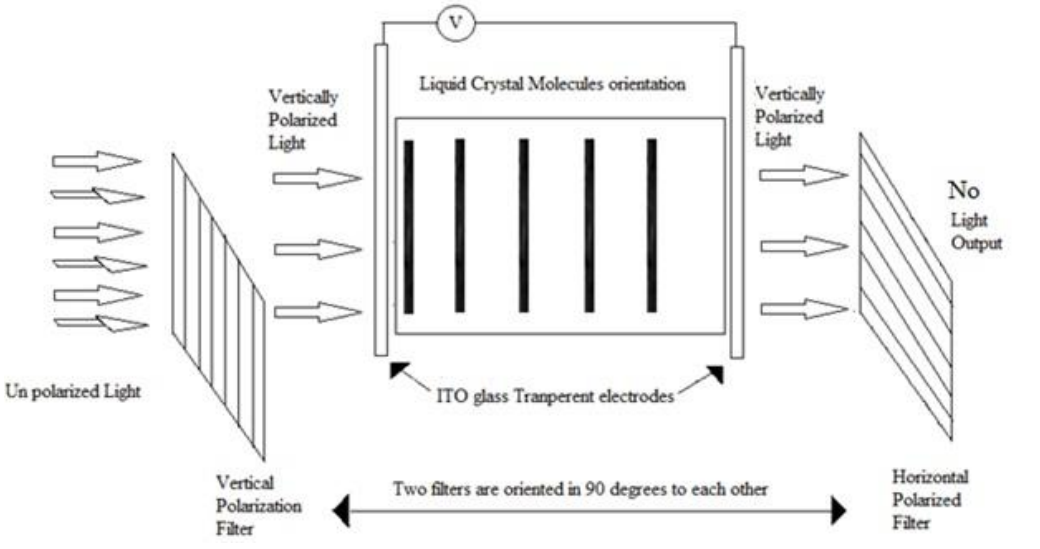
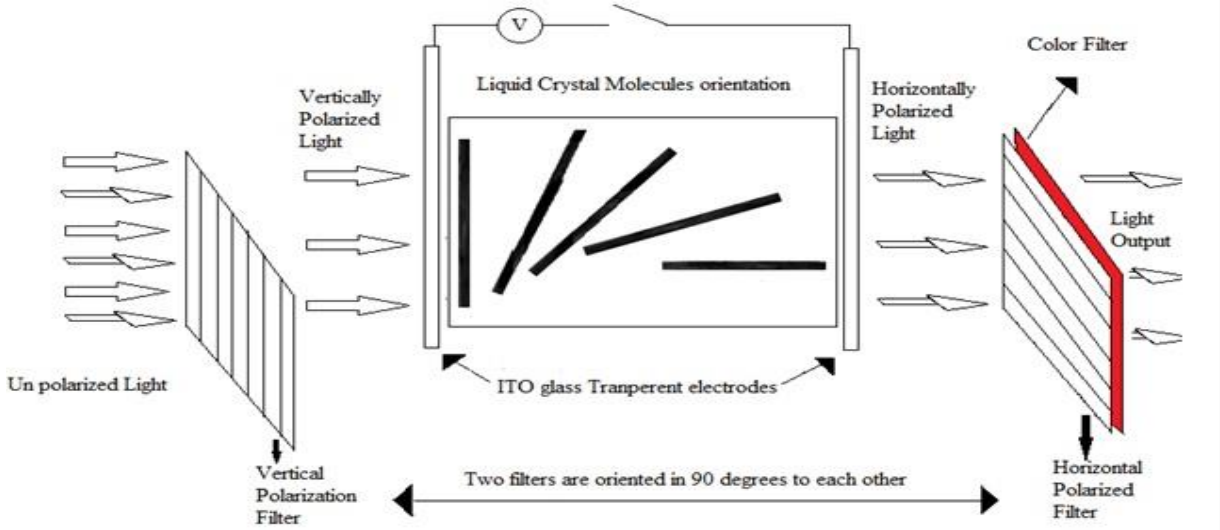
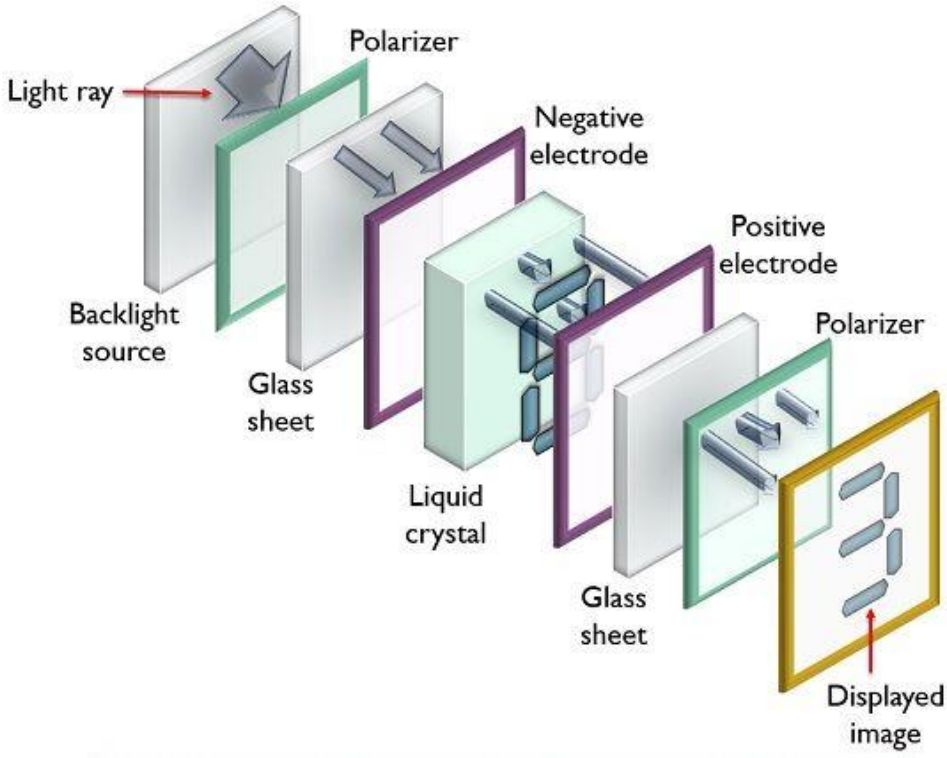

V
Liquid Crystal Molecules orientation
Vertically
Polarized
Light
Vertically
Polarized
Light
No
Light
Output
Un polarized Light
ITO glass Tranperent electrodes
Vertical
Polarization
Filter
Two filters are oriented in 90 degrees to each other
Horizontal
Polarized
Filter

Figure 1.3

molecules will remain twist at 90 degrees and the light passes through the outer polarization filter thus pixel appears as complete white. If the voltage is applied large enough the molecules in the liquid crystal layer changes its orientation (untwist) so that light orientation also changes and then blocked by the outer polarization filter thus the pixel appears black. In this way, black and white images or characters are produced. By arranging small pixels together as a matrix will produce on which it is possible to show different sizes of images and characters. By controlling the voltage applied between liquid crystal layers in each pixel, light can be allowed to pass through outer polarization filter in various amounts, so that it can possible to produce different gray levels on the LCD screen.





Generally the electrodes is made up of Indium Tin Oxide (ITO) which is transparent material, hence it is simply called glass electrodes plates. LCD display is also “twisted nematic LCD” because of twist and untwist of molecules in liquid crystal layer.

In order to produce color images a color filter is placed in front of the outer polarization plate as shown in figure1.5. The red, green and blue are the three standard colors filters are placed for every three pixels to produce different color images by varying the intensity of each color.

Advantages

- LCD’s consumes less amount of power compared to CRT and LED
- LCD’s are consist of some microwatts for display in comparison to some mill watts for LED’s
- LCDs are of low cost
- Provides excellent contrast
- LCD’s are thinner and lighter when compared to cathode-ray tube and LED

Disadvantages of an LCD’s

- Require additional light sources
- Range of temperature is limited for operation
- Low reliability
- Speed is very low
- LCD’s need an AC drive

Applications of Liquid Crystal Display

Liquid crystal technology has major applications in the field of science and engineering as well on electronic devices.

- Liquid crystal thermometer
- Optical imaging
- The liquid crystal display technology is also applicable in the visualization of the radio frequency waves in the waveguide
- Used in the medical applications

LED TV

LED (Light Emitting Diodes) TVs are basically LCDs only. The difference is that the lamp behind the screen that was used to illuminate the fluorescent display in LCD is replaced by small LEDs. The working of the TV remains the same, but due to the use of LEDs the screen is much slimmer in size, power efficient and can yield a true black effect to a much greater extent.

Graphics Display

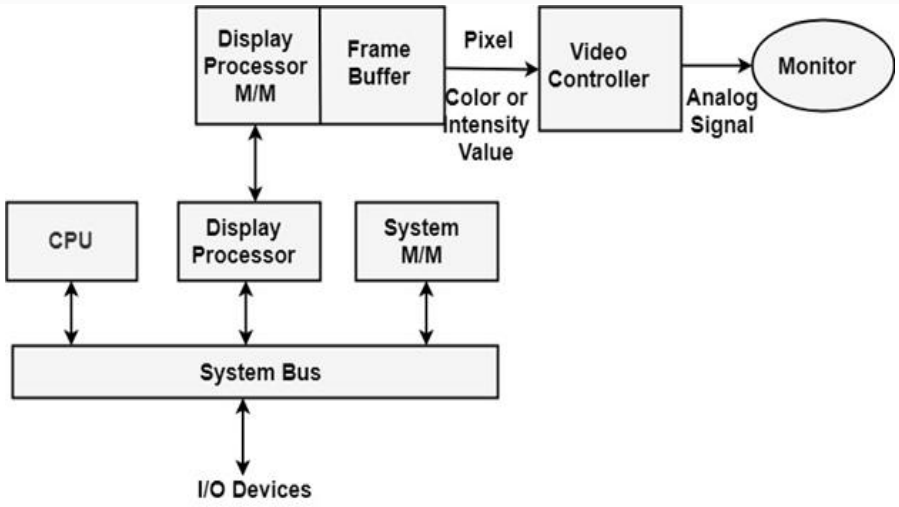


Fig: Architecture of a Raster Display System with a Display Processor

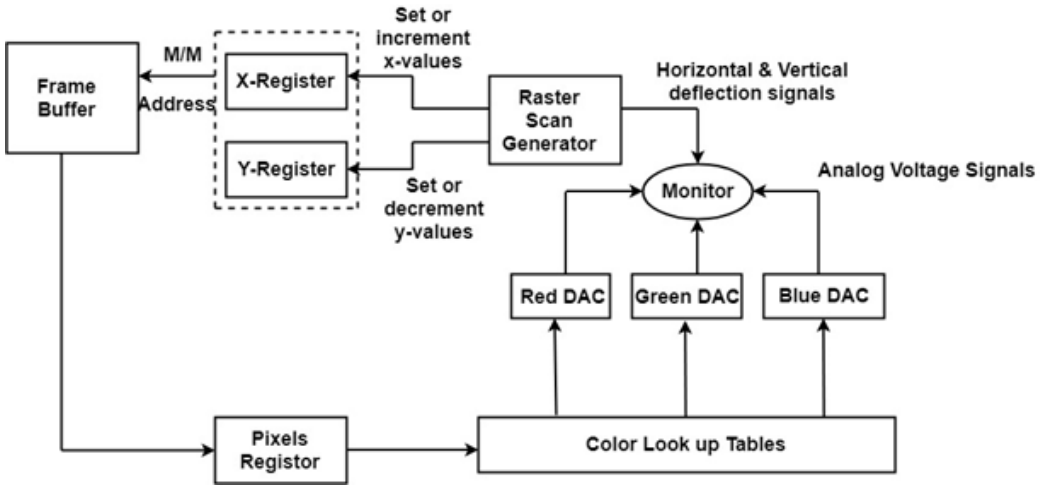
- Interactive raster-graphics systems typically employ several processing units.
- In addition to the CPU, a special purpose processor called the video controller or display controller is used to control the operation of the display device.
- Here the frame buffer is in the system memory, the video controller access the frame buffer to refresh the screen.

Video Controller

- A fixed area of the system memory is reserved for the frame buffer, and the video controller is given direct access to the frame buffer memory.
- The co-ordinates of the graphics monitor starts at the lower left screen corner. Positive x values increasing to the right and y values iincreasing from bottom to top.

Display Processor

- The purpose of the display processor or graphics controller is to free the CPU from the graphics chores. In addition to the system memory a separate display processor memory area can also provided.
- A major task of the display processor is digitizing a picture definition given in an application program into a set of pixel-intensity values for storage in the frame buffer. This digitization process is called scan conversion.
- Lines and other geometric objects are converted into set of discrete intensity points. Characters can be defined with rectangular grids, or they can be defined with curved outlines.
- To reduce the memory space required to store the image information, each scan line are stored as a set of integer pairs.



The above diagram shows the refresh operation of video controller. Two registers are used to store the co-ordinates of the screen pixels. Initially x=0 and $y=y_{max}$. One number of each pair indicates an intensity value, and the second number specifies number of adjacent pixels the scan line that is also having same intensity. This technique is called run-length encoding.

- The value stored in the frame buffer corresponding to this pixel position is retrieved.
- And the x value is incremented by 1 and the corresponding y value is retrieved, like that the pixel values are retrieved line by line.
- Once the last pixel is reached again the registers are reset to initial value to repeat the process

At the start of a Refresh Cycle:

- X register is set to 0 and y register is set to y_{max}. This (x, y') address is translated into a memory address of frame buffer where the color value for this pixel position is stored.
- The controller receives this color value (a binary no) from the frame buffer, breaks it up into three parts and sends each element to a separate Digital-to-Analog Converter (DAC).
- These voltages, in turn, controls the intensity of 3 e-beam that are focused at the (x, y) screen position by the horizontal and vertical drive signals.
- This process is repeated for each pixel along the top scan line, each time incrementing the X register by Y.
- As pixels on the first scan line are generated, the X register is incremented through x_{max}.
- Then x register is reset to 0, and y register is decremented by 1 to access the next scan line.
- Pixel along each scan line is then processed, and the procedure is repeated for each successive scan line units pixels on the last scan line (y=0) are generated.
- For a display system employing a color look-up table frame buffer value is not directly used to control the CRT beam intensity.

- It is used as an index to find the three pixel-color value from the look-up table. This lookup operation is done for each pixel on every display cycle.

- As the time available to display or refresh a single pixel in the screen is too less, accessing the frame buffer every time for reading each pixel intensity value would consume more time what is allowed:

- Multiple adjacent pixel values are fetched to the frame buffer in single access and stored in the register.

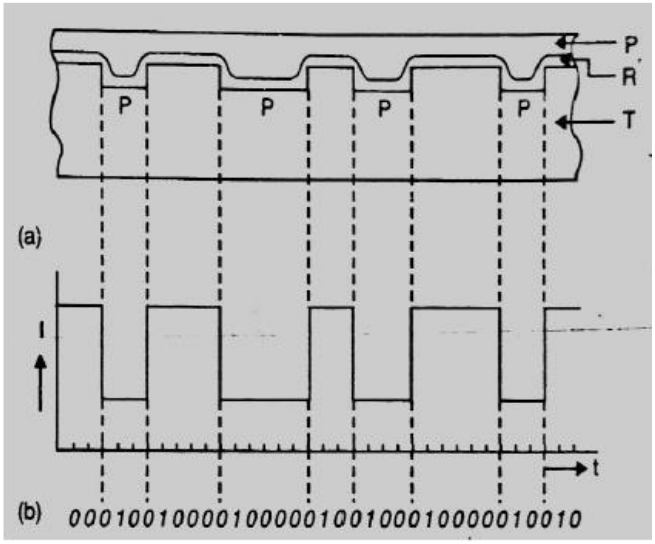
- After every allowable time gap, the one-pixel value is shifted out from the register to control the warm intensity for that pixel.

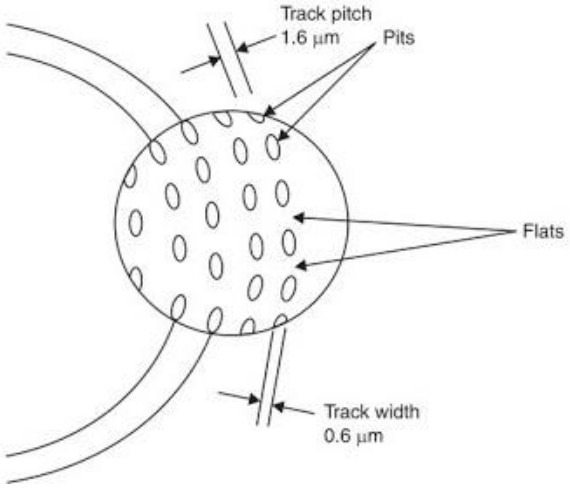
- The procedure is repeated with the next block of pixels, and so on, thus the whole group of pixels will be processed.

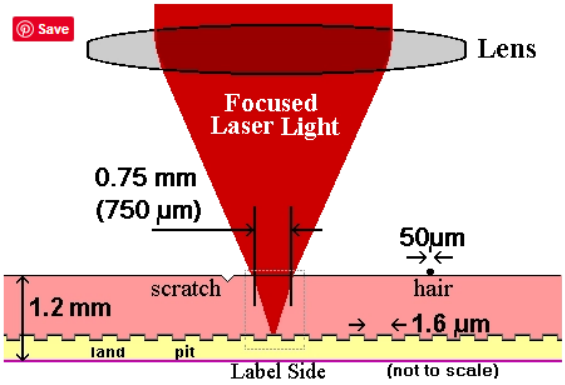
Compact DISC

In the *Laser Vision System,* which records audio or *video* information, the signal is recorded on the disc in the form of a *spiral track* that consists of a succession of *pits.* The intervals between the pits are known as *lands.* The information is present in the track in *analog* form. Each *transition* from land to pit and vice versa marks a zero crossing of the modulated signal. On the *compact disc,* the signal is recorded in a similar manner, but the information is present in the track in *digital* form. Each pit and each land represents a series of bits called *channel bits.* After each land/pit or pit/land transition there is a 1, and all the channel bits in between are 0, (figure 1).

The *density of the information* on the compact disc is very high; the smallest unit of audio information (the *audio hit)* covers an area of 1 μm^2 on the disc, and the diameter of the *scanning light spot* is only 1 µm. The *pitch* of the track is 1.6 µm, the *width* 0.6 µm and the *depth* 0.12 µm.







The *minimum length* of a pit or the land between two pits is 0.9 µm; the *maximum length* is 3.3 µm. The side of the transparent carrier material

T in which the pits are impressed, the upper side during playback if the spindle is vertical, is covered with a *reflecting layer R* and a *protective layer* P. *The track is optically scanned from below the disc at a constant velocity of 1.25 m/s.* The *speed of rotation* of the disc therefore varies from about 8 rev/s to about 3.5 revs (or 480 rpm to about 210 rpm).

What is a DVD?

A Digital Versatile Disc/Digital Video Disc [DVD], is an optical disc storage medium like a compact disc [CD], but with greater data storage and high quality audio and video formats. The clarity, when comparison with a CD is almost six times higher

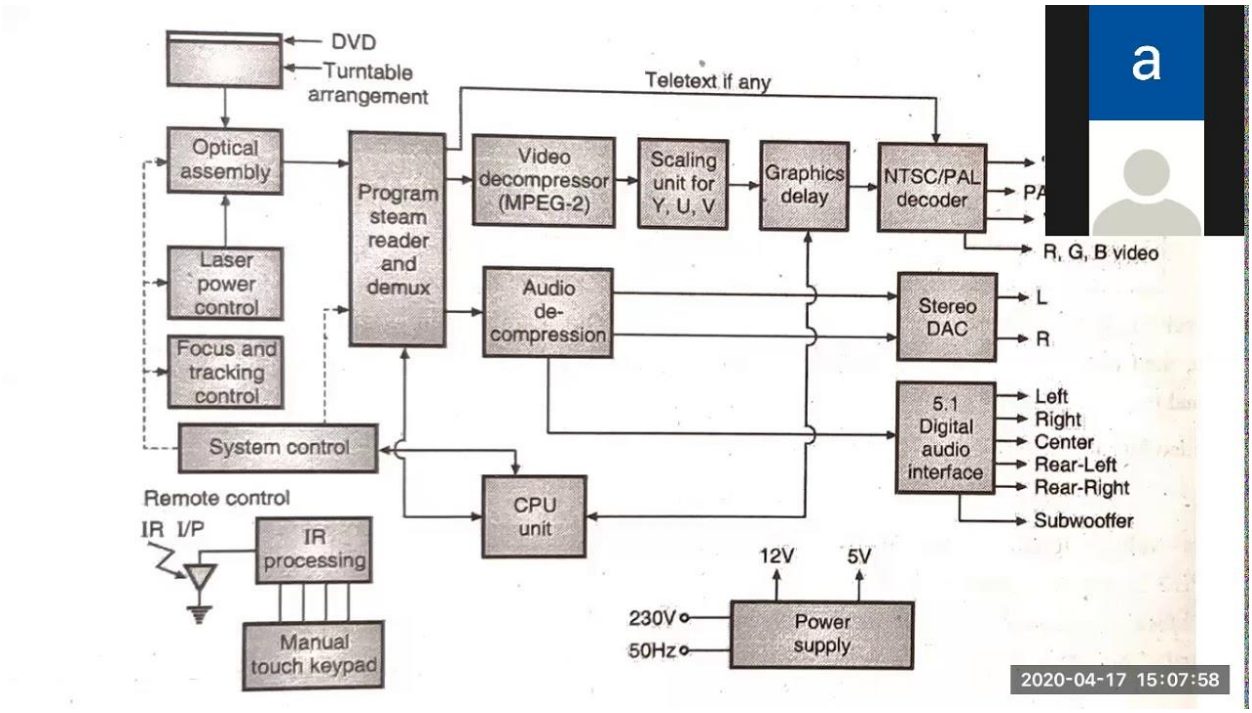
Specifications of DVD

- DVD has a total capacity of 4.7 GB.
- It can run a high-quality video for a maximum of 133 minutes.
- DVD has a video compression ratio of 40:1 with an MPEG-2 compression.
- Wavelength of a DVD is almost 650 nanometres laser diode light.
- DVD's can be written at a speed of almost 18x to 20x. [1x = 1318 Kbps].

Advantages of DVD

- The picture quality is far better than a CD.
- Most DVD's have Dolby Digital or DTS. Thus the clarity of the sound will be nearly equal to that in a theatre.
- Though the technology of CD is gone, they were made with a compatibility with audio CD's.
- The DVD has a special on-screen index quality which helps you to take a closer look at important scenes of a movie which was earlier indexed by the publisher of the movie. This method is not common.
- Unlike a CD player, the DVD player is specialised in taking you to the correct part which you prefer to see. Thus, there will be no need of fast-forwarding.
- The format of a DVD can be changed according to the type of view you need. It can be a standard TV size format and also a wide-screen TV format.

Block diagram of DVD player



Important parts of DVD player

Optical system

The optical system is made up of a laser, photo detector, prism, mirrors, and lenses. The laser and photo detector are installed on a plastic housing, and the other components are placed in specific places. Great care is taken in the positioning of each of these pieces because without proper alignment, the system will not perform properly. Electrical connections are attached and the optical system is then ready to be attached to the disk drive mechanism.

A Laser and Lens system: to focus in on the pits and land and read them. The light from this laser has a smaller wavelength (650nm) than the light from the laser in a CD player (780 nm), which allows the DVD laser to focus on the smaller DVD pits

Disk drive mechanism

The optical system is attached to the motor that will drive it. This in turn is connected to the other principle parts of the disk drive including the loading tray (if present) and the spindle motor. Other gears and belts are attached and the entire assembly is placed in the main body.

To work properly, the DVD player must focus the laser on the track of bumps. The laser can focus either on the semi-transparent reflective material behind the closest layer, or, in the case of a double-layer disc, through this layer and onto the reflective material behind the inner layer. The

laser beam passes through the polycarbonate layer, bounces off the reflective layer behind it and hits an opto-electronic device, which detects changes in light. The bumps reflect light differently than the "lands," the flat areas of the disc, and the opto-electronic sensor detects that change in reflectivity. The electronics in the drive interpret the changes in reflectivity in order to read the bits that make up the bytes.

Inside the DVD player, there is a good bit of computer technology involved in forming the data into understandable data blocks, and sending them either to the DAC, in the case of audio or video data, or directly to another component in digital format, in the case of digital video or data.

Blu-ray Disc – Definition

A Blu-ray Disc is a high density optical disc storage medium, which is used for the storage of all high-definition digital formats like audio, video, and play-station games and so on. They have the same physical appearance as a DVD. The name “BLU-RAY” is actually a combination of the colour “blue” and “ray”. Here blue refers to the blue colour of the laser that is used for its reading and ray refers to the optical ray. While trade marking a product, you are not supposed to include a common or everyday used word. Thus the letter ‘e’ from the word “blue” was omitted.

Blu-Ray Disc Specifications

- BD is present in both single layer and double layer. The single layer Blu-Ray Disc has a capacity of up to 25 GB and double layer has a capacity of 50 GB. Though this is a practical storage capacity meant for the present Blu-Ray players, there are BD’s that have capacities up to 200 GB. These discs, though not marketed yet, can be played in any Blu-Ray player without any additional equipment.
- Blu-Ray Disc needs a wavelength of 400 nanometer violet-blue laser for its reading at different speeds like 4.5 MBPS, 9 MBPS, 18 MBPS, 27 MBPS, 36 MBPS and 54 MBPS.
- Blu-Ray disc can run formats that are encoded in MPEG-4 and MPEG-2.
- BD is used for data storage, playing 1080p HD video and audio, 3-D Stereophonic and so on.

Construction and Working of Blu-Ray Disc

1. Like a DVD, the BD also has pits and bumps. The only difference is that the pits and bumps are smaller and very closely packed. Blu-ray disc also has spiral tracks running from the centre to the edges of the disc. The information is stored in these tracks in the form of audio and video. These audio and video are introduced into the DVD after encoding it.
2. As told earlier a blue laser is used to focus on the DVD. The laser has a small wavelength of precisely 405 nanometers and must be highly accurate because the pits and bumps are smaller

and packed closely. The information stored in the Blu-Ray disc is usually very small in size. They are only 0.15 x 10-6 meters long. Since all these are very small in size, a single-layer itself is more than enough to hold more than 25 GB of data. Thus if a double layer is used, they can easily hold information up to 5o GB.

3. The Blu-Ray disc does not have these issues because the data is stored on top of a poly-carbonate layer which is about 1 millimeter thick. This stops the problem of birefringence and causes no distortion to the reading of data. This also has an advantage in regard to the closeness of the data to the objective lens. Due to this closeness to the surface, the BD has a outside hard cover to prevent scratching and finger prints.

Types of Blu-Ray Disc

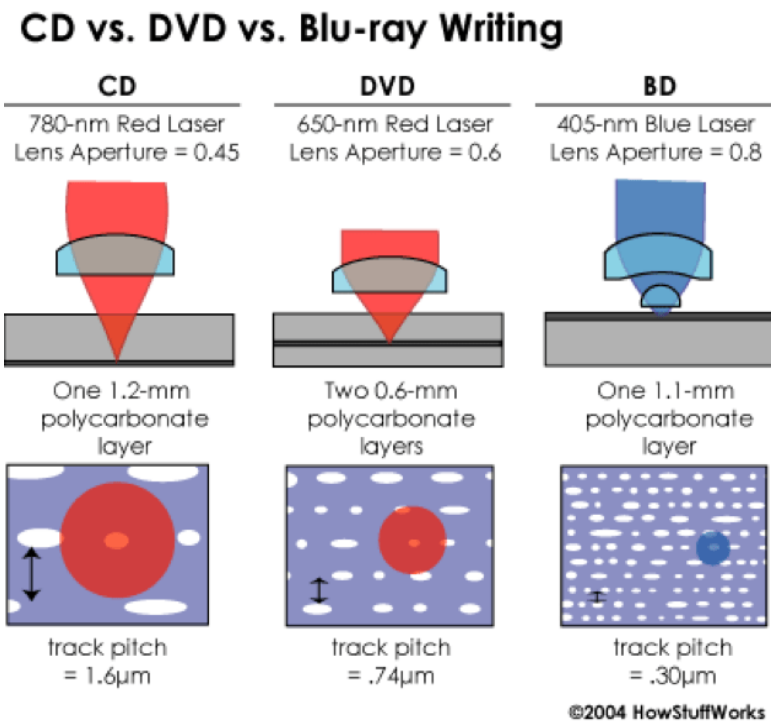
Similar to a DVD, BD also has different versions according to its application. The common types are

1. Read only memory Blu-Ray disc [BD-Rom] – This type of BD can only be read but cannot be written over. The content will be pre-recorded.
2. Recordable Blu-Ray disc [BD-R] – This BD is mainly used for storage of PC data.
3. Re-writable Blu-Ray disc [BD-RW] – This BD is mainly used for storage of PC data. The contents in this disc can be written over and over.
4. Re-writable Blu-Ray disc [BD-RE] – This BD is mainly used for recording of data to be used in HDTV. This disc can also be written over again and again.

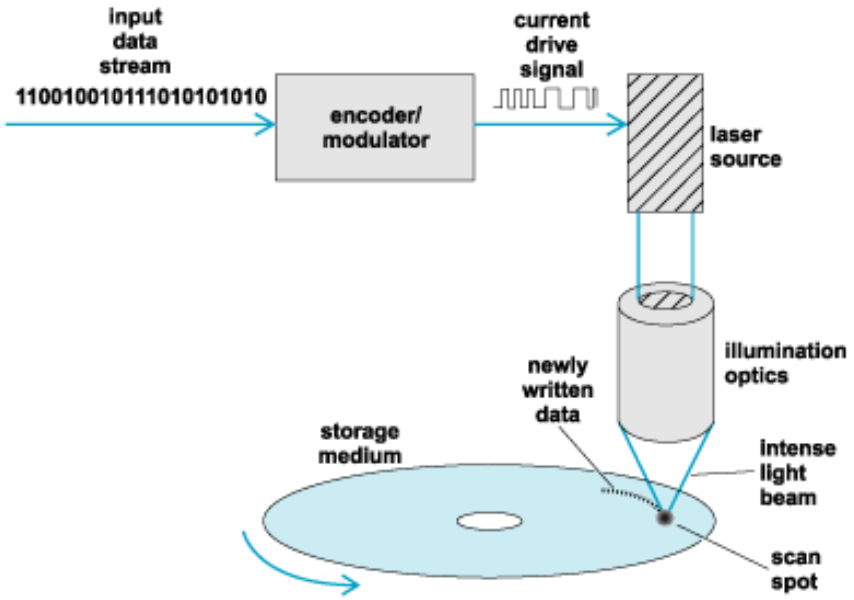
Blu-Ray Disc (BD) vs DVD

- Both of them have the same physical appearence. [Thickness = 1.2 mm]
- The single layer Blu-ray disc can store up to 27 GB data. A singe layer DVD can hold only 4.7 Gb of data. Thus a BD can hold almost 13 hours of normal video and 2 hours of high-definition video. A double layer BD gas a storage capacity of 50 GB which can play almost 20 hours of normal video and 5 hours of HD.
- A DVD needs two substrates and they should be bonded. But a Blu-ray disc requires only one substrate.
- The production cost of Blu-ray is lesser than that of a DVD because there is no need for bonding of substrates. Thus the production materials are lessened. This causes a lesser production time than that for a DVD.
- The Blu-Ray disc uses violet-blu laser with improved lens specifications, while a DVD uses red laser. This causes the focus to increase, thus helping in the recording of both small and high density pits on the BD.

- The wavelength used for BD is 400 nanometers. DVD has a wavelength of 650 nanometers. This decrease in wave lenth helps in high density medium storage.
- The layer in a blu-Ray disc is very close to the laser lens on its player. Thus the precision of the data displayed will be higher with less distortion than a DVD.

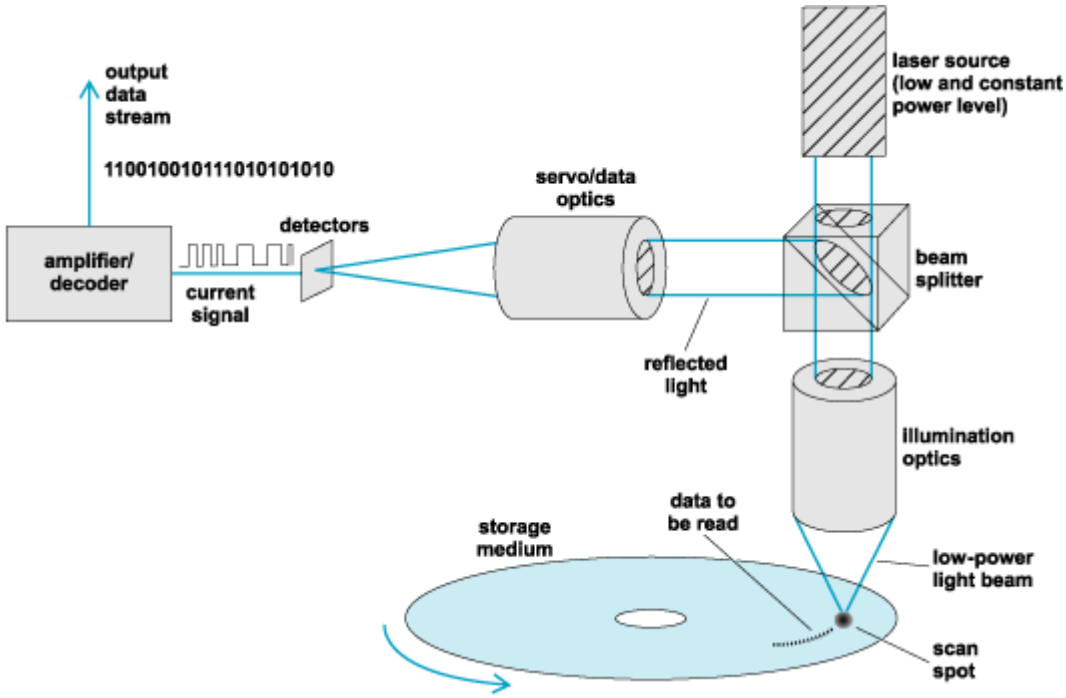


Storing of data



In the recording process an input stream of digital information is converted with an encoder and modulator into a drive signal for a laser source. The laser source emits an intense light beam that is directed and focused into the storage medium with illumination optics. As the medium moves under the scanning spot, energy from the intense scan spot is absorbed, and a small localized region heats up. The storage medium, under the influence of the heat, changes its reflective properties. Since the light beam is modulated in correspondence to the input data stream, a circular track of data marks is formed as the medium rotates. After every revolution, the path of the scan spot is changed slightly in radius to allow another track to be written.

Readout from the Disc

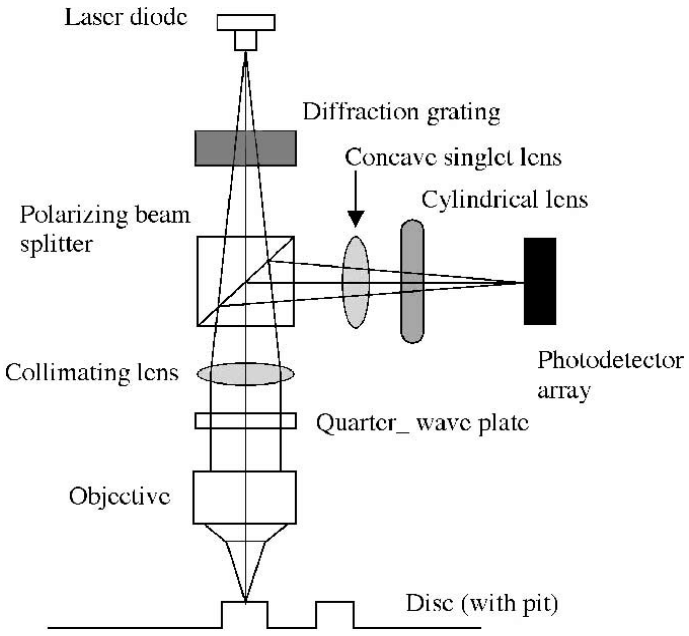


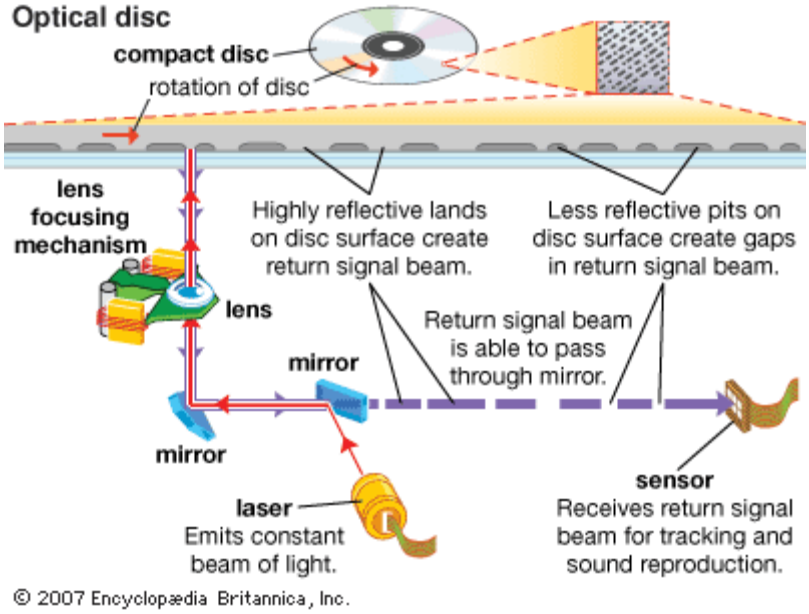
In the optical keep pick-up unit, the laser diode emits laser beam from a small point into an elliptical or conical distribution. This beam is passed through various prism and lens to form a very small diameter light beam on the disc surface at the centre of the track.

The objective lens is controlled by the tracking and focusing coil to keep the beam focused on the CD and keep the condensed beam at the centre of the track. This laser beam is reflected back by the flat area and the pits on the disc surface.

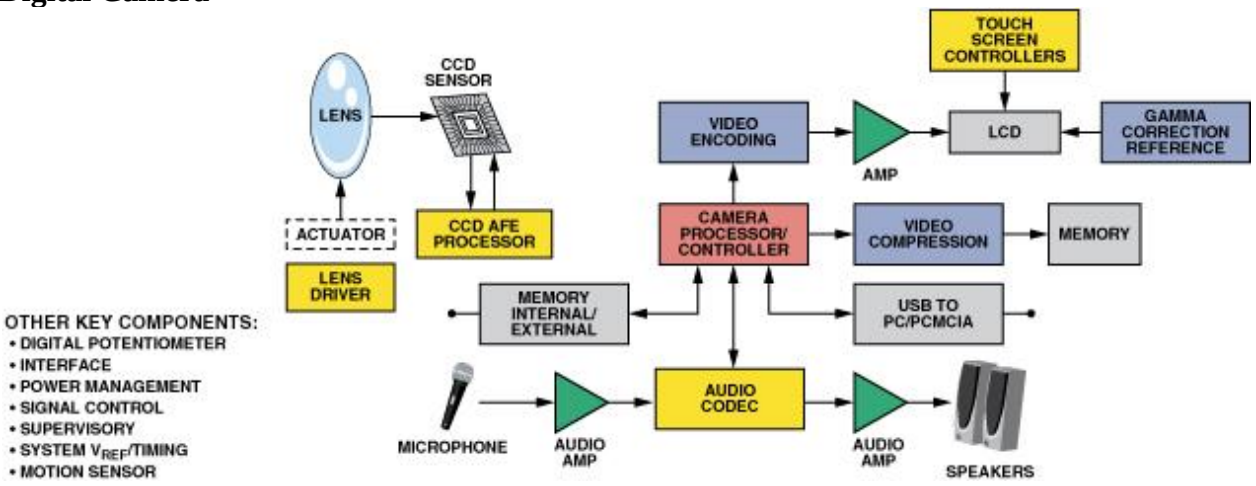
This reflected beam is applied to a group of photo diodes through objective lens, collimator lens and some prism arrangement. This photo diode induce voltage according to the reflected beam falling on it. Focus error and tracking error voltage generated by this photo diode array is applied to the tracking and focusing coil to control the objective lens and data signal generated by this photo diode

array is sent to an amplifier to amplify the data signals picked up from the disc. Finally the output from the amplifier is processed to produce the audio/video signal stored on the disc surface.





Digital Camera



The digital camera can be considered as an alteration of the conventional analog camera. Most of the associated components are also the same, except that instead of light falling on a photosensitive film like an analog camera, image sensors are used in digital cameras. Though analog cameras are mostly dependent on mechanical and chemical processes, digital cameras are dependent on digital processes. This is a major shift from its predecessor as the concept of saving and sharing audio as well as video contents have been simplified to earth.

As told earlier, the basic components are all the same for both analog and digital cameras. But, the only difference is that the images received in an analog camera will be printed on a photographic paper. If you need to send these photos by mail, you will have to digitally convert them. So, the photo has to be digitally scanned.

This difficulty is not seen in digital photos. The photos from a digital camera are already in the digital format which the computer can easily recognize (0 and 1). The 0's and 1's in a digital camera are kept as strings of tiny dots called pixels.

The image sensors used in an digital can be either a Charge Coupled Device (CCD) or a Complimentary Metal Oxide Semi-conductor (CMOS). The image sensor is basically a micro-chip with a width of about 10mm. The chip consists arrays of sensors, which can convert the light into electrical charges. Though both CMOS and CCD are very common, CMOS chips are known to be more cheaper. But for higher pixel range and costly cameras mostly CCD technology is used.

A digital camera has lens/lenses which are used to focus the light that is to be projected and created. This light is made to focus on an image sensor which converts the light signals into electric signals. The light hits the image sensor as soon as the photographer hits the shutter button. As soon as the shutter opens the pixels are illuminated by the light in different intensities. Thus an electric signal is generated. This electric signal is then further broke down to digital data and stored in a computer.

Color Filtering using Demosaicing Algorithms

The sensors used in digital cameras are actually coloured blind. All it knows is to keep a track of the intensity of light hitting on it. To get the colour image, the photosites use filters so as to obtain the three primary colours. Once these colours are combined the required spectrum is obtained. The main advantage of this method is that only one sensor is required for the recording of all the colour information. Thus the size of the camera as well as its price can be lessened to a great extent.

Pixel Resolution of a Digital Camera

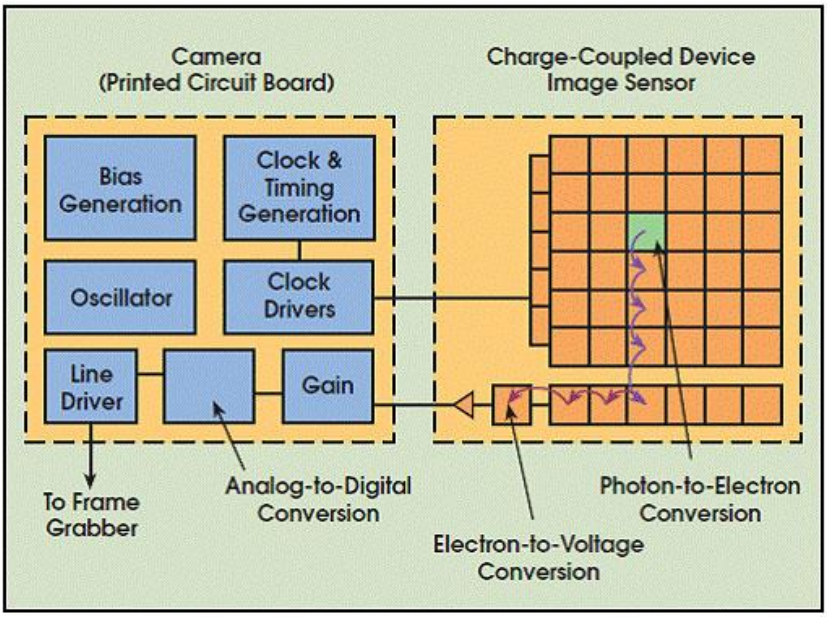
The clarity of the photos taken from a digital camera depends on the resolution of the camera. This resolution is always measured in the pixels. If the numbers of pixels are more, the resolution increases, thereby increasing the picture quality. There are many type of resolutions available for cameras. They differ mainly in the price.

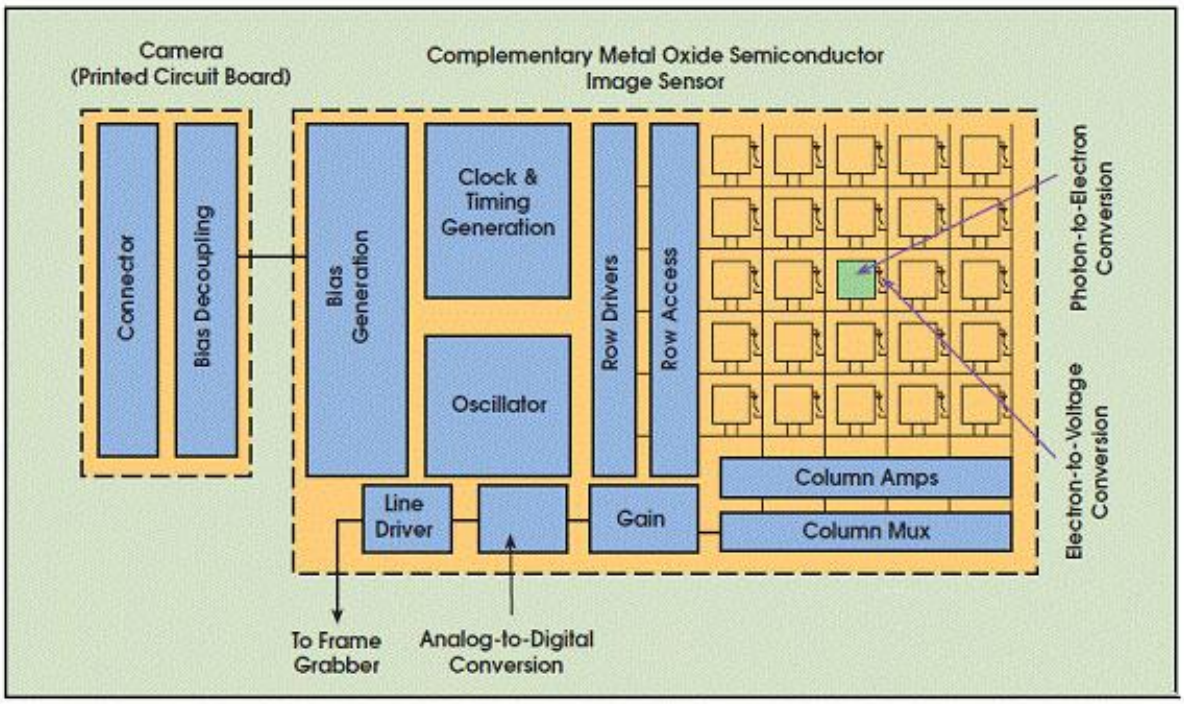
Parameters of a Digital Camera

Like a film camera, a digital camera also has certain parameters. These parameters decide the clarity of the image. First of all the amount of light that enters through the lens and hits the sensor has to be controlled. For this, the parameters are

1. **Aperture –** Aperture refers to the diameter of the opening in the camera. This can be set in automatic as well as the manual mode. Professionals prefer manual mode, as they can bring their own touch to the image.
2. **Shutter Speed –** Shutter speed refers to the rate and amount of light that passes through the aperture. This can be automatic only. Both the aperture and the shutter speed play important roles in making a good image.
3. **Focal Length –** The focal length is a factor that is designed by the manufacturer. It is the distance between the lens and the sensor. It also depends on the size of the sensor. If the size of the sensor is small, the focal length will also be reduced by a proportional amount.**Lens –** There are mainly four types of lenses used for a digital camera. They differ according to the cost of the camera, and also focal length adjustment. They are

1. **Fixed-focus, fixed-zoom lens** – They are very common and are used in inexpensive cameras.
2. **Optical-zoom lenses with automatic focus** – These are lenses with focal length adjustments. They also have the “wide” and “telephoto” options.
3. **Digital zoom** – Full-sized images are produced by taking pixels from the centre of the image sensor. This method also depends on the resolution as well as the sensor used in the camera.
4. **Replaceable lens systems** – Some digital cameras replace their lenses with 35mm camera lenses so as to obtain better images.





In a CCD sensor, every pixel's charge is transferred through a very limited number of output nodes to be converted to voltage, buffered, and sent off chip as an analog signal. In a CMOS sensor, each pixel has its own charge-to-voltage conversion, and the sensor often also includes amplifiers, noise correction, and digitization circuits, so that chip outputs are digital bits

Camcorder

The word camcorder comes from combining the two words, camera and recorder. How a camcorder works is by recording audio and video and then saving those to a storage device, there by creating your own movies/videos and capturing life on video.

One of the most popular camcorders today is the DVD type, which can replay video on a home DVD player via the digital camcorders recording and hence burning directly to DVD.

The convenience of recording directly to the high-resolution DVD format is incomparable. Also, instant access to any scene eliminates the time and hassle of fast-forwarding and rewinding, as with tape formats. These camcorders work by allowing the DVD format to save memories securely in high-resolution. Also it is important to note that the DVD type camcorders LCD displays a list of the recorded scenes for quick, easy searching.

DVD camcorders provide superb recording quality by digitally recording to a DVD disc and not on tape. Another benefit of recording with a DVD camcorder is its flexibility. You can use your camera to record at home, use it as a storage medium, or in the office connected to your PC. Images recorded onto DVD-RAM or DVD-R discs can also be played on a DVD recorder or DVD player, so you don't have to hook the camcorder up to a TV to watch your recordings.

Advantages of LED TV

1. **Consumes less power compared to LCD, plasma and CRT**
2. **Thinner and lighter compared to CRT and LCD**
3. **Contrast is better than LCD**
4. **It has very good brightness**

Disadvantages of LED TV

1. **Need additional light source**
2. **Limited range of temperature for operation**
3. **Narrow viewing angle**
4. **Little motion blur**

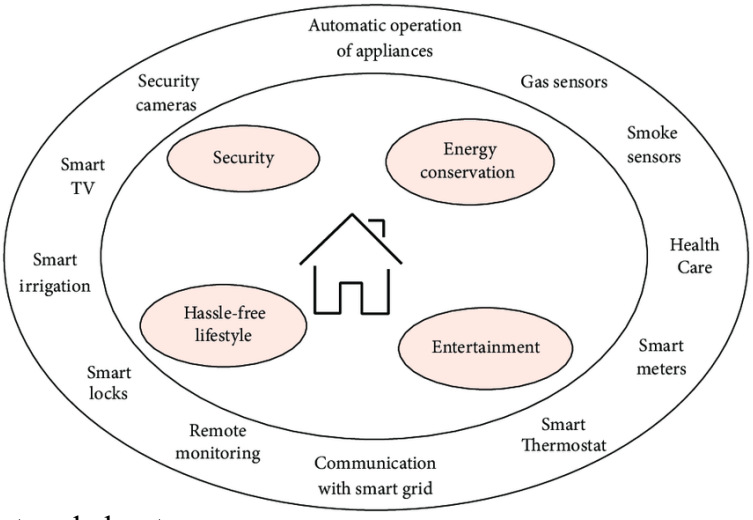
UNIT III: Smart Home - Technology involved in Smart home, Home Virtual Assistants- Alexa and Google Home. Home Security Systems - Intruder Detection, Automated blinds, Motion Sensors, Thermal Sensors and Image Sensors, PIR, IR and Water Level Sensors.

Smart Home technology

Smart home technology is the general term given to basic home amenities that have been fitted with communication technology, enabling some degree of either automation or remote control. It includes things like:

- Appliances, like washing machines, fridges, and garage door openers
- Home entertainment systems
- Home security systems
- Environmental controls, like air conditioning, heating, and lighting

It also includes the various devices that have hit the market that regulate and control all these devices, Like ZigBee, Z-Wave, Lutron, and Wink. These are systems that unite all your smart devices are give you one node to access everything, and they usually come with some mobile software or app so you can do it from wherever you want in the house or when you're out and about.



So far, the development of smart home tech has been modular, and aside from a few experiments or dedicated projects, we have yet to see a truly smart home from the ground up. However, this modular development, made possible by programs that let home owners add or subtract smart appliances as they acquire or retire them, opens the floor to infinite combinations of smart technology. It also means that people can invest as much or as little as they want into improving the IQ of their house.

THE BIG ADVANTAGES

1. **Managing all of our home devices from one place.** The convenience factor here is enormous. Being able to keep all of the technology in your home connected through one interface is a massive step forward for technology and home management.

2. **Flexibility for new devices and appliances.** Smart home systems tend to be wonderfully flexible when it comes to the accommodation of new devices and appliances and other technology. Being able to integrate these newcomers seamlessly will make your job as a homeowner much easier, and allow you to keep upgrading to the latest lifestyle technology.

3. **Maximizing home security.** When you incorporate security and surveillance features in your smart home network, your home security can skyrocket. For example, home automation systems can connect motion detectors, surveillance cameras, automated door locks, and other tangible security measures throughout your home so you can activate them from one mobile device before heading to bed.

4. **Remote control of home functions;**

5. **Increased energy efficiency: S**mart homes also provide some energy efficiency savings. Because systems like Z-Wave and Zig-Bee put some devices at a reduced level of functionality, they can go to sleep and wake up when commands are given. Electric bills go down when lights are automatically turned off in empty rooms, and rooms can be heated or cooled based on who's there at any given moment.

6. **Improved appliance functionality.** Smart homes can also help you run your appliances better. Program your television so that your children can watch only at certain times. Warm the bedroom before you get out of bed so that it's nice and toasty when you getup. Turn on the coffee maker from bed

7. **Home management insights.** There's also something to be said for your ability to tap into insights on how your home operates. You can monitor how often you watch TV (and what you watch), what kind of meals you cook in your oven, the type of foods you keep in your

refrigerator, and your energy consumption habits over time. From these insights, you may be able to analyze your daily habits and behaviors, and make adjustments to live the lifestyle you desire.

Setting up of smart home

X10, Insteon, ZigBee and Z-Wave provide only the fundamental technology, called protocols for smart home communication. They've created alliances with electronics manufacturers who actually build the end-user devices. Here are some examples of smart home products and their functions.

1. Cameras will track your home's exterior even it it's pitch-black outside.
2. You can control a thermostat from your bed,
3. Led lights let you program colour and brightness right from your smartphone.
4. Motion sensors will send an alert when there's motion around your house, and they can even tell the difference between pets and burglars
5. Smartphone integration lets you turn lights and appliances on or off from your mobile device.
6. Door locks and garage doors can open automatically as your smartphone approaches.
7. Auto alerts from your security system will immediately to to your smartphone, so you instantly know if there's a problem at home.
8. Many devices also come with built in web servers that allow you to access their information online.

Smart home challenges

A smart home probably sounds like a nightmare to those people not comfortable with computers. Those who routinely fumble around with a remote control just trying to change the TV channel might have stopped reading by now.

One of the primary mental blocks of installing a smart home system is balancing the complexity of the system against the usability of the system. If it's downright exasperating, then it's actually making your life harder instead of easier. When planning the system, it's important to consider a few factors:

- What kinds of components are part of the system? Are they basic, such a light dimmer, or more imposing, like an alarm system or a video camera?

- How intuitive will the system be to a non-user?

- Is the device actually fulfilling a need or is it just a fancy and potentially frustrating toy?

- How many people will be required to use the system?

- Who will know how to operate the system? Who will know how to maintain the system and address failures?

- How easy is it to make changes to the interface? For example, if your house is programmed to wake you up at 7 a.m., how will you let it know that you're away overnight on business or sleeping in on a Saturday

- **Wi-Fi:** Most people know Wi-Fi, but they may not realize that it has a place in home automation. Lots of smart devices on the market connect to smartphones or hubs via Wi-Fi, and that makes sense—it's a widely available network that people know how to use. However, on the downside, many devices already operate via Wi-Fi. Adding another, potentially bandwidth-intensive one could cause traffic congestion and, in some cases, signal interference.

- **Z-Wave:** Many smart home products use the Z-Wave protocol, which usually transmits on the 908.42 MHz frequency. The protocol employs a mesh network—a chain that turns individual smart devices into nodes. These nodes pass data packets from device to device until the packets reach their final destination. Z-Wave devices are known for interoperability, although it occurs solely within the Z-Wave home automation network.

- **Zigbee:** Like Z-Wave, Zigbee relies on a mesh network. However, it generally runs on the 2.4 GHz frequency. Many smart home devices use the frequency because of its long range. Some developers enjoy working with the Zigbee protocol because of its security and low power usage. Consumers, in turn, benefit from that built-in security in their Zigbee devices.

- **Bluetooth Low Energy (BLE):** Bluetooth Low Energy is another well-known protocol. In the past, the technology relied on short-range radio frequencies to communicate between two devices that were near each other. Now, though, the technology is capable of mesh networking, helping some of the protocol's old range issues. Its other primary benefit is security—it relies on government-grade encryption.

- **X10:** Some protocols have fallen out of favor or see little use today. X10 is one of these. It has been around for years and relies on a home's powerline system to transmit signals. This standard likely won't work well with smart home devices needing fast connections.

- **Insteon:** Insteon tries to bridge the gap between wireless and powerline-based protocols. It's a versatile protocol, perhaps explaining why its devices and hubs are relatively easy to install. Like Zigbee and Z-Wave, the protocol employs a mesh network. The difference is that Insteon uses two bands to increase reliability and performance—and that's in addition to its powerline networking, too. However, Insteon works in fewer smart home verticals than some of the other protocols. The protocol tends to emphasize lighting, security, and climate control.

- **Thread:** Thread is so new that many consumers are unaware of it. This protocol has received attention from the likes of Google and Samsung, and it aims to create a secure home network that can handle over 250 smart home devices. That kind of potential capability could cause Thread to become a more common protocol over the next few years.

- **Universal Powerline Bus (UPB):** Universal Powerline Bus is relatively uncommon, too, though it's more current and more reliable than X10. This system effectively turns your home wiring into a network for transmitting signals. While UPB devices operate better than the X10 ones, other protocols and products far surpass UPB in terms of speed, security, and interoperability

Home Virtual Assistants

Alexa -Overview of the Alexa Voice Service (AVS) Device SDK

The Alexa Voice Service (AVS) Device SDK provides you with a set of C ++ libraries to build an Alexa Built-in product. With these libraries your device has direct access to cloud-based Alexa capabilities to receive voice responses instantly. Your device can be almost anything – a smartwatch, a speaker, headphones – the choice is yours.

The SDK is modular and abstract. It provides separate components to handle necessary Alexa functionality including processing audio, maintaining persistent connections, and managing Alexa interactions.

Each component exposes Alexa APIs to customize your device integrations as needed. The SDK also includes a sample app, to test interactions before integration.

SDK architecture

The following diagram illustrates components of the SDK and how data flows between them.

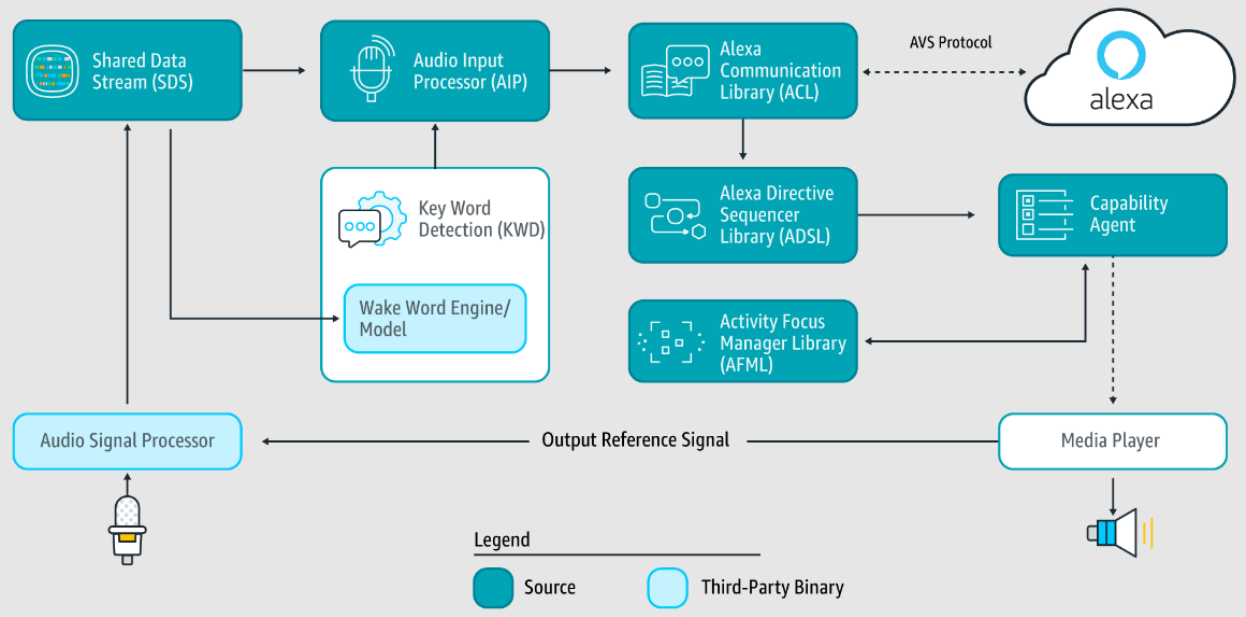
The green boxes are official components of the SDK – they include the following items:

- Audio Input Processor (AIP)
- Shared Data Stream (SDS)
- Alexa Communication Library (ACL)
- Alexa Directive Sequencer Library (ADSL)
- Activity Focus Manager Library (AFML)

- Capability Agent

The white and blue boxes aren't official components and depend on external libraries – these include the following items:

- Audio Signal Processor (ASP)
- Wake Word Engine (WWE)
- Media Player



For general information about Alexa and client interaction, see the Interaction Model.

Here's an example interaction with the SDK. This process might vary if you've added or removed any components.

1. You ask a question, "Alexa, what is the weather?"
2. The microphone captures the audio and writes it to the SDS.
3. The WWE is always monitoring the SDS. When the WWE detects the wake word Alexa, it sends the audio to the AIP.
4. The AIP sends a Speech Recognizer event to AVS using the ACL.
5. AVS processes the event and sends the appropriate directive back down through the ACL. The SDS then picks up the directive and sends it to the ADSL.
6. The ADSL examines the header of the payload and determines what Capability Agent it must call.
7. When the Capability Agent activates, it requests focus from the AFML.

8. The Media Player plays the directive. For this example, Alexa responds with "The weather is nine degrees and cloudy with a chance of rain."

Here are some details about each individual component in the sequence.

Audio Signal Processor (ASP)

The ASP isn't actually a component of the AVS Device SDK. It's Software On a Chip (SOC) or firmware on a dedicated Digital Signal Processor (DSP). Its job is to clean up the audio and create a single audio stream, even if your device uses a multi microphone array. Techniques used to clean the audio include Acoustic Echo Cancellation (AEC), noise suppression, beam forming, Voice Activity Detection (VAD), Dynamic Range Compression (DRC), and equalization.

Shared Data Stream (SDS)

The SDS is single producer, multi-consumer audio input buffer that transports data between a single writer and one or more readers. This ring buffer moves data throughout the different components of the SDK without duplication. This process minimizes the memory footprint, as it continuously overwrites itself. SDS operates on product-specific and user-specified memory segments, allowing for inter process communication. Keep in mind, the writer and readers might be in different threads or processes.

SDS handles these key tasks:

1. Receives audio from the ASP and then passes it to the WWE.
2. Passes the audio from the WWE engine to the ACL. The ACL then passes the audio to AVS for processing.
3. Receives data attachments back from the ACL and passes it to the appropriate Capability Agent.

Wake Word Engine (WWE)

The WWE is software that constantly monitors the SDS, waiting for a preconfigured wake word. When the WWE detects the correct wake word, it notifies the AIP to begin reading the audio. When using the AVS Device SDK, the wake word is always "Alexa." The SDK includes a connector for the Sensory wake word engine – However, you can use any wake word engine of your choice

The WWE consists of following two binary interfaces

- **Interface 1** – Handles general wake word detection.
- **Interface 2** – Handles specific wake word models.

Note: Alexa doesn't *require* a WWE to operate. Alexa can also activate with Tap-to-Talk or through a companion app. By default, the SDK uses Tap-to-Talk. If you require a WWE, you must install it separately and license it for commercial use.

Audio Input Processor (AIP)

Responsibilities of the AIP include reading audio from the SDS and then sending it to AVS for processing. The AIP also includes the logic to switch between different audio input sources. The AIP triggers with the some inputs:

External audio – Captured with on-device microphones, remote microphones and other audio input sources.
Tap-to-Talk – Captured with designated Tap-to-Talk inputs.
Speech directive – Sent from AVS to continue an interaction. For example, multiturn dialog.

When triggered, the AIP continues to stream audio until it receives a Stop directive or times out. AVS can only receive one audio input source at any given time.

Alexa Communications Library (ACL)

The ACL manages the network connection between the SDK and AVS. The ACL performs the following key functions:

- Establishes and maintains long-lived persistent connections with AVS.
- Provides message sending and receiving capabilities. These capabilities include support JSON-formatted text, and binary audio content.
- Forwards incoming directives to the ADSL.
- Handles disconnect and reconnections. If the device disconnects, it automatically attempts to reconnect for you.
- Manages secure connections.

Alexa Directive Sequencer Library (ADSL)

The ADSL Manages handles incoming directives, as outlined in the AVS Interaction Model. The ADSL performs the following key functions:

- Accepts directives from the ACL.
- Manages the lifecycle of each directive, including queuing, reordering, or canceling directives as necessary.
- Forwards directives to the appropriate Capability Agents by examining the directive header and reading the namespace of the interface.

Capability Agents

A Capability Agent is what performs the desired action on a device. They map directly to interfaces supported by AVS. For example, if you ask Alexa to play a song, the Capability Agent is what loads the song into your media player and plays it. A Capability Agent performs the following two tasks:

1. Receives the appropriate directive from the ADSL.
2. Reads the payload and performs the requested action on the device.

Google Home

Google Assistant offers voice commands, voice searching, and voice-activated device control, letting you complete a number of tasks after you've said the "OK Google" or "Hey Google" wake words. It is designed to give you conversational interactions.

The products work with Google Home

- Lighting
- Appliances and fixtures
- Security systems
- Thermostats and other temperature control units
- Entertainment systems
- Computer accessories, such as printers and routers

Google Assistant will:

- Control your devices and your smart home
- Access information from your calendars and other personal information
- Find information online, from restaurant bookings to directions, weather and news
- Control your music
- Play content on your Chromecast or other compatible devices
- Run timers and reminders
- Make appointments and send messages
- Open apps on your phone
- Read your notifications to you
- Real-time spoken translations
- Play games

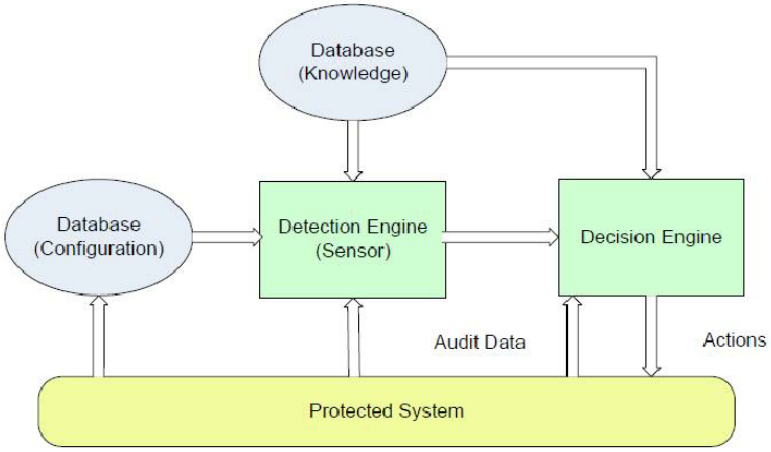
Other highlights of the Google Home's resume include:

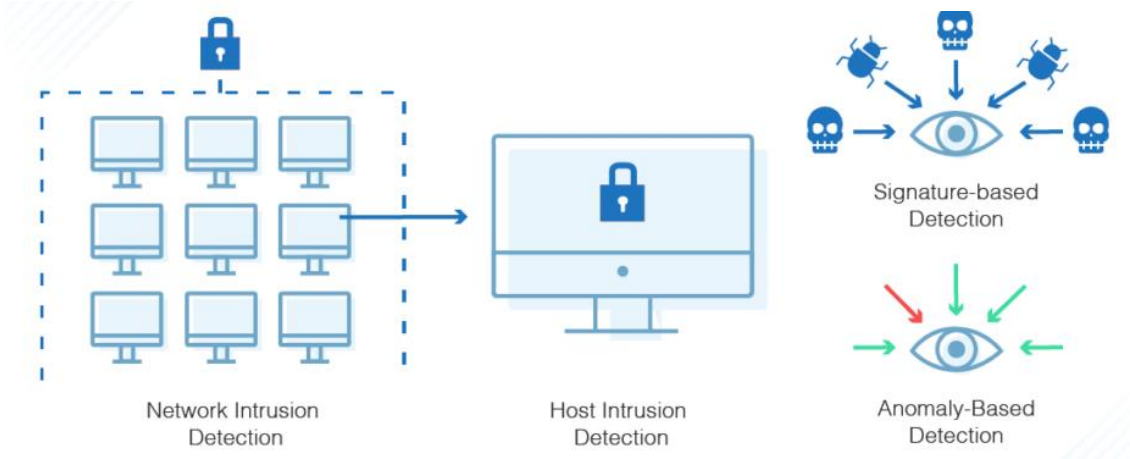
- Broadcasting: Make an announcement to one Google Home and it will play on all connected smart speakers throughout our home or we can broadcast to a specific device. we can also reply to a broadcast with a simple voice command.
- Recipe assistance: Your Google Home can help you cook with step-by-step instructions, skipping forward and back as needed.
- Calling: we can use your Google Home speaker to make a phone call. (Note: You can't use Google Assistant to make calls on third-party speakers for now.)
- Multiple commands: we can issue two commands to our Google Home in sequence.

- Night mode: google can automatically lower the volume of its vocal responses and music streaming at certain times of the day.
- Storytime: Your smart speaker can read aloud a number of stories from Disney and Nickelodeon. Better yet, you can read certain stories while your Google Home provides appropriate music and sound effects.
- Multiple lists: we can make shopping lists with our voice. Now you can create to-do lists, gift lists and more.
- Routines: Give a command such as "Good morning" or "I'm leaving" and so we can customize our Google Home to respond in a variety of ways, including telling you about our commute, playing the news and controlling our compatible smart home devices.

Intrusion Detection System (IDS)

An **intrusion detection system** (**IDS**) is a monitoring system that passively monitors incoming and outgoing network traffic for suspicious attacker activity. An IDS is a module that can alert network devices, but it cannot stop attacks from happening. Generally, an IDS is configured in promiscuous mode because it cannot block the attacks, but only send alerts:





Types of IDS

Network Intrusion Detection System (NIDS)
Host Intrusion Detection System (HIDS)
Host Intrusion Detection System (HIDS):
Protocol-based Intrusion Detection System (PIDS):

Application Protocol-based Intrusion Detection System (APIDS):

Network Intrusion Detection System (NIDS)

Network intrusion detection systems (NIDS) are set up at a planned point within the network to examine traffic from all devices on the network. It performs an observation of passing traffic on the entire subnet and matches the traffic that is passed on the subnets to the collection of known attacks. Once an attack is identified or abnormal behavior is observed, the alert can be sent to the administrator. An example of a NIDS is installing it on the subnet where firewalls are located in order to see if someone is trying crack the firewall.

Host Intrusion Detection System (HIDS):

Host intrusion detection systems (HIDS) run on independent hosts or devices on the network. A HIDS monitors the incoming and outgoing packets from the device only and will alert the administrator if suspicious or malicious activity is detected. It takes a snapshot of existing system files and compares it with the previous snapshot. If the analytical system files were edited or deleted, an alert is sent to the administrator to investigate. An example of HIDS usage can be seen on mission critical machines, which are not expected to change their layout.

Protocol-based Intrusion Detection System (PIDS):

Protocol-based intrusion detection system (PIDS) comprises of a system or agent that would consistently resides at the front end of a server, controlling and interpreting the protocol between a user/device and the server. It is trying to secure the web server by regularly monitoring the HTTPS protocol stream and accept the related HTTP protocol. As HTTPS is un-encrypted and before instantly entering its web presentation layer then this system would need to reside in this interface, between to use the HTTPS.

Application Protocol-based Intrusion Detection System (APIDS):

Application Protocol-based Intrusion Detection System (APIDS) is a system or agent that generally resides within a group of servers. It identifies the intrusions by monitoring and interpreting the communication on application specific protocols. For example, this would monitor the SQL protocol explicit to the middleware as it transacts with the database in the web server.

Hybrid Intrusion Detection System:

Hybrid intrusion detection system is made by the combination of two or more approaches of the intrusion detection system. In the hybrid intrusion detection system, host agent or system data is combined with network information to develop a complete view of the network system. Hybrid intrusion detection system is more effective in comparison to the other intrusion detection system. Prelude is an example of Hybrid IDS.

Detection method of IDS

Signature-based Method:

Signature-based IDS detects the attacks on the basis of the specific patterns such as number of bytes or number of 1's or number of 0's in the network traffic. It also detects on the basis of the already known malicious instruction sequence that is used by the malware. The detected patterns in the IDS are known as signatures. Signature-based IDS can easily detect the attacks whose pattern (signature) already exists in system but it is quite difficult to detect the new malware attacks as their pattern (signature) is not known.

Anomaly-based Method:

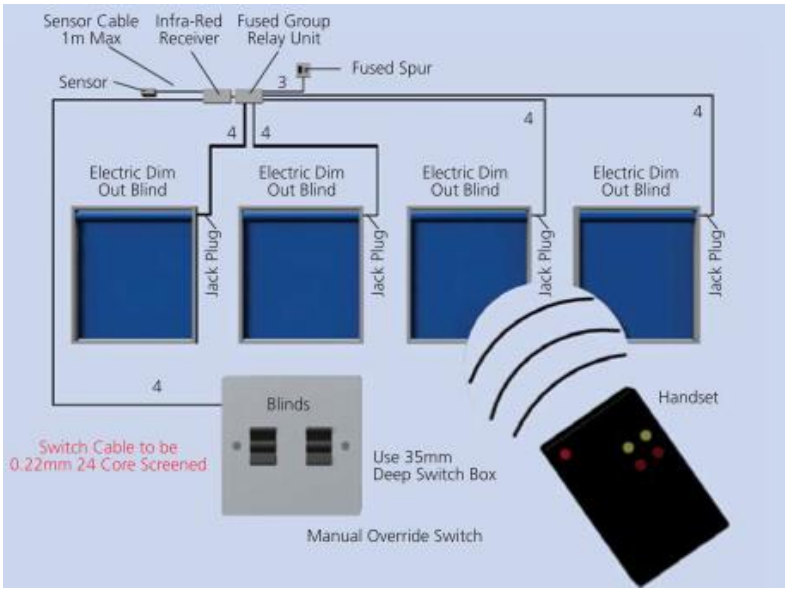
Anomaly-based IDS was introduced to detect the unknown malware attacks as new malware are developed rapidly. In anomaly-based IDS there is use of machine learning to create a trustful activity model and anything coming is compared with that model and it is declared suspicious if it is not found in model. Machine learning based method has a better generalized property in comparison to signature-based IDS as these models can be trained according to the applications and hardware configurations.

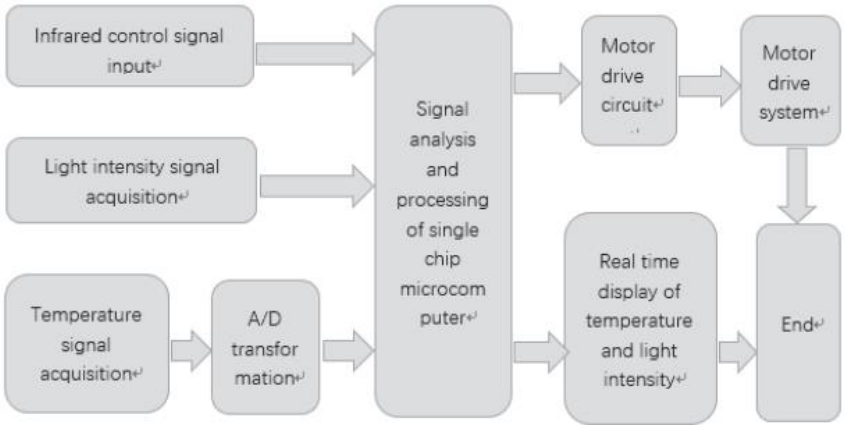
Anomaly-based systems are typically **more useful than signature-based ones** because they're better at detecting new and unrecognized attacks. However, they can set off many false positives, since they don't always distinguish well between attacks and benign anomalous behavior.

Smart blinds

smart blinds are window coverings that can be opened or closed through an app or a voice command on your smartphone. They come in various styles, such as accordion, slat, honeycomb, roller and light filtering. While these style choices are important, there is one major feature to consider above all: the power source. Blinds can be **hardwired** or powered by **solar,** battery or electrical cord.

Fig. 1 shows the overall design of the control system block diagram. It mainly consists of microcontroller module, key control module, wireless transceiver module, display module, control module, timing module, motor control module and other components.





Temperature Acquisition Circuit Module

Temperature sensor is used to detect the indoor environment temperature, whether it is in the suitable human living temperature range. By comparing the temperature detected by the circuit with the preset temperature, if the detected temperature is greater than the upper limit, the curtain is close; if the detected temperature is lower than the lower limit, the curtain is open. If users encounter special circumstances require manual intervention and adjustment, it can be manually controlled by remote control, and the curtain can get any open.

Light intensity collection circuit module: The light intensity sensor to detect the indoor light intensity, whether it is suitable for human living. By comparing the light intensity detected by the

circuit with the preset temperature, if the detected light intensity is greater than the upper limit, the curtain is close; if the detected light intensity is lower than the lower limit, the curtain is open. If the user encounter special circumstances need manual intervention and adjustment, the curtain can be manually controlled by remote control, and the curtain can get any open.

Infra-red sensor (IR sensor)

IR sensor is an electronic device, that emits the light in order to sense some object of the surroundings. An **IR sensor** can measure the heat of an object as well as detects the motion. Usually, in the **infrared spectrum**, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, but infrared sensor can detect these radiations.

Types of IR Sensor

There are two types of IR sensors are available and they are,

- Active Infrared Sensor
- Passive Infrared Sensor

Active Infrared Sensor

Active infrared sensors consist of two elements: infrared source and infrared detector. Infrared sources include the LED or infrared laser diode. Infrared detectors include photodiodes or phototransistors. The energy emitted by the infrared source is reflected by an object and falls on the infrared detector.

IR LED and IR Photodiode

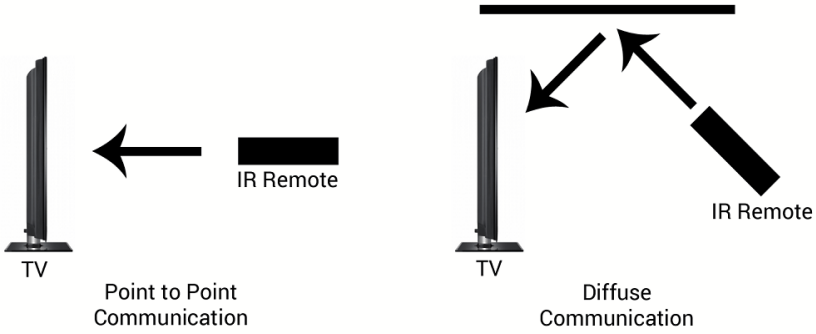
- IR light is like visible light but it is invisible to our eyes, because of which they are suitable in application of wireless communication.
- The band for IR (Infrared) in electromagnetic spectrum is 300GHz to 430 THz and wavelength range of around 700nm to 1mm.
- Along with the IR LED some other sources like sun, light bulbs, human and animal bodies etc. also emit infrared energy.
- IR communication is used for short and medium distance applications.

Principle of Working

- IR LEDs transmit digital (logical 1 and 0) data in the form of infrared light.
- Logical 1 is emitted by keeping IR LED ON and logical 0 by keeping it OFF.
- This ON and OFF sequence of data is collected by IR photodiode at receiver end.

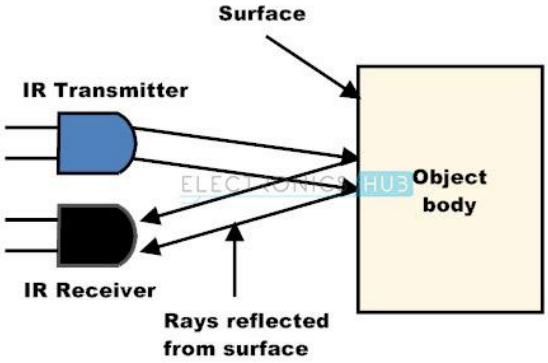
Types of communication

1) **Point to point communication :** In point to point communication, line of sight is required between transmitter and receiver devices.



2) **Diffuse communication :** In diffuse communication, no need to keep transmitter and receiver in straight line of sight. It can be done by reflecting or bouncing the transmitted signal from surfaces like wall, ceilings etc.

The working principle of an infrared sensor is similar to the object detection sensor. This sensor includes an IR LED & an IR Photodiode, so by combining these two can be formed as a photo-coupler otherwise optocoupler.



Applications of IR Sensor

Night Vision Devices: An Infrared technology implemented in night vision equipment if there is not enough visible light available to see unaided. Night vision devices convert ambient photons of light into electrons and then amplify them using a chemical and electrical process before finally converting them back into visible light.

Radiation Thermometers: IR sensors uses in radiation thermometers to measure the temperature depend upon the temperature and the material of the object and these thermometers have some of the following features

- Measurement without direct contact with the object
- Faster response
- Easy pattern measurements

Infrared Tracking: An Infrared tracking or Infrared homing, is a missile guidance system which operates using the infrared electromagnetic radiation emitted from a target to track it.

IR Imaging Devices: IR image device is one of the major applications of IR waves, primarily by virtue of its property that is not visible. It uses for thermal imagers, night vision devices etc.

Human Body Detection: This method is used in intrusion detection, auto light switches, etc. Intrusion alarm system sense temperature of human body.If the temperature is more than threshold value, it sets on the alarms. It uses electromagnetic system which is suitable for human body in order to protect it from unwanted harmful radiations.

Gas Analyzers: Gas Analyzers are used to measure gas density by using absorption properties of gas in IR region. Dispersive and Non-Dispersive types of gas analyzers are available

Item Counter: This uses direct incidence method to count the items. Constant radiation is maintained in between transmitter and receiver. As soon as object cuts the radiation, item is detected and count is increased. The same count is shown on display system.

Advantages of Infrared Sensor

- Their low power requirements make them suitable for most electronic devices such as laptops, telephones, PDAs.
- They are capable of detecting motion in presence/ absence of light almost with same reliability.
- They do not require contact with object to for detection.
- There is no leakage of data due to beam directionality IR radiation.
- They are not affected by corrosion or oxidation.
- They have very strong noise immunity.

Disadvantages of Infrared Sensor

- Required Line of sight.
- Get blocked by common objects.
- Limited range.
- Can be affected by Environmental conditions such as rain, fog, dust, pollution.
- Transmission Data rate is slow.

Passive Infrared Sensor (PIR)

Passive infrared **sensors** are basically Infrared detectors. Passive infrared sensors do not use any infrared source and detector. They are of two types: quantum and thermal. Thermal infrared sensors use infrared energy as the source of heat. **Thermocouples**, pyroelectric detectors and bolometers are the common types of thermal infrared detectors. Quantum type infrared sensors offer higher detection performance. It is faster than thermal type infrared detectors. The photo sensitivity of quantum type detectors is wavelength dependent.

PIR Sensor

All living objects, whose body temperature is more than 0^{o}C, emit the heat in form of infrared radiation through their body, also called as thermal radiations. This Radiated energy is invisible to human eye. These Signals can be detected by using PIR sensor which is specially designed for such purpose. (Fig: **Grid eye illusion)**

- In Passive Infrared (PIR) Sensor, passive word indicates PIR Sensor does not generate or radiate any energy for detection purposes.
- PIR Sensors don't detect or measure "**HEAT**"; they detect the infrared radiation emitted or reflected from objects.
- They are small, inexpensive, low power and easy to use. They are commonly found at home, medical, factories etc. areas.

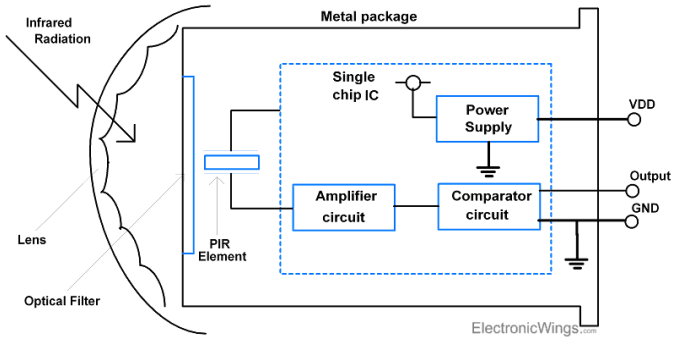
PIR Sensor Working (PIR Sensor Blocks)

PIR Element

PIRs are basically made of a pyroelectric sensor, which can detect levels of infrared radiation.

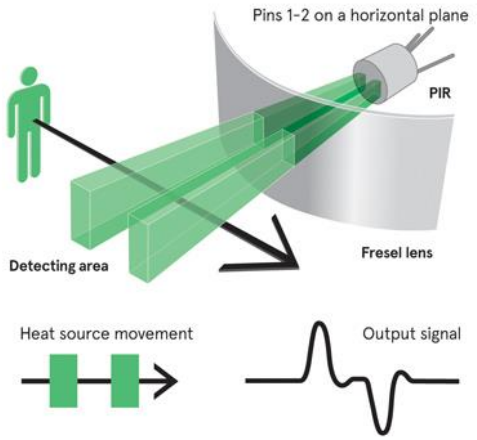
Above figure of PIR element shows the round metal can with a rectangular crystal in the centre.

Every object emits some low-level radiation, and the hotter objects emits more radiations.



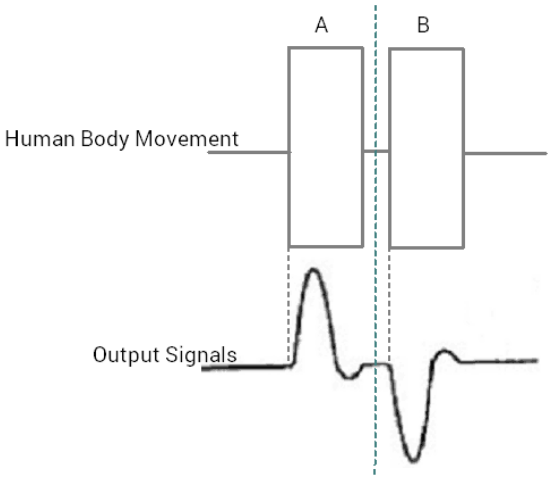
In a typical PIR motion sensor there are two rectangular windows that allow IR to penetrate. Behind each window is a sensor with electrodes attached in such a way that one sensor provides a positive output signal and the other a negative output signal. If no object is detected, both sensors receive the same amount of infrared radiation and their signals cancel out. But if a warm body passes into the view of one of the detection sources, its value deviates from its paired sensor, causing the sensor electronics to register change in output.

A Fresnel lens in front of the window area can be used to increase the sensing range of the sensor and detection angles and detection patterns to be matched to the requirements of the respective application



Object in Motion

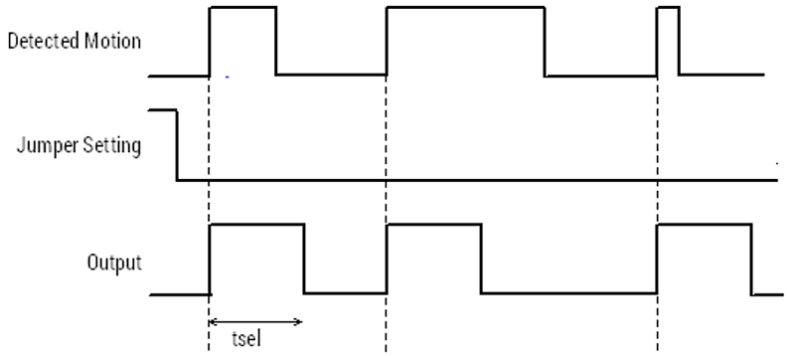
- When any warm object passes in front of the sensor, it intercepts one slot of the PIR sensor. This causes a positive differential change between the two slots. This change is indicated by Part A in below figure.
- When the warm body leaves the sensing area, the sensor generates negative differential change. This change is indicated by Part B in below figure.
- Both these changes in pulse are the detection of warm body which radiate infrared signals.



Modes of Operations

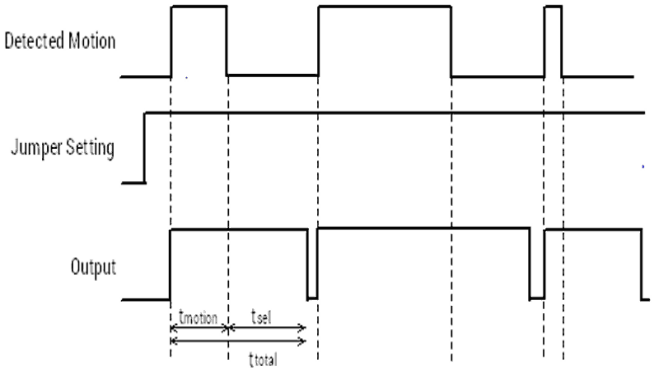
This sensor has two modes of operations:

Single trigger mode



- To select Single Trigger mode, the jumper setting on PIR sensor must be set on LOW.
- In case of Single Triggered Mode, Output goes HIGH when motion is detected.
- After specific delay (tsel) the output goes to LOW even if the object is in motion.
- The output is LOW for some time and again goes HIGH if object remains in motion.
- This delay (tsel) is provided by user using the potentiometer. This potentiometer is on board of PIR sensor module.
- In this way, the PIR sensor gives HIGH/LOW pulses if object is in continuous motion(Fig Differential changes between the slots)

Repeat trigger mode (Fig: Repeat trigger mode timing diagram)

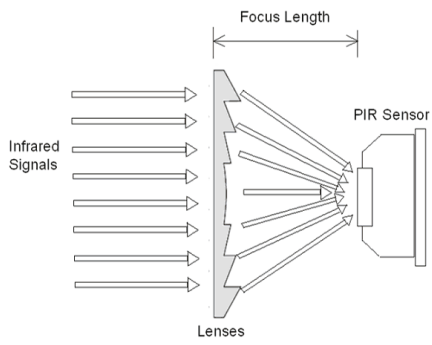


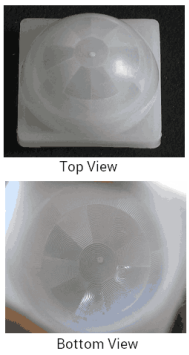
- To select Repeat Trigger mode, the jumper setting on PIR sensor must be set on HIGH.
- In case of Repeat Triggered Mode, Output goes HIGH when motion is detected.
- The output of PIR sensor is HIGH until the object is in motion.
- When object stops motion, or disappears from the sensor area, the PIR continues its HIGH state up to some specified delay (tsel).
- We can provide this delay (tsel) by adjusting the potentiometer. This potentiometer is on board of PIR sensor module.
- In this way, the PIR sensor gives HIGH pulse if object is in continuous motion.

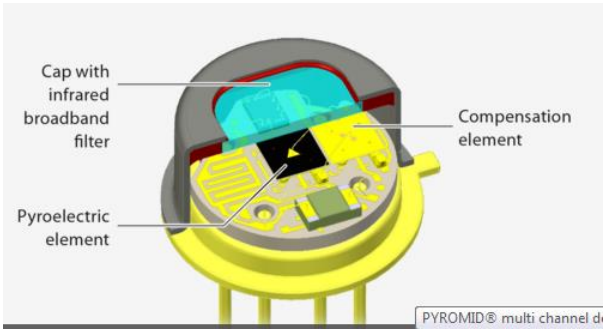
Changing Sensitivity and Delay time

- There are two potentiometers on PIR motion sensors board: Sensitivity Adjust and Time delay adjust.
- It is possible to make PIR more sensitive or Non-Sensitive Enough. The maximum sensitivity can be achieved up to 6 meters.
- Time Delay Adjust potentiometer is used to adjust the timetsel shown in above timing diagrams.
- Clockwise Movement makes PIR more Sensitive.

Lenses(PIR Detector with Fresnel Lenses)







Temperature sensor

Temperature Sensors measure the amount of heat energy or even coldness that is generated by an object or system, allowing us to "sense" or detect any physical change to that temperature producing either an analogue or digital output.

There are many different types of **Temperature Sensor** available and all have different characteristics depending upon their actual application. A temperature sensor consists of two basic physical types:

- **Contact Temperature Sensor Types** – These types of temperature sensor are required to be in physical contact with the object being sensed and use conduction to monitor changes in temperature. They can be used to detect solids, liquids or gases over a wide range of temperatures.
- **Non-contact Temperature Sensor Types** – These types of temperature sensor use convection and radiation to monitor changes in temperature. They can be used to detect liquids and gases that emit radiant energy as heat rises and cold settles to the bottom in convection currents or detect the radiant energy being transmitted from an object in the form of infra-red radiation (the sun).

The two basic types of contact or even non-contact temperature sensors can also be sub-divided into the following three groups of sensors, *Electro-mechanical*, *Resistive* and *Electronic* and all three types are discussed below.

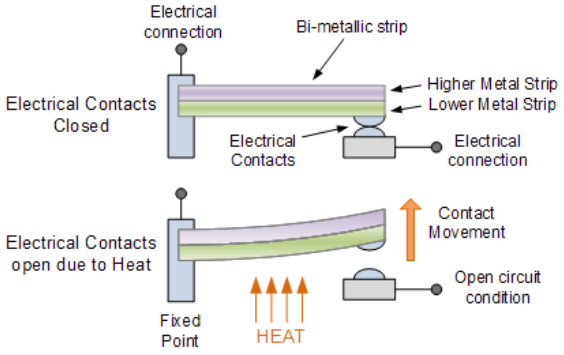
The Thermostat

The **Thermostat** is a contact type electro-mechanical temperature sensor or switch, that basically consists of two different metals such as nickel, copper, tungsten or aluminium etc, that are bonded together to form a **Bi-metallic strip**. The different linear expansion rates of the two dissimilar metals produces a mechanical bending movement when the strip is subjected to heat.

The bi-metallic strip can be used itself as an electrical switch or as a mechanical way of operating an electrical switch in thermostatic controls and are used extensively to control hot water heating elements in boilers, furnaces, hot water storage tanks as well as in vehicle radiator cooling systems.

The Bi-metallic Thermostat

The thermostat consists of two thermally different metals stuck together back to back. When it is cold the contacts are closed and current passes through the thermostat. When it gets hot, one metal expands more than the other and the bonded bi-metallic strip bends up (or down) opening the contacts preventing the current from flowing.



There are two main types of bi-metallic strips based mainly upon their movement when subjected to temperature changes. There are the "snap-action" types that produce an instantaneous "ON/OFF" or "OFF/ON" type action on the electrical contacts at a set temperature point, and the slower "creep-action" types that gradually change their position as the temperature changes.

Snap-action type thermostats are commonly used in our homes for controlling the temperature set point of ovens, irons, immersion hot water tanks and they can also be found on walls to control the domestic heating system.

Creeper types generally consist of a bi-metallic coil or spiral that slowly unwinds or coils-up as the temperature changes. Generally, creeper type bi-metallic strips are more sensitive to temperature changes than the standard snap ON/OFF types as the strip is longer and thinner making them ideal for use in temperature gauges and dials etc.

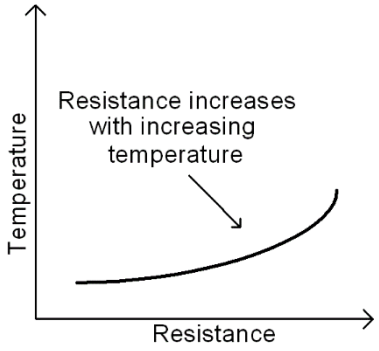
Thermistor

A thermistor is a type of resistor whose resistance is strongly dependent on temperature, more so than in standard resistors. The word is a combination of thermal and resistor

- Thermistor is short form of thermal resistor, whose resistance changes with change in temperature.
- Thermistors are inexpensive, rugged, reliable and responds quickly. Because of these qualities thermistors are used for simple low temperature measurements, but not for high temperatures.
- Thermistors are mostly used in digital thermometers and home appliances such as refrigerator, ovens, and so on.
- Thermistors are available in different shapes like rod, disc, bead, washer, etc.
- Thermistor differs from RTD. In Thermistor, semiconductor materials are used while RTD has pure metals.

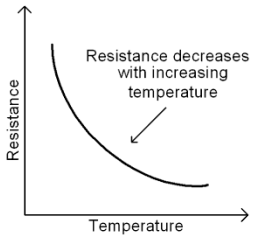
Positive temperature coefficient (PTC) type thermistor

In positive temperature coefficient thermistor, resistance of thermistor increases with increase in temperature.



- PTC thermistor are divided into two groups based on
  1. Material used
  2. Their structure and manufacturing process
- In first group, thermistor comprises of silistors, which use silicon as the semi conductive material. They are used as PTC temperature sensors for their linear characteristic.
- The second group is the switching type PTC thermistor. This type of PTC thermistor is widely used in PTC heaters, sensors etc.
- PTC thermistors are mostly used as self-regulating heaters, for overcurrent protection, etc.

Negative Temperature coefficient(NTC) type thermistor:



- In negative temperature coefficient thermistor, resistance decreases with increase in temperature.
- NTC thermistor are made from semiconductor material (such as metal oxide and ceramic)
- Most NTC thermistor sensors are typically suitable for temperature range between -55°C to +150°C
- Generally, NTC thermistors are used for temperature measurement.

Resistive Temperature Detectors (RTD).

Another type of electrical resistance temperature sensor is the **Resistance Temperature Detector** or **RTD**. RTD's are precision temperature sensors made from high-purity conducting metals such as platinum, copper or nickel wound into a coil and whose electrical resistance changes as a function of temperature, similar to that of the thermistor. Also available are thin-film RTD's. These devices have a thin film of platinum paste is deposited onto a white ceramic substrate.

Resistive temperature detectors have positive temperature coefficients (PTC) but unlike the thermistor their output is extremely linear producing very accurate measurements of temperature.

However, they have very poor thermal sensitivity, that is a change in temperature only produces a very small output change for example, 1Ω/°C.

The more common types of RTD's are made from platinum and are called **Platinum Resistance Thermometer** or **PRT**'s with the most commonly available of them all the Pt100 sensor, which has a standard resistance value of 100Ω at 0°C. The downside is that Platinum is expensive and one of the main disadvantages of this type of device is its cost.

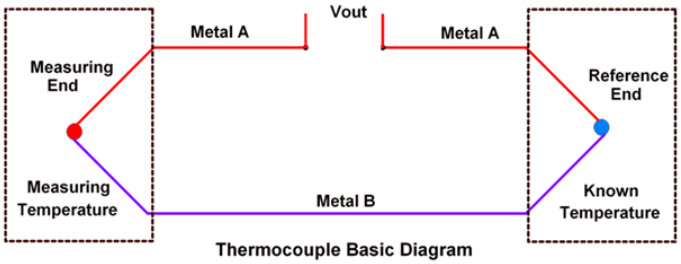
Like the thermistor, RTD's are passive resistive devices and by passing a constant current through the temperature sensor it is possible to obtain an output voltage that increases linearly with temperature. A

typical RTD has a base resistance of about 100Ω at 0°C, increasing to about 140Ω at 100°C with an operating temperature range of between -200 to +600°C.

Because the RTD is a resistive device, we need to pass a current through them and monitor the resulting voltage. However, any variation in resistance due to self heat of the resistive wires as the current flows through it, I^2R , (Ohms Law) causes an error in the readings. To avoid this, the RTD is usually connected into a Wheatstone Bridge network which has additional connecting wires for lead-compensation and/or connection to a constant current source.

Thermocouple

- A thermocouple measures the difference in potential across a hot and cold end for two dissimilar materials. This potential difference is proportional to the temperature difference between the hot and cold ends
- Thermocouple is made by two different metal wires (thermoelements) joined at one end called measuring end (also called as junction end). Another end is either joined or not joined, called as reference end of which temperature is known.

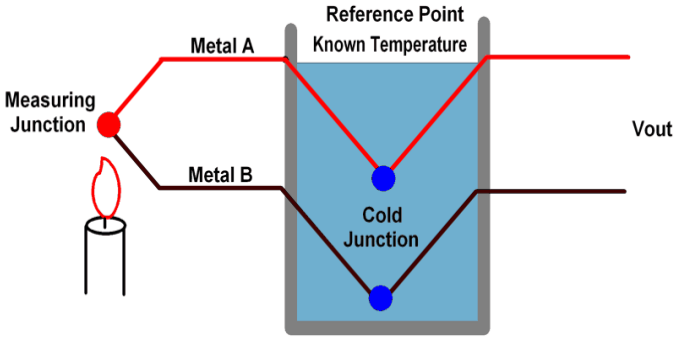


Thermocouple Basic Diagram

- The temperature difference between these two ends produce voltage difference and this voltage is used to measure the temperature.
- Generally, thermocouples are used for measuring temperature over large range i.e. -270 to 3000 degree Celsius.
- Thermocouples are widely used in industries, which includes measuring temperature of burner, diesel engines, furnace etc.

Working Principle

- Thermocouples consist of two dissimilar metals (wires), metal A and metal B. These metals are joined at an end called as measuring junction, while the other end is called as reference point as shown in above figure.



- Note that measuring Junction point is used to measure the temperature. The reference point in figure is a known temperature.
- As per Seebeck effect, thermoelectric voltage is generated which is proportional to the temperature difference between two junctions. This voltage can be measured at reference point.
- The Seebeck effect states that when two different or unlike metals are joined together at two junctions, an electromotive force (EMF) is generated at the two junctions

Advantages

- It is simple and rugged in construction
- It can measure wide range of temperatures up to 2600°C
- Fast Response
- Inexpensive
- Calibration can be checked easily

Limitations

- It is least stable and least repeatable.
- It requires cold junction compensation for accurate temperature measurement.
- The emf induced verses temperature characteristics is non linear.
- Lowest accuracy.

Application

- Thermocouple is extensively used in steel processing, turbine and diesel engine for temperature measurement
- It is used in gas feed heat appliances such as ovens and water heaters.
- It is used in power production.
- A thermocouple can be used as a vacuum gauge over the range of approximately 0.001 to 1 torr absolute pressure
- Thermoelectric cooling
- Medical equipment and Packaging equipment

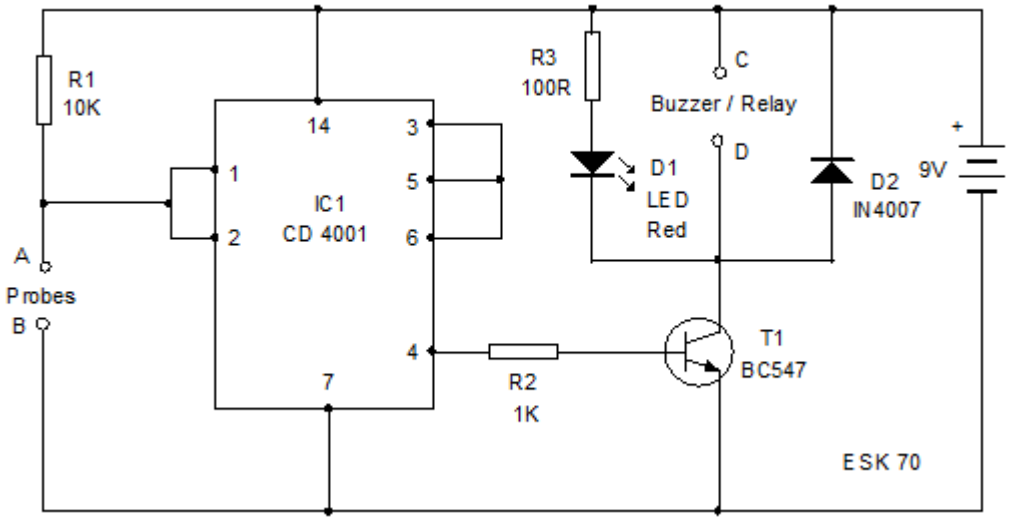
Water controller sensor

A common type of liquid level sensor is known as a conductive sensor. Only liquids which conduct electricity can be used in this liquid level sensor. A conductive sensor includes a source of power, usually of a low voltage. At least two electrodes are placed within the container. When a conductive liquid reaches a certain point, it will come into contact with both a longer and a shorter electrode, and thus completed a circuit and activate an internal switch.

Here a simple circuit to control the Water pumps. When the water level in the overhead tank exceeds the required level, the pump automatically turns off and stops the pumping process thus preventing the over flow of water. It uses a relay to cut off the power supply to the water pump.

The circuit is build using the following components:

- **CMOS IC CD4001**: It is a versatile 14 pin IC which contains 4 NOR gates. Each NOR gate has two inputs and one output. Thus the IC has 8 input pins and 4 output pins, one Vcc pin (connected to positive voltage supply) and one Vss (connected to negative supply). Its basic features include – Maximum supply voltage: 15V, Minimum supply voltage: 3V, Maximum speed of operation: 4MHz. It can be used in tone generators, metal detectors etc.
- **Transistor BC547**: It is a NPN bipolar junction transistor and it is used mainly for amplification and switching purpose. Its features include maximum current gain of 800.It is used in CE configuration when used as an amplifier.
- **Battery**: A DC supply of 9V is given through a battery to power up the circuit.



The circuit uses a CMOS IC CD 4001 / 4011 to drive the relay. Its input gate 1 is used to connect the probe to detect the water level. One probe is connected to the gate 1 of the IC and the other probe to the ground. When the probe A connected to the gate 1 of IC is floating, the input of gate 1 remains high and the output pin 4 goes high and the relay driver transistor conducts. The relay will be activated. The power supply of the water pump is connected through the common and the NO contacts of the relay so that when the relay turns on, water pump works. LED indicates the working of the relay. When the water level rises and makes contact with the probes A and B, output of IC turns low and the relay de-energizes to stop the pumping.

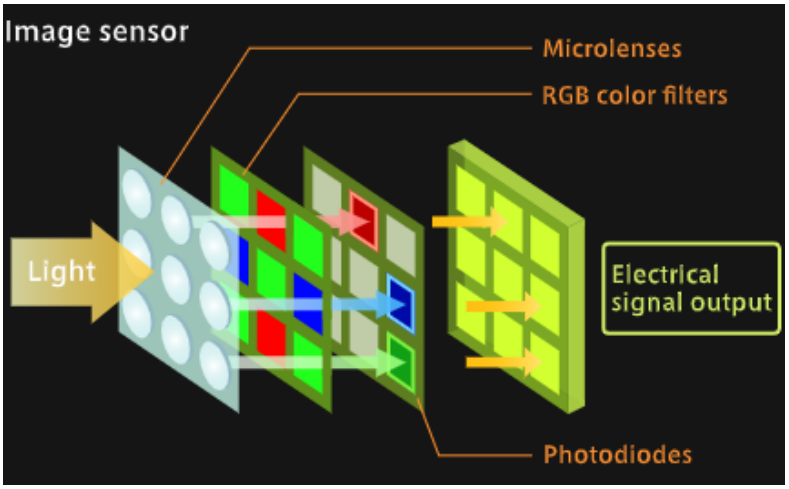
Initially when A and B are not conducted, i.e. water level is low, the input pin1 of the IC is at logic high and according to NOR gate truth table, the output at pin3 will be at logic low. Since pin3 is shorted to pins 5 and 6, hence the input to other NOR gate will be logic low signals. This gives a logic high signal to the corresponding output pin 4. As current flows through the resistor to the base of transistor, it starts conducting and acts as a closed switch. The relay connected to the collector of the transistor gets energized and the NO contacts get connected to the common contact and the water pump gets power supply from the mains and starts working.

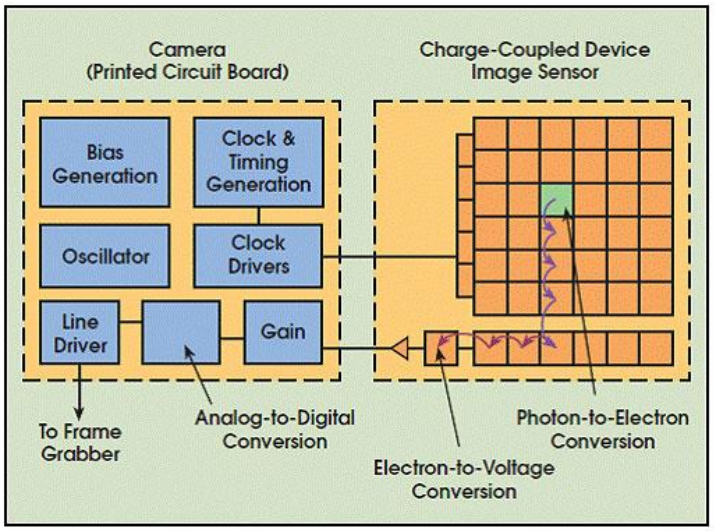
Now when water level rises in the tank rises such that probes A and B are connected through water, current flows through them (As water is a conductor) and the pins 1 and 2 are connected through A and B to the negative supply of the battery.

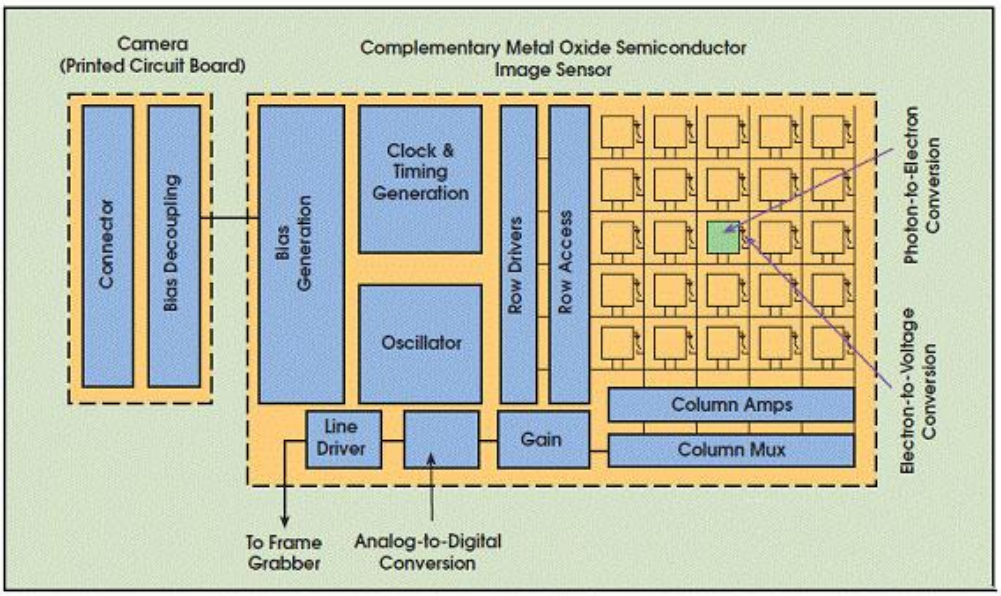
The output pin3 is thus, at logic high level, causing the input pins of the other NOR gate to be at logic high level and thus the corresponding output pin4 is at logic low level. The transistor gets cutoff due to lack of bias current and the relay gets correspondingly de-energized and the power supply to the water tank gets cut off.

Image sensor

The image sensors used in an digital camera can be either a Charge Coupled Device (CCD) or a Complementary Metal Oxide Semi-conductor (CMOS). The image sensor is basically a micro-chip with a width of about 10mm. The chip consists of arrays of sensors, which can convert the light into electrical charges. Though both CMOS and CCD are very common, CMOS chips are known to be cheaper. But for higher pixel range and costly cameras mostly CCD technology is used.







A charge-coupled device (CCD) image sensor has an array of capacitors, each carrying an electric charge corresponding to the light intensity of a pixel. A control circuit causes each capacitor to transfer its contents to its neighbor, and the last capacitor in the array dumps its charge into a charge amplifier. The bucket-brigade style of data transfer is characteristic of CCD sensors.

In contrast, a complementary metal oxide semiconductor (CMOS) image sensor has a photodiode and a CMOS transistor switch for each pixel, allowing the pixel signals to be amplified individually. By operating the matrix of switches, the pixel signals can be accessed directly and sequentially, and at a much higher speed than a CCD sensor. Having an amplifier for each pixel also gives another advantage: it reduces the noise that occurs when reading the electrical signals converted from captured light.

CMOS image sensors cost less to produce than CCD image sensors, because existing semiconductor manufacturing equipment can be repurposed for their production. Unlike CCD sensors that use high-voltage analog circuits, CMOS sensors employ a smaller digital circuitry that uses less power and are in principle free from smear (vertical white streak in the image taken under bright light) and blooming (corruption of images such as white spots). Since a logic circuitry can be built into the chip during the manufacturing process, CMOS sensors with an on-chip image processing circuit are being developed for such applications as image recognition and artificial vision, and some devices are already being put to practical use.

UNIT IV: Home Appliances - Home Enablement Systems: RFID Home, Lighting control, Automatic Cleaning Robots, Washing Machines, Kitchen Electronics- Microwave, Dishwasher, Induction Stoves, Smart Refrigerators, Smart alarms, Smart toilet, Smart floor, Smart locks.

RFID

RFID System is an abbreviation of Radio Frequency Identification System. It is an "Identification system using wireless communication" that enables transferring data between "RF Tags (or Data Carriers)" that are held by men or attached to objects and "Antenna (or Reader/Writers)". It is a kind of radio communication system.

The RFID systems consists of RFID Reader and a tag which is normally used in identification and tracking of objects. Today in most cases barcodes are used for identifying an item in a warehouse or a supermarket using a barcode scanner, this existing system can be upgraded with the RFID technology. Similar to barcode the RFID can also give unique identification number to all products but the added advantage is unlike the barcode system's line of sight, this system can detect the RFID tag within its proximity range.

Classification

According to the availability of power, RFID is divided into Passive and Active.
1) Passive Tag: the Passive sensor itself does not have a power supply. Its power supply is generated by a sensor that activated by emitting frequency from Reader, where the data is finally transmitted back to. The Passive Tag is thin and short and has a long service life, but the sensing distance is relative short.

2) Active Tag: the price is relatively high, volume is larger than Passive tag because of built-in battery. It has longer service life and longer sensing distance.

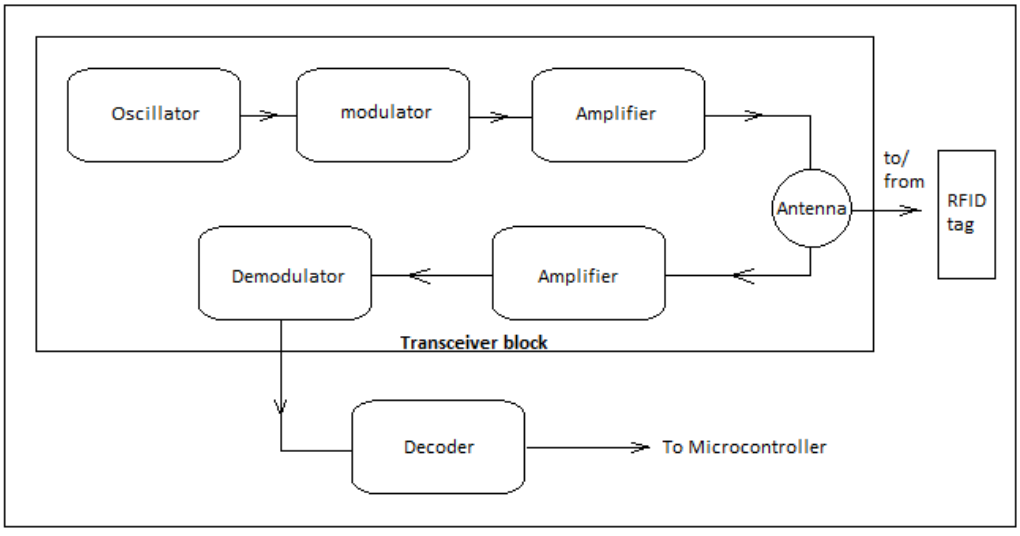
According to the frequency, RFID can be divided into three types: LF, HF and UF:
1) **Low Frequency RFID (100~500KHz):** low frequency RFID has shorter inductive distance; the reading speed is slower. low frequency RFID of 125KHz is commonly used, whose penetration ability is good.

2) **High Frequency RFID (10~15MHz):** high frequency RFID has longer sensing distance; the reading speed is relatively high. High frequency RFID of 13.56MHz is the mainly used.

3) **Ultra High Frequency RFID (850~950MHz~2.45GHz)** : Ultra High Frequency RFID has the longest sensing distance and fastest reading speed, but penetration ability is bad.

RFID System Construction

Any RFID System will consist of a RFID reader and a RFID tag. The tag will often be small and portable with little to no electronics in it.



RFID Reader

It is a device which consists of an antenna, transceiver and a decoder.

- **Transceiver**: It can be used either as a

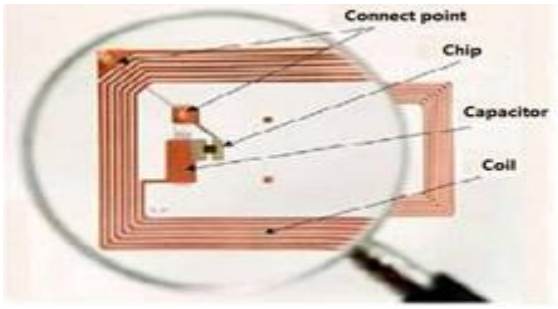
transmitter or a receiver. It consists of an oscillator to generate a continuous signal which is modulated to a required frequency and then transmitted into air through an antenna.

- **Antenna**: It is a device which converts the electrical signal into electromagnetic signal which is efficient in propagating the signal in air.
- **Decoder**: When a RF signal is detected at the antenna from a tag, the decoder helps in retrieving the data

RFID Tag

Electronic Tag also known as the transponder or Smart Label, is a miniature wireless transceiver consisting mainly of built-in antennas and chips.

- **Microchip:** It is a semiconductor device which consists of a circuit etched in it with some KB of memory storage, capable of storing data and transmitting it whenever needed.
- **Antenna**: It is used to transmit the data that is present in the chip into air so that it can be detected by a reader.



Incase of an active tag it consists of Microchip, battery and an antenna

- **Battery**: In active devices in order to power up the microchip battery is externally used

Controller

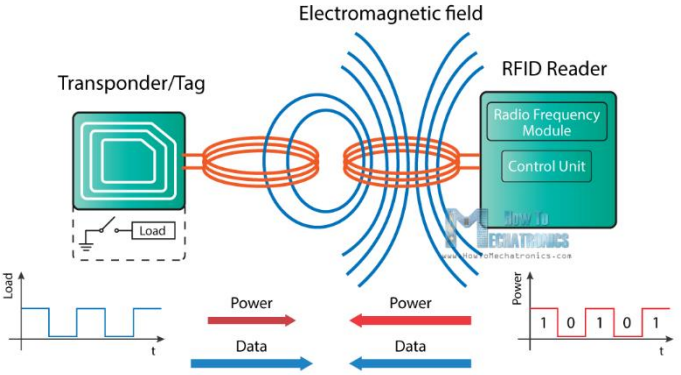
Controller is the command center for the orderly operation of the reader chip. Its main functions:

- Communicate with application system software.
- Execute the action instructions sent from the application system software.
- Control the communication process with the tag.
- Encoding and decoding of baseband signals.
- Implement anti-collision algorithm.
- Encrypting and decrypting data transmitted between the reader and the tag.
- Implement identity authentication between the reader and the electronic tag.
- Control of other external devices such as keyboards and display devices.
- Control's operation of the reader chip (the most important).

Working principle

A RFID reader stays powered on all the time and is normally powered from an external power source. So when it is ON, the oscillator in it generates a signal with a desired frequency but as the signal strength will be very less (which may lead to fading off the signal if it is transmitted directly) it has to be amplified which can be done using an amplifier circuit, in order to propagate the signal to a longer distance we need to modulate the signal which is done by a modulator.

The RFID reader signals are everywhere with its proximity to detect a tag. When a RFID tag comes in the proximity of the RFID reader the tag detects the readers signal through a coil present in it which converts the received RF signal into a electrical signal. This converted signal alone is sufficient to power up the microchip present in the



tag. Once the microchip gets powered up, its function is to send the data (unique ID) which it is stored in it. The same way the signal came in, it is sent out through the same coil into the air.

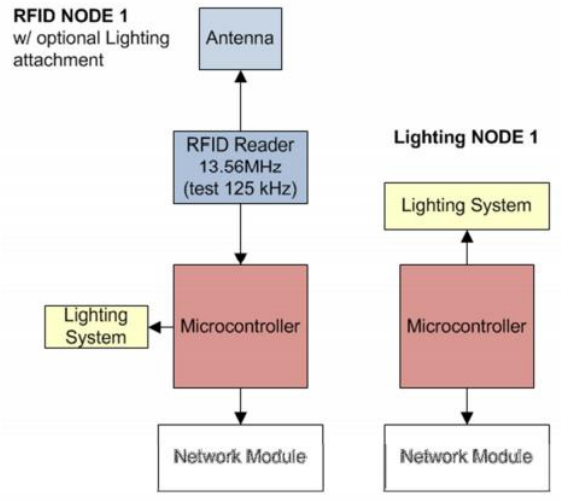
As discussed earlier the RFID reader also has a transceiver in it. When the signal comes back from the tag through the antenna of RFID reader it is fed to the demodulator and then decoded by a decoder where the original data can be obtained and then further processed by a microcontroller or a microprocessor to perform a specific task.

In case of an active RFID tag it detects the signal from the reader only to trigger the circuit and make the tag ready to send the data to the reader, since active tags have built-in power source.

Advantages:

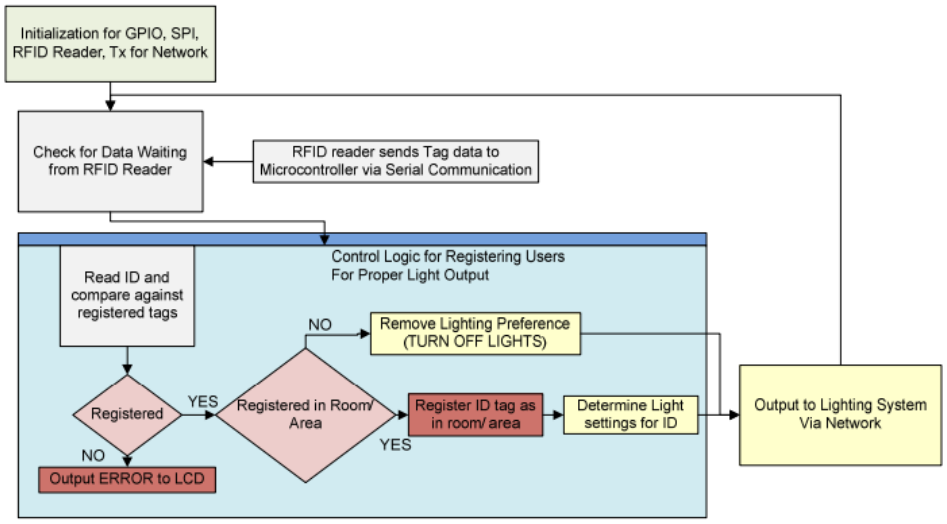
- **Fast scan**: RFID recognizer can read and write multiple RFID tags at the same time, and the reading speed is very fast. The sketch capability of active RFID system can be used for interactive services such as process tracking and maintenance tracking.
- **Miniaturization and variety of shapes**: RFID labels develop into miniaturization and variety for different products. The reading of information is not limited by the size and shape of the chip, and it is not necessary to match the fixed size or printing quality of the paper to read accurately. Moreover, the RFID tags are being miniaturized and diversified to be used in different products.
- **The RFID label is to store the data in the chip**: The RFID chip and the RFID card reader have a strong resistance to water, oil and chemicals, which is not only free from contamination but also easy to preserve.
- **Reusable:** RFID tags repeatedly add, modify, delete the data stored in the RFID volume label, facilitate the update of information.
- **Penetration and unbarrier reading**: RFID technology is more accurate than traditional smart chips, and the distance of recognition is more flexible. It can achieve penetration and non-barrier reading. RFID can penetrate materials such as paper, wood and plastics for penetrating communication. It also can read labels though snow, fog, ice, paint, dirt and other harsh environment like bar code can not be used.
- **Large memory capacity**: The maximum capacity of RFID is several megabytes, which can be recorded in large quantities. And as technology advances, capacity has increased.
- **Safety**: Since RFID carries electronic information, its data content can be protected by passwords, making its content difficult to be forged and altered.

RFID Home- Lighting control

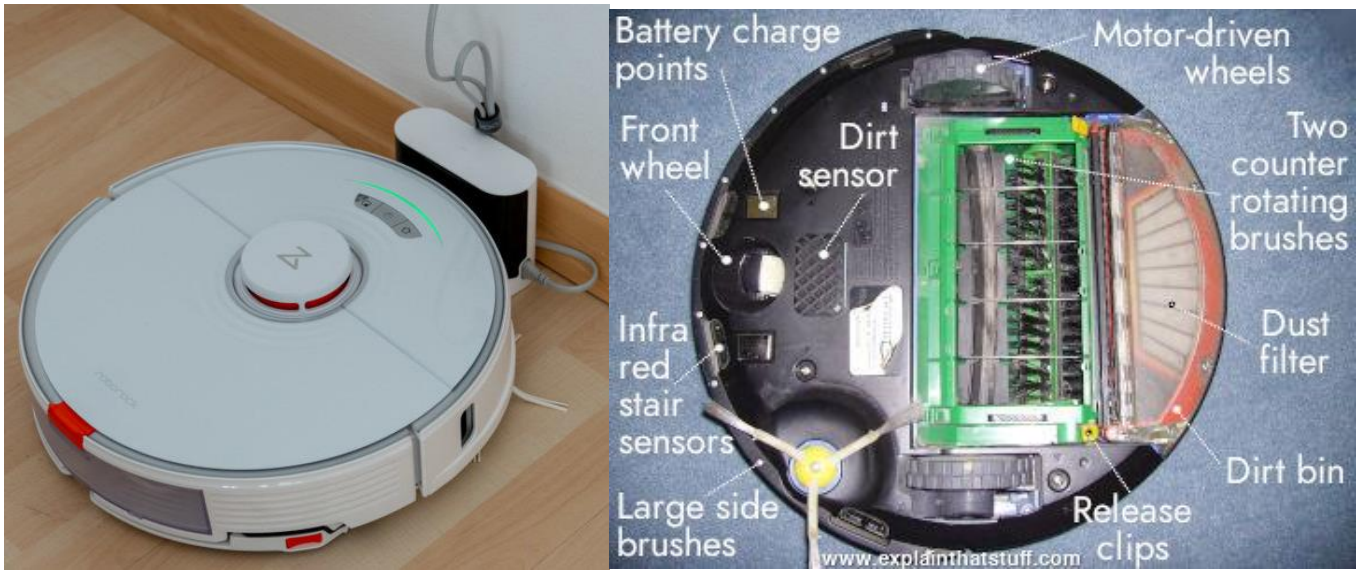


The system uses multiple low power RFID readers with approximately 1-3ft range operating at 13.56 MHz's The lighting nodes use a microcontroller and some form of network connection, this can either be wired or the Xbee wireless microcontroller. The system is capable of using as few as 1-2 RFID nodes and up to several dozen lighting nodes, allowing the system to fit to the application.

The hardware portion of the design includes two components, the RFID nodes and the lighting nodes. Lighting nodes control the high voltage lighting in the environment using solid state relays (SSR), a microcontroller, and the Xbee wireless communicator. The lighting node program remains simple, compared to the complexity of the RFID node, which allows for quick design changes to meet the demands of the application. The node is fully adaptable for connection via wired or wireless network and provides complete control over the light attached to the node.



Automatic Cleaning Robots



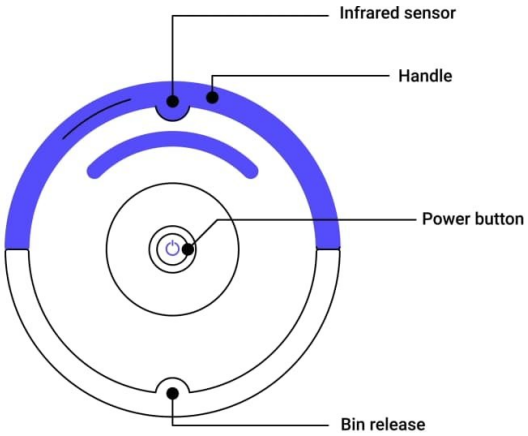
Automatic cleaning robots is a compact, computerized vacuum cleaner that automatically guides itself around the home. There are four main parts: sensors, bump, wheels, and brushes. These parts work in tandem to tackle tile, hardwood floors, carpet, and anything in between

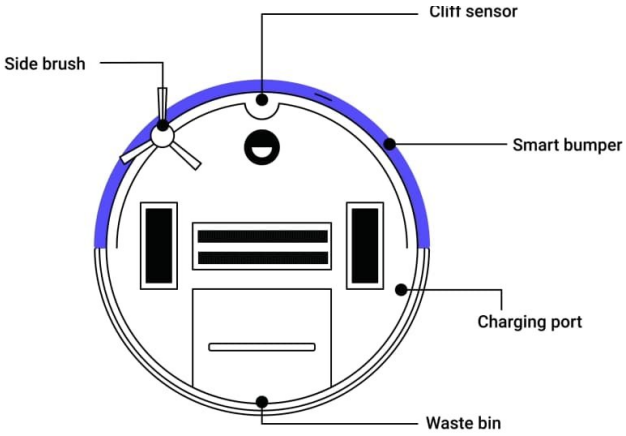
Like a conventional cleaner, it picks up dirt with spinning brushes and a vacuum. There's a side-mounted, flailing brush that pushes dirt underneath the machine and, once there, two more counter-rotating brushes (turning in opposite directions) pick up the dirt and direct it toward the powerful vacuum, which sucks it away into a little storage bin.

The **suction** or vacuum power works just like a regular vacuum. A motor pulls air up from under the vacuum to draw in the dirt. Then the air passes through a filter, and clean air comes out from the output vent in the sides or back of the machine. Most robot vacs have manual cleaning modes that allow you to adjust the suction power from low to high for various floor types and situations, such as edge or spot cleaning. More advanced models have auto-adjusting vacuum power that increases the suction on carpet or heavily soiled areas

Unlike a normal cleaner, cleaning robots moves itself around the room with two large tractor-style wheels, each one independently driven by a separate electric motor. The wheels can turn in opposite directions, which means robots can literally "spin on a dime" and clean almost any space it can drive into. It has numerous onboard sensors to detect

dirt, dodge obstacles, and steer clear of things like tassels on rugs and telephone cords that could cause it problems. When it's finished, it nips back into its "docking" station and recharges itself for next time.





Sensors

- **cliff sensors** – These use infrared light that bounces off objects, sending the signal back to a receiver on the vac. If the signal doesn't bounce back, the receiver assumes a "cliff" such as a staircase is coming up, so it tells the vacuum to back away and head another direction.
- **Object sensors** – These are mechanical sensors, much like a car's airbag sensors, located on the sides of the vacuum. When it bumps into an object, the sensors tell it to back up, rotate, and move in another direction.
- **Wall sensors** – Most vacuums just treat walls as objects. The more advanced models use infrared sensors on the bumper to detect walls so they can follow right up to the edge without bumping against them. These are great for edge and corner cleaning.
- **Dirt sensors** – Not as common, usually only found on the most advanced models. These sensors are located on the bottom of the vacuum near the agitator brush. They're acoustic sensors, so when the brush kicks up a bunch of dirt, it causes a lot of vibration on the sensors' metal plates. This tells the vacuum to either increase the suction or go over that area again

Optical encoders are the most important: these sensors on the wheels of the robot tell it how far it has gone. They are called optical encoders because they use a light sensor to detect how many times the wheels have rotated. From this (and any difference between wheels, which indicates a turn), the robot can figure out how far it has traveled. Different models may include additional sensors (such as a dust scanner to see how much dust is being picked up), but those are the basic sensors that all robotic vacuums include.

Washing Machine

The main principles behind the working of a washing machine are the centrifugal and centripetal forces, Where centrifugation helps quicken the process of sedimentation of different density particles to clean the laundry in the washing machine.

The washing machine operates in two primary cycles. These are the wash cycle and the rinse cycle.

The wash cycle involves the principle of centrifugal force. This force's direction is from inside to outside, which makes sure that every part of the cloth is rinsed adequately in the soap water mixed in the machine.

The rinse cycle involves the principle of centripetal force. This force acts from outside to inside and creates a vacuum-like space in the middle of the washing machine. These two cycles work one after another several time, and as a result, the entire cleaning process occurs.

Push button keyboard enables the desired program to be selected. The microcontroller checks firstly that the safety cut out is in the ON position. The water is then admitted (valve opened) and the water level is constantly monitored. When the required quantity of water has been provided the valve closes.

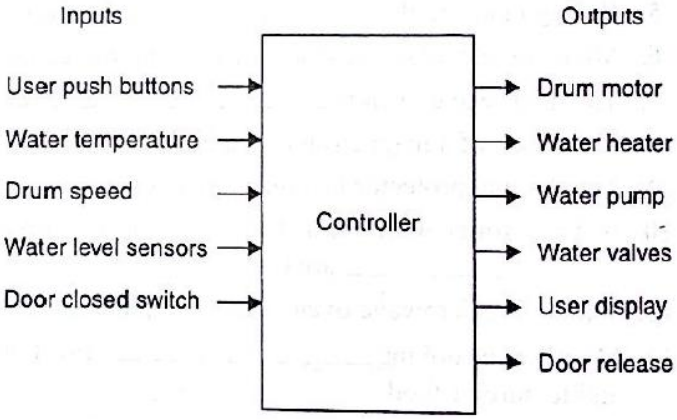


Fig. 51.1 *Inputs and outputs in an electronic washing machine*

The water temperature is measured and the heater is switched until the water reaches the required temperature. In the meantime, the washing powder is admitted from a container and the hardness of water is noted, at the same time the drum motor is switched on so that the dirty washing is evenly moved through the water. After the required time has elapsed. According to the selected programs, the motor is switched to high speed spinning and the suction pump is switched on to move the washing water and the rinsing water to waste. At the end of the washing cycle the machine switches off and provides a signal to indicate this.

Types of washing machines

Three types, namely washer, semi-automatic and automatic. Washers are single tub machines that only wash. Since washers don't have the facilities for drying the clothes, these cost less than semi-automatic and fully automatic machines.

In semi-automatic the controls are not fully automatic and manual intervention is required.

In fully automatic machines, no manual intervention is required during the washing process. For automatic machines, programs have to be selected and set by the user prior to the start of washing cycle.

Sensors sense the wash load and decide the program ideal for washing the clothes, water level time required to wash, number of rinses and spins, type of fabric etc

Washing Machine Hardware

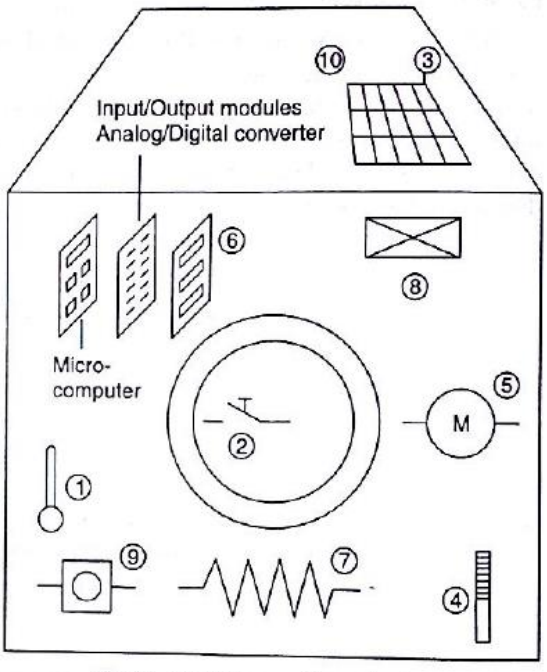
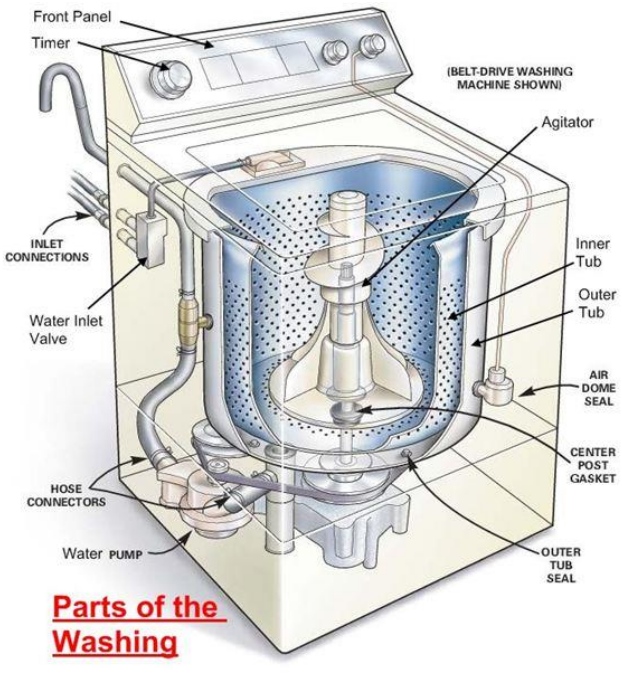


Fig. 51.4 *Washing machine—hardware*



1. Temperature sensor which senses the washing water temperature. (The analog/digital converter changes the analog values to binary numbers).

2. Safety cut-out switch. 3. keyboard for program selection. 4. Water level gauge.

5. Motor for washing drum. 6. Power switches for motor, heater, etc. 7. Heater for washing water.

8. Water inlet valve. 9. Water suction pump.

10. Control lamps and indicators

Water inlet control valve: Near the water inlet point of the washing there is water inlet control valve. When you load the clothes in washing machine, this valve gets opened automatically and it closes automatically depending on the total quantity of the water required. The water control valve is actually the solenoid valve.

Water pump: The water pump circulates water through the washing machine. It works in two directions, re-circulating the water during wash cycle and draining the water during the spin cycle.

Tub: There are two types of tubs in the washing machine: inner and outer. The clothes are loaded in the inner tub, where the clothes are washed, rinsed and dried. The inner tub has small holes for draining the water. The external tub covers the inner tub and supports it during various cycles of clothes washing.

Agitator or rotating disc: The agitator is located inside the tub of the washing machine. It is the important part of the washing machine that actually performs the cleaning operation of the clothes. During the wash cycle the agitator rotates continuously and produces strong rotating currents within the water due to which the clothes also rotate inside the tub. The rotation of the clothes within water containing the detergent enables the removal of the dirt particles from the fabric of the clothes. Thus the agitator produces most important function of rubbing the clothes with each other as well as with water. In some washing machines, instead of the long agitator, there is a disc that contains blades on its upper side. The rotation of the disc and the blades produce strong currents within the water and the rubbing of clothes that helps in removing the dirt from clothes.

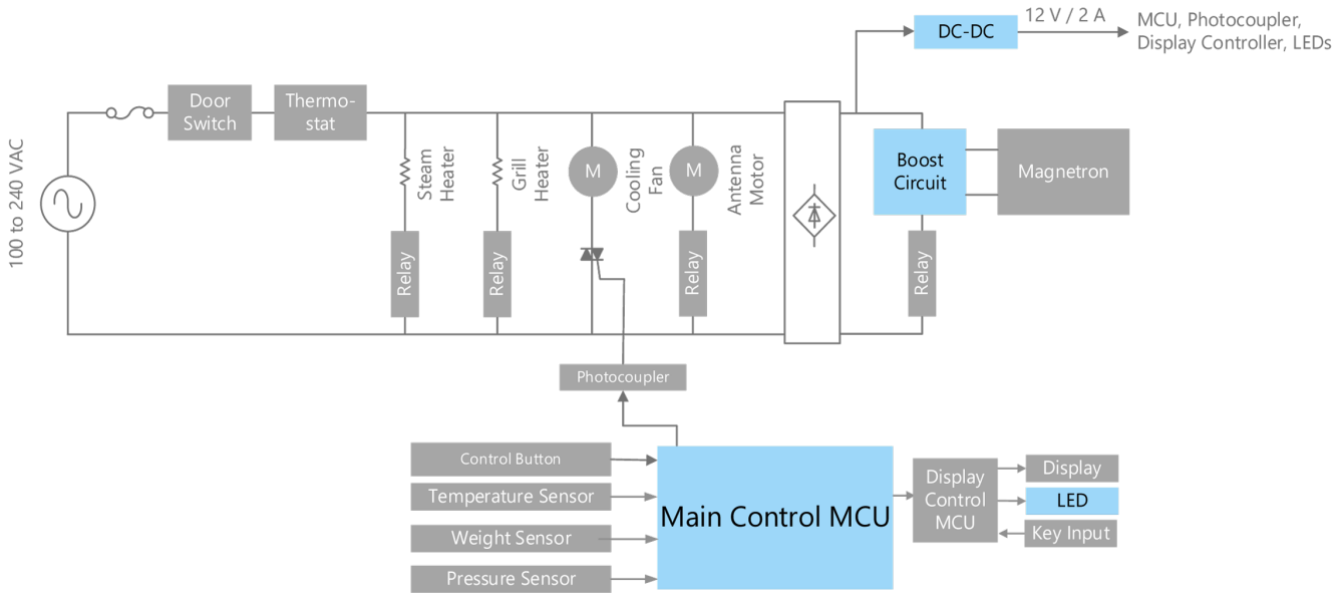
Motor of the washing machine: The motor is coupled to the agitator or the disc and produces it rotator motion. These are multispeed motors, whose speed can be changed as per the requirement. In the fully automatic washing machine the speed of the motor i.e. the agitator changes automatically as per the load on the washing machine.

Timer: The timer helps setting the wash time for the clothes manually. In the automatic mode the time is set automatically depending upon the number of clothes inside the washing machine.

Printed circuit board (PCB): The PCB comprises of the various electronic components and circuits, which are programmed to perform in unique ways depending on the load conditions (the condition and the amount of clothes loaded in the washing machine). They are sort of artificial intelligence devices that sense the various external conditions and take the decisions accordingly. These are also called as fuzzy logic systems. Thus the PCB will calculate the total weight of the clothes, and find out the quantity of water and detergent required, and the total time required for washing the clothes. Then they will decide the time required for washing and rinsing.

Drain pipe: The drain pipe enables removing the dirty water from the washing that has been used for the washing purpose

Microwave oven



Microwave ovens work on the principle of conversion of electromagnetic energy into thermal energy

Traditional cooking methods suggest heat input to the food surface. Further heat is distributed inside due to heat conduction. The heating food process in a microwave oven differs fundamentally. In this case, heat is generated inside the food using water molecules.

Therefore, the rate of volumetric heating by microwaves is significantly higher. The microwave radiation does not cause chemical changes in food and preserves from 75 to 98 % of the vitamins in food. For comparison, conventional heat treatment ensures the preservation of only 35-60%.

Main Components of Microwave Oven

High Voltage Transformer: Unlike many other household appliances, the microwave oven requires more power than the normal voltage that the home's electrical wiring carries. To accomplish this, a step-up transformer with a high-voltage output is placed inside the oven. The 240V supply is jumped to a few thousand volts, which is then fed to the cavity magnetron

Cavity Magnetron: A cavity magnetron is a high-powered vacuum tube that transforms the electrical energy into long-range microwave radiations, and hence it is the most important component of a microwave oven.

Micro-controller: A microcontroller is something that enables communication between a user and a machine. It is a controlling unit that contains one or more processing cores along with memory and programmable input/output peripherals. It processes the instructions that a user gives to the microwave oven and also displays them on a seven-segment display or a LED screen, depending on the model of the oven.

Wave Guide: As the name suggests, a waveguide is a hollow metallic tube that guides the waves generated at the magnetron's output toward the cavity (the place where we place the food).

Cooling Fan: Cooling fans reduce the magnetron's operating temperature and ensure its efficacy and longevity.

Working Mechanism

The microwaves penetrate through the surface of the food and reach the water molecules present inside it. As the orientation of the electric field changes over time, the polar molecules of water attempt to follow the field by changing their orientation inside the material to line up along the field lines in an energetically favourable configuration (namely, with the positive side pointing in the same direction as the field lines). As these molecules change direction rapidly (millions of times per second at least), they gain energy, which increases the temperature of the material. This process is called dielectric heating.

Advantages

- The volumetric heating process of microwaves is their most prominent characteristic. In the conventional cooking method, the heat must spread inwards from the surface of the food item, whereas the spread of heat in the case of microwave oven is done in a controlled manner with the help of the microwaves.
- It's a quick and convenient method of heating food and leftovers.
- Since microwaves can only interact with polar substances like water, they cannot affect the nutritional value of those ingredients that are non-polar. Other conventional cooking methods, however, may destroy some polar as well as non-polar ingredients during the process.
- The user interface and micro-controller facilitate precise control over the cooking temperature.
- The ease of the cooking process in a microwave oven also results in easier cleaning of the equipment after use

Disadvantages

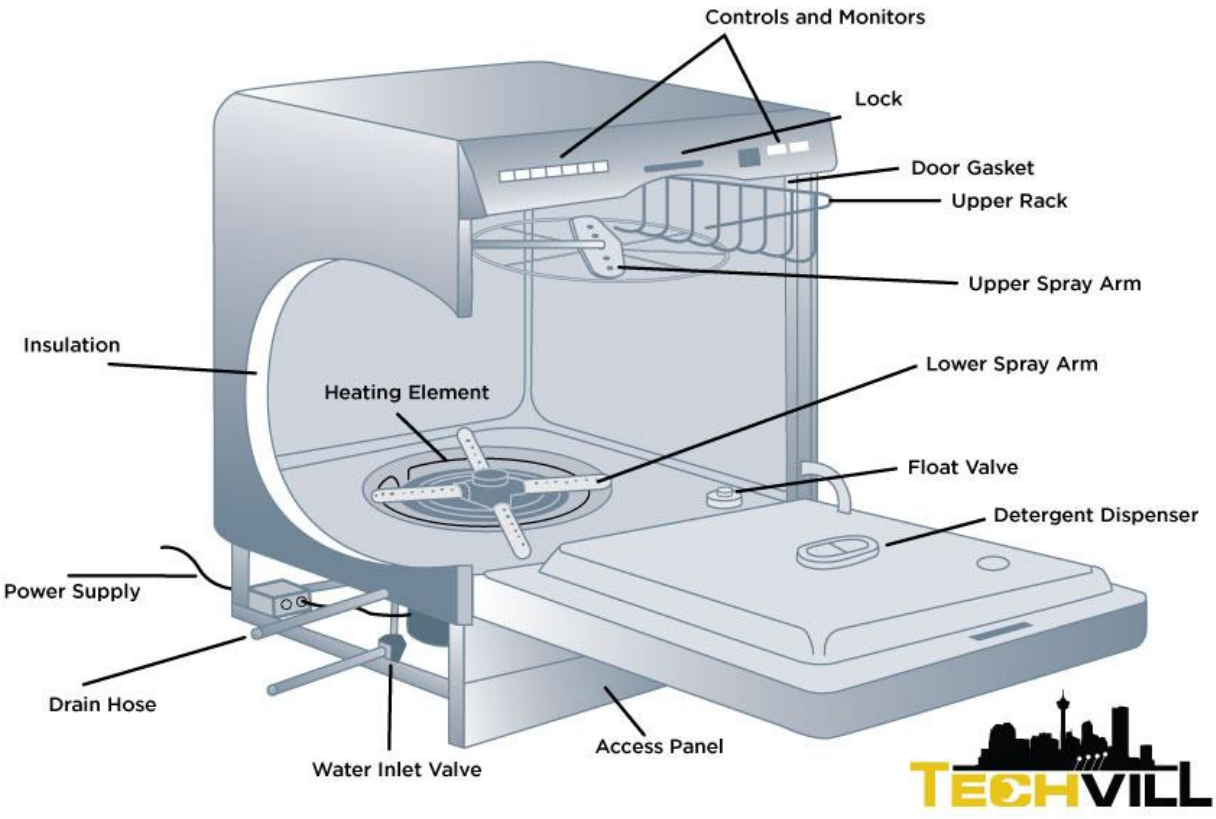
- It is important to take care of what kind of utensils are being used in a microwave. A dish that is not microwave-safe will set off a chemical reaction between the food and the container.
- The cost of equipment is high in comparison to other conventional cooking methods.
- Microwave leakage may lead to electromagnetic interference with other electrical equipment present in the surrounding vicinity. The pacemakers installed in some patients are particularly vulnerable to such radiation leakage.
- Microwave radiation can heat body tissue the same way it heats food. Exposure to high levels of microwaves can cause a painful burn. In particular, the eyes and the testes are vulnerable to microwave heating because there is relatively little blood flow in them to carry away excess heat.
- Another disadvantage of microwaves is that they have limited capacity and because of this, they are not the best option for large families.

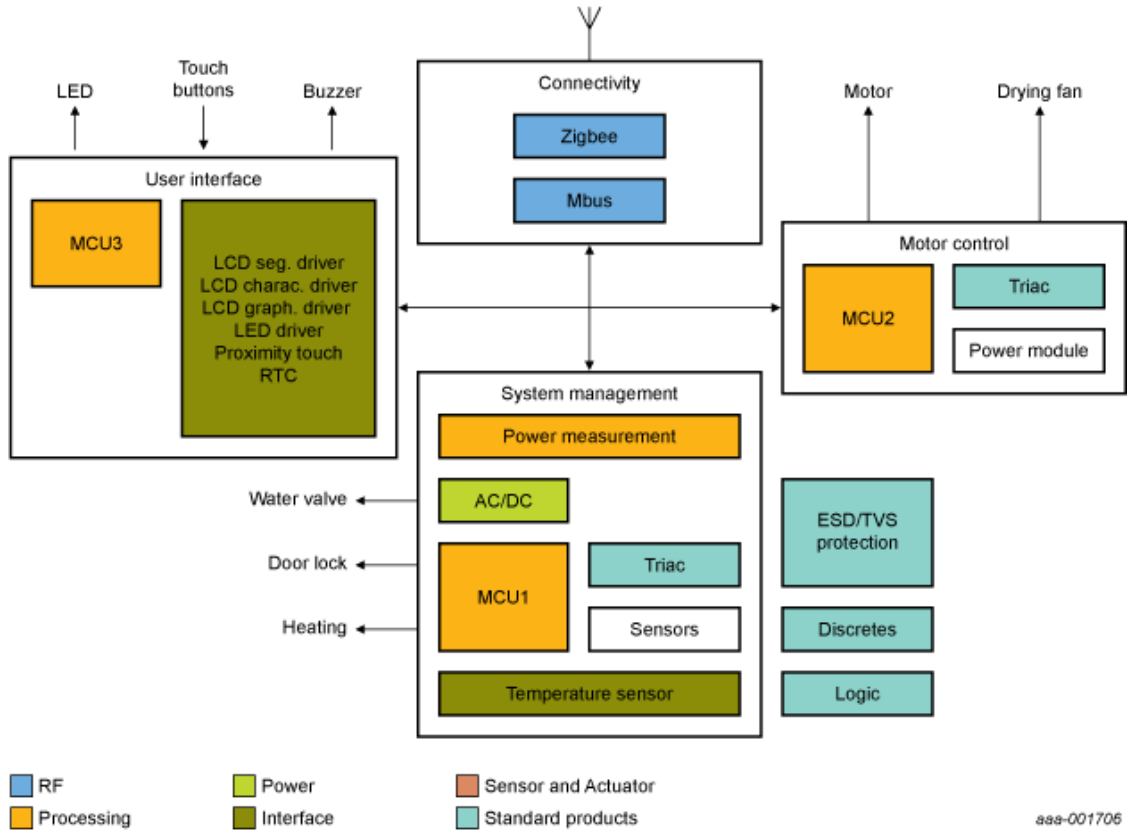
Precautions While Using Microwave Oven

- Like many other electrical appliances, it is important to follow the manufacturer's instruction manual for recommended operating procedures and safety precautions for your oven model.
- Use microwave-safe cookware specially manufactured for use in the microwave oven.
- A microwave oven should not be operated with an open, bent, or broken door.
- To avoid any mishappening, it is recommended not to stand directly in the front of a microwave oven while it is operating.
- The liquids should not be heated longer than the recommended temperature as it can cause the water vapours to reach the electric components and interfere with their working.
- It is essential to periodically clean the cavity with water and mild detergent. It is recommended to not use scouring pads, steel wool, or other abrasives for the cleaning process.

Dishwashers

Basically, a dishwasher is a robot that cleans and rinses dirty dishes. Humans have to load the dishes, add detergent, set the proper washing cycles and turn it on, but the dishwasher accomplishes a whole series of functions by itself.





1. Cold water is piped into the machine from your home water supply.
2. The heating element at the bottom of the machine, powered by electricity, warms the water to a temperature of 30–60°C (86–140°F). That's far hotter than the water most people would use to wash by hand, which is one reason why dishwashers are more hygienic (remove more bacteria) than ordinary hand-washing. The other reason is that the dishes are washed for much longer.

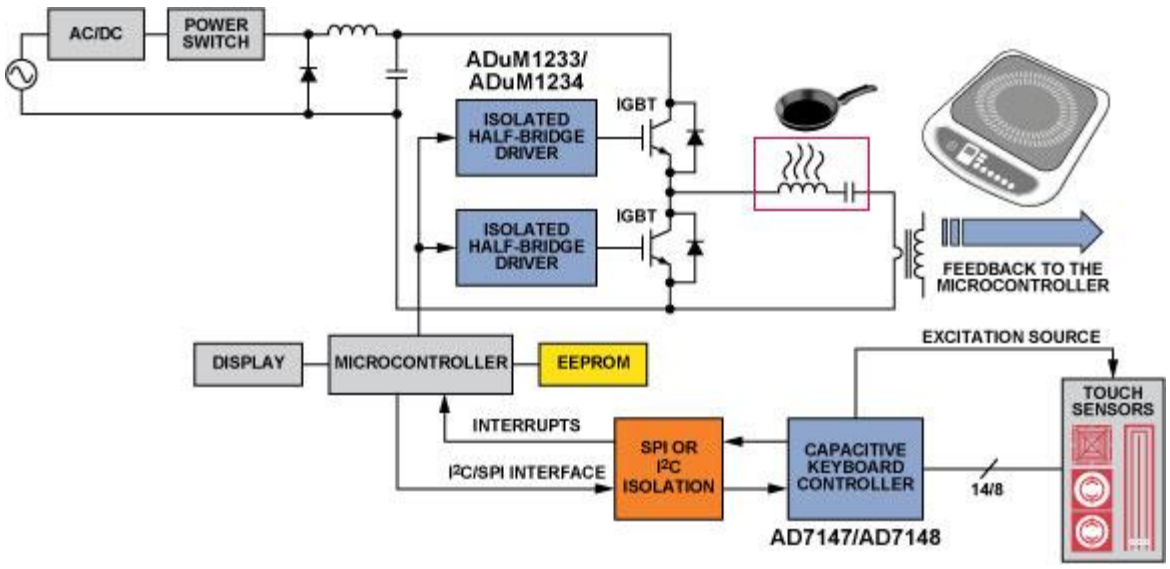
3. An electric pump at the bottom of the machine pumps the water up through the side walls
4. The water squirts up through holes in the bottom, metal paddle, making it spin around. The bottom paddle is made of metal because it needs to withstand hotter temperatures at the base of the machine.
5. Slightly cooler water squirts up through holes in the upper, plastic paddle, making it spin around too. Remember that the top of the machine is slightly cooler than the bottom so a plastic paddle is acceptable here.
6. After the water has bounced off your plates, it falls back to the bottom of the machine, where it is heated and pumped around the circuit again. (After it flips out of the automatic dispenser on the door, the dishwasher tablet falls into the bottom of the machine and dissolves in the hot water there. If your dispenser stops working, you can usually put the tablet in the bottom of the machine instead.)

In addition, dishwashers monitor themselves to make sure everything is running properly. A timer (or a small computer) regulates the length of each cycle. A sensor detects the water and air temperature to prevent the dishwasher from overheating or damaging your dishes. Another sensor can tell if the water level gets too high and activates the draining function to keep the dishwasher from overflowing. Some dishwashers even have sensors that can detect the dirtiness of the water coming off the dishes. When the water is clear enough, the dishwasher knows the dishes are clean.

When the washing and rinsing is finished, the water drains down to the basin again, where the pump propels the water out of the dishwasher. Depending on the type of dishwasher, the drain water might go right into the pipes under your sink, or travel up a hose into your sink itself

The final step in a wash cycle is optional - the dry cycle. The heating element at the bottom of the dishwasher heats the air inside to help the dishes dry. Some people just let them dry without heat to save energy

Induction stove



Description of the System

As with a transformer, the inductive element generates a magnetic field. When a metal pan is placed in the field, eddy currents are generated. Their energy is dissipated as heat, causing the pan and, by conduction, its contents to become hot. From an electrical point of view, the inductive element drives a lossy LC resonant circuit, and the losses produce heat. Figure 1 shows the elements of an inductive heating system.

The inductor current waveform is created by a high-efficiency switched dc power supply and a pair of IGBT switches. The switches are driven by a microcontroller, which responds to a feedback loop that forces

conditions monitored by sensors to correspond to settings established by the user—and to remain within safe limits.

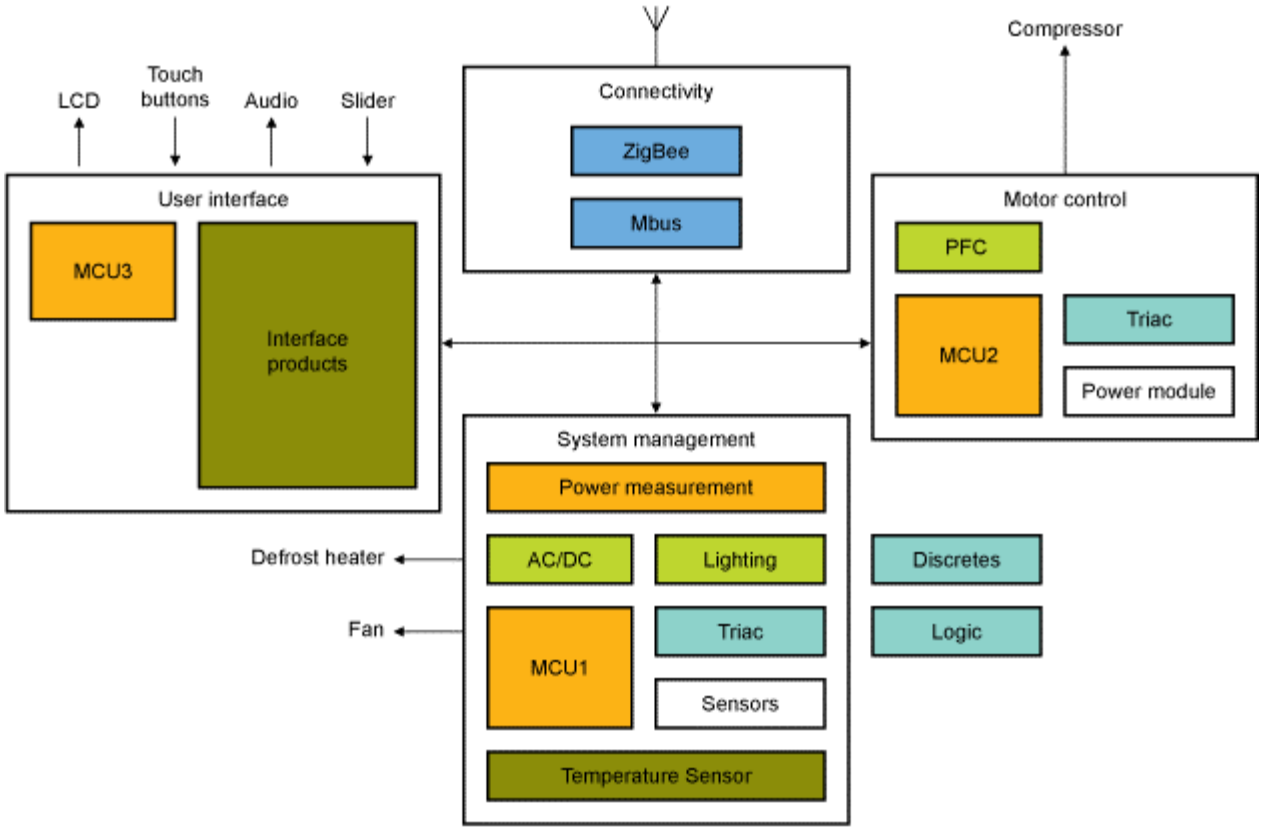
The main sensor, a transformer in series with the inductive plate, monitors the value of the current through the inductive plate in order to maintain the appropriate current value for the selected cooking level. This prevents damage to the power stage—the inductive plate and IGBTs—by decreasing the current level as necessary to avoid an over current condition.

Pan Detection

It is important to detect the presence of the pan on the inductive hob. The IGBTs have to manage high voltage rails that are connected to their collector (+HV). By sampling these voltages with resistive dividers, a signal representing them can be sent to the microcontroller to detect any variation of the voltage at the collector of the IGBT. If a user chooses a heating level and places a pan on the inductive hob, the resultant energy transfer and current spike will produce a voltage variation at the collector, and thus at the resistive-divider output. When the pan is removed from the inductive hob, the change will be in the opposite direction. Thus, by comparing the voltage variation with a fixed threshold, using a comparator from the ADCMP3xx family, for example, the pan's presence on the inductive hob can be detected. If no pan is detected, an interrupt is sent to the microcontroller, which will adjust the PWM frequency until the IGBTs stop providing current to the inductive element. This provides extra safety in case the user forgets to switch off the inductive

Smart Refrigerator

A smart refrigerator is a refrigerator that has Internet access and is able to recognize and manage items stored inside it. Automatic detection requires a barcode or RIFD on each item, or items can also be registered manually. A smart refrigerator allows a user to know which items are inside the refrigerator without opening it, by simply checking the display list on an LCD and the ability to connect to the internet through Wi-Fi to provide a number of additional features.



Smart refrigerators include internal cameras, more flexible user-controlled cooling options, and the ability for you to interact with its features using your smartphone or tablet when away from home. Some smart refrigerators can even connect with other smart devices in your home; such as speakers, smart TVs, and even your smart dishwasher or smart microwave or other output device.

Smart Refrigerator Features

Use the touchscreen interface to:

- Coordinate schedules for every member of the family.
- Look up recipes and have your fridge read the steps while you cook.
- Create grocery lists that sync to your smartphone in real-time.
- Set expiration dates and receive notifications to use food while it's fresh.
- Upload photos for display.
- Create individual profiles for each family member to send them personal notes and to-do lists.
- Use a whiteboard option to leave messages for your family.
- Transparent touchscreens allow you to look inside the fridge without opening the door.

The touchscreen is not the only novel thing a smart fridge can do. You can also use your smart fridge features to:

- Customize temperature by drawer or compartment.
- Use interior cameras while at the store to double-check if you're low on milk or eggs.
- Alert you when the water filter needs to be changed.
- Turn the ice maker on or off from your smartphone.

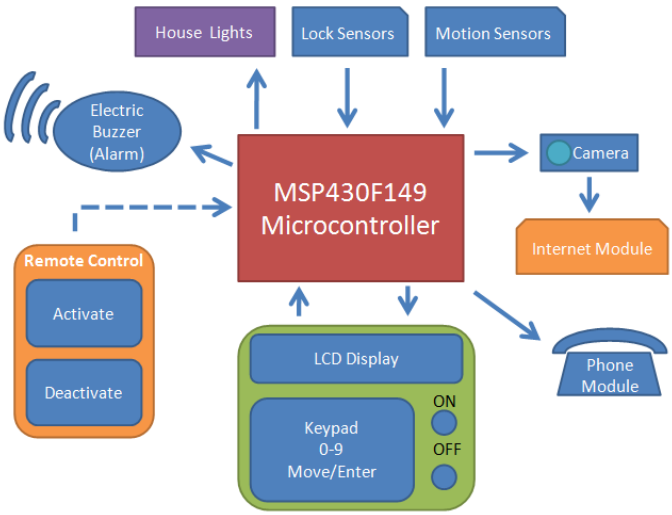
More Ways Smart Refrigerators Impress

Some models of smart refrigerators provide both cold and hot water. You select a temperature and amount of water you want to be heated and your smart refrigerator sends a notification to your smartphone when your heated water is ready. A few even come with a Keurig single-cup coffee maker built in, saving counter space and making your morning routine just a bit simpler.

Smart refrigerators have also incorporated sensors to make opening the door with your hands full no trouble at all. Sensors in the door respond to a gentle bump by opening the door for you. Some models have sensors at the bottom of the unit that respond to foot gestures to open the fridge door for you. And if the door isn't closed securely, the sensors respond and automatically pull the door shut to keep your food fresh and prevent cool air from getting out and running up your energy bills.

Smart alarm

A smart alarm is a wireless version of a traditional burglar alarm that uses your home wifi network to connect the different components of the alarm, rather than wires. Just like a traditional alarm system, it's made up of a siren that will trigger when any of the sensors are activated.



Indoor sensors:
The two most popular types of sensors are open/close and PIR. Open/close sensors should be placed on windows or doors. They're made up of two parts that form a connection when the door or window is closed. If the connection is broken, because the door or window has been opened and the alarm is armed, the siren will trigger.

PIR: PIR sensors detect motion and should be positioned in a hallway or other rooms that have an entry point to your home to detect the presence of intruders. Again, if the alarm is armed and the sensor detects motion, the siren will sound.

Ultrasonic detectors: These sensors send ultrasonic sound waves and receive them as they bounce back from the fixed objects in the room. So, if any object moves the wave length changes and the sensor detects moving object.

Microwave detectors: This type of sensor emits microwaves and detects discrepancies in the signals through the receiver.

Photoelectric beam systems:
These sensors also emit infrared light beams. However, they observe whether there is any obstruction in its way.

Outdoor sensors:
Vibration sensors: These sensors are mounted on walls or other structures. They detect any vibration that occurs when that structure is attacked.
Passive magnetic field detection: These sensors can be buried and it monitors the area with the help of electro-magnetic field.

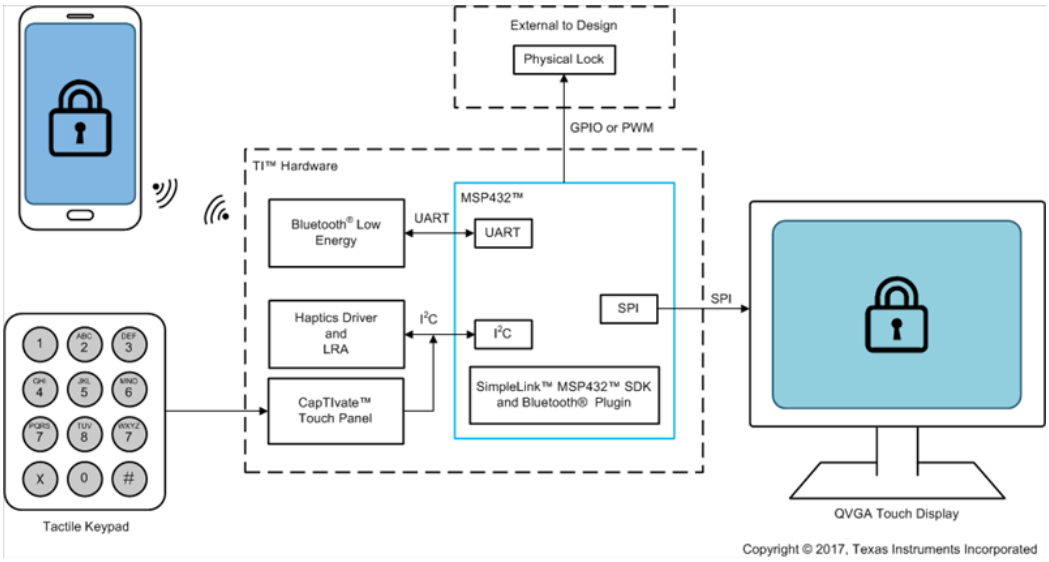
E-field: These sensors too, work in a similar fashion; however, they are more programmable and can provide vigilance up to 4 meters of height

Smart lock

Smart locks are keyless door locks that allow us to open the door without a physical key. They can be controlled remotely using a smartphone app. Many models feature a numeric keypad on the lock for entering a unique access code. A smart lock connects to your home's WiFi network, which allows it to receive the code or smartphone command to lock or unlock.

The smart code lock consists of a smart monitor and an electronic lock. The two are placed off-site, the intelligent monitor supplies the power required by the electronic lock and receives the alarm information and status information sent by it.
Smart lock working principle

1. The basic principle of intelligent monitor



The intelligent monitor is composed of a single chip, a lock, a keyboard, an LCD display, a memory, a demodulator, a line multiplexing and monitoring, an A/D conversion, a buzzer and the like. Mainly complete the communication with the electronic lock, intelligent analysis and security monitoring of communication lines.

The intelligent monitor is always in the receiving state, receiving alarm information and status information from the electronic lock in a fixed format. For the alarm information, the sound and light alarms are immediately sent through the LCD display and the buzzer; for the status information, it is stored in the memory and compared with the historical state of the electronic lock before this time, and the trend is changed to predict the future.

2. The basic principle of electronic locks

The electronic lock is also based on the 51 series single chip microcomputer (AT89051), with the corresponding hardware circuit, completes the setting, storage, identification and display of the password, drives the electromagnetic actuator and detects the driving current value, and receives the alarm signal sent by the sensor, send data and other functions.

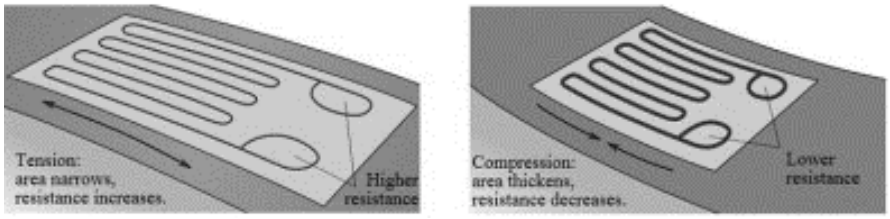
The MCU receives the typed code and compares it with the password stored in the EEPROM. If the password is correct, the electromagnetic actuator is unlocked; if the password is incorrect, the operator is allowed to re-enter the password, up to three times; if three times If it is not correct, the MCU will alarm the intelligent monitor through the communication line. The single-chip microcomputer sends the unlocking operation and the driving current value of the electromagnetic actuator as the status information to the intelligent monitor at this time, and also sends the alarm information received from the sensor interface to the intelligent monitor as the basis of the intelligent analysis.

Advantages

- **Control your front door no matter where you are.** With a smart lock, your smartphone doubles as your key. There's no need to rush home to beat your guests or a delivery driver to the door; simply log onto your app and unlock your front door from wherever you are.
- **Codes over keys**. If you've ever stood at your front door while digging through your bag to find your keys, you'll appreciate the keyless functionality that lets you unlock your door with a simple code—no key required.
- **No more hide-a-keys.** Smart locks eliminate the need for making copies of your key for everyone. This is also much safer than having multiple copies of your house key floating around, protecting your home from potential burglaries.
- **Notifications help you remember to lock up.** If you've ever left your house in a rush to make it to work or drop off your kids on time, you know the worried feeling that comes with wondering whether or not you remembered to lock your door on the way out. Many smart locks will send you notifications on your phone if you forgot to lock your door, so you can quickly lock it with the tap of a button.
- **Know who's coming or going**. You can make up to 30 unique access codes for everyone who needs to get into your house, from the babysitter to dog sitter to your own kids. Your system keeps a log of which code was used and when, so you know exactly who is coming and going. You can also receive notifications on your smartphone when a code is used.
- **Keep your packages safe.** If you do online shopping, you know the threat of packages being stolen off your porch is real. With a Vivint Doorbell Camera Pro, you can see when your delivery driver arrives, then unlock the smart lock on your front door and use the camera's two-way talk feature to ask him or her to put your package inside—all from your phone.
- **Create guest codes for visitors.** Preparing for out-of-town visitors can be stressful enough without having to run and get a copy of your key made or coordinate your schedules so your home when they arrive. Just make a temporary access code for your guests so they can come and go as they please. Then, when they leave, you can delete the code.
- **Create custom rules.** You can also create custom rules for your smart lock, such as locking doors automatically after a certain amount of time, or arming your security system and turning off your lights when you lock your front door.
- **Lock your door with the sound of your voice.** Want to make sure your door is locked, but your smartphone is charging in another room? No problem, when your smart lock is integrated with a system that includes a Google Home or Amazon Echo. Just say, "Hey Google, lock the front door." It's that simple.

Smart floor

As its name suggests the smart floor is just that- an intelligent floor. Through the 'intelligent tiles' the floor is able to determine where you are stood on the floors surface and the way you are stood. The smart floor consists of a number of 'intelligent tiles', mounted on a supporting framework, a projector, projection screen and a controlling computer. Actually, the smart floor made of load cell or strain gauge, is a sensor or a transducer that converts a load or force acting on it into an electronic signal. This electronic signal can be a voltage change, current change or frequency change depending on the type of load cell and circuitry used.



The Smart Floor is a proven measuring instrument for motion analysis. It consists of a thin sensor film that is placed under or on the floor surface of a care, nursing home, rehabilitation center, hospital, physiotherapy practice or sports floor. Data is generated by means of a wearable sensor (walking sensor) worn around the lower leg, after which the information can be viewed by a Smart Floor software application. This application visualizes and quantifies movement information (position, orientation, speed, acceleration) of the feet and the person. People can also be identified through the wearable.
Smart Floor makes it possible to measure people remotely.

- **Position, speed, acceleration, orientation, distance travelled**
- **Fall prediction and fall detection**
- **Testing for rehabilitation**
- **Tests for physiotherapy**
- **Sports monitoring**
- **Life style monitoring**

Smart Floors in the Hospital
Smart floors with antennas built into their base are able to pick up data from employee badges, equipment badges, patient wristbands and more. The floor can monitor the location and status of patients, personnel and equipment. Administrators set up alarms to alert them to possible equipment theft and patient accidents. Smart floors in emergency wards can help medical staff keep track of patients in many ways.

Smart Floors at Home
For example, an elderly patient living at home can receive audio instructions when he wanders into the wrong room or takes the wrong path down a hallway. Sensors in the floors detect the movement and trigger an announcement that alerts the patient when he's in the wrong area.

Lowering Health-Care Costs: The smart floor sends data about daily changes in their walking routine and detects potential falls and illnesses. It's a seamless solution that's always on, providing monitoring around the clock

Foot Power Generates Electricity: In addition to security and medical applications, some entrepreneurs are using the energy displaced by people walking on floors to generate power. Floor tiles and sensors collect the kinetic energy from people's footsteps and convert it into energy stored in batteries

Smart toilet
smart toilets known as Smart Wash which is made to free from UTI (urinary tract infection). **Smart toilet** has features like germ free, easy to install, self-cleaning with warm water, warm air, warm seat, and designed for Females to reduces the risk of UTI.

Smart toilets come packed with added features and sensors that perform a wide variety of functions beyond just flushing. Some top-of-the-line models even connect to the internet so you can stream music or use a voice assistant like Amazon's Alexa

Smart Toilet Benefits

In addition to offering an enhanced bathroom experience, smart toilets often use far less water than conventional toilets. That makes them a great choice for the eco-conscious consumer and those looking to save on utility bills.

They also boast conveniences such as self-closing lids and nightlights. These kinds of features are ideal for kids, seniors and people with disabilities. Smart toilets are often more compact than traditional toilets, making them a great choice for anyone in a small space, too.

Urine contains a virtual liquid history of an individual's nutritional habits, exercise, medication use, sleep patterns and other lifestyle choices. Urine also contains metabolic links to more than 600 human conditions, including some of the major killers such as cancer, diabetes and kidney disease.

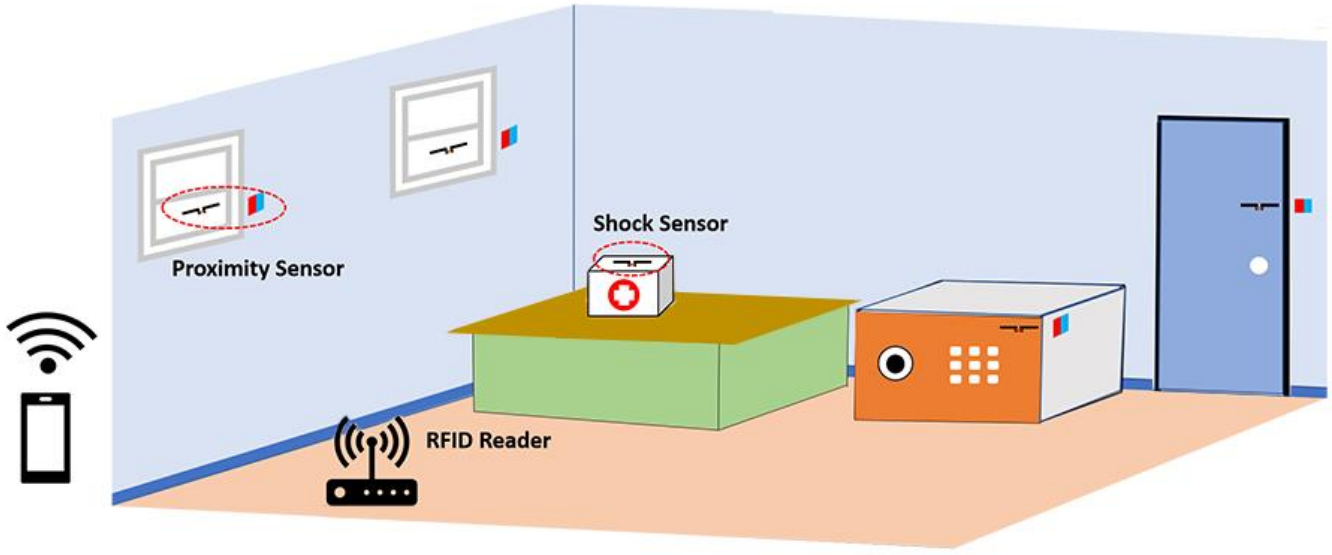
Popular Smart Toilet Features

- **Touchless flushing:** A sensor notes when you move away from the toilet (or when you wave a hand in front of it) for convenient and hygienic flushing.

- **Automatic lid:** Sensors also know when to raise or lower the lid.
- **Seat warmers:** Most smart toilets don't just warm the toilet seat, they even let you specify exactly how toasty you prefer it.
- **Nightlight:** There's no stumbling in the dark when you have a smart toilet that automatically flips on an ambient light when it gets dark.
- **Spray adjustment:** It comes with a bidet feature that lets you specify your desired water pressure, temperature and other wash settings.
- **Self-cleaning features:** Smart toilets come with everything from a robotic cleaning arm to ultraviolet light to keep things clean.
- **Overflow protection:** Some smart toilets can help avert an overflow by preventing you from flushing when there's a clog.
- **Remote control:** A remote control lets you input your desired settings and manage your smart toilet at the press of a button.

RFID Home

The sensors provide a low-cost, compact solution for the security monitoring system shown in Figure 1. RFID tags equipped with motion sensors can be attached to the window, the door and the safe, while a shock sensing tag can be attached to the medication box. A commercial RFID reader serves two functions: a) it detects any sensor that was brought to its active state by its motion or shock sensing switch b) the reader also floods the area with low-power RF radiation that powers the tags when they are activated. Since each RFID tag has its own unique ID, the RFID reader knows where the detected activity occurs. Once captured, the activity data can be transmitted to the cloud for analysis and, when appropriate, notification of the user via smartphone or an email alert.

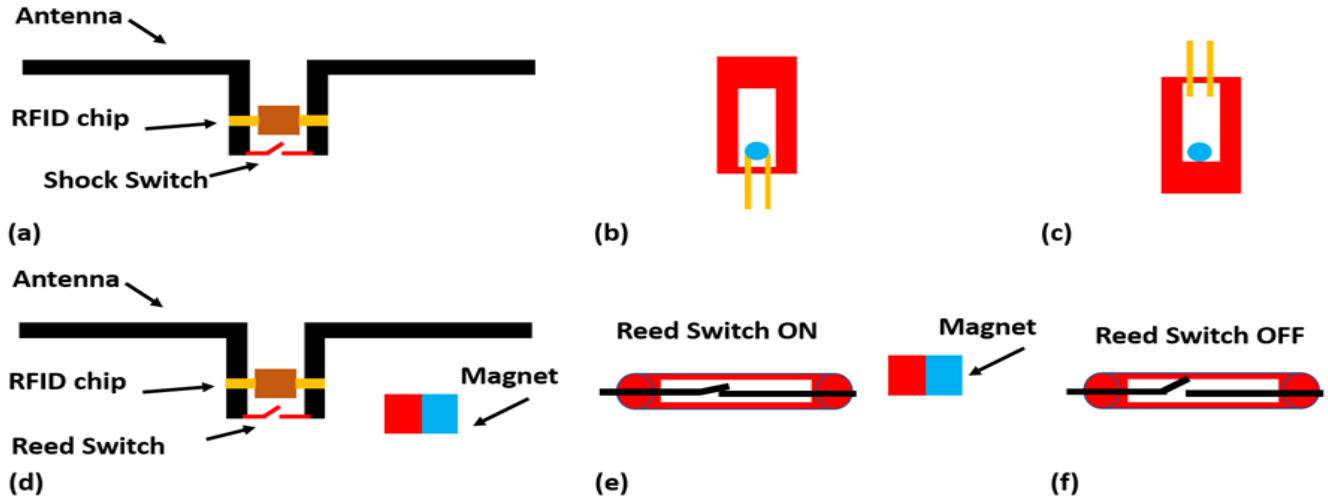


sensor working principles

The functional diagrams in Figure 2 illustrate the working mechanisms of the shock sensor and motion sensor.

Shock detector

The shock sensor consists of an RFID chip and an antenna, as shown in Figure 2a. The shock switch



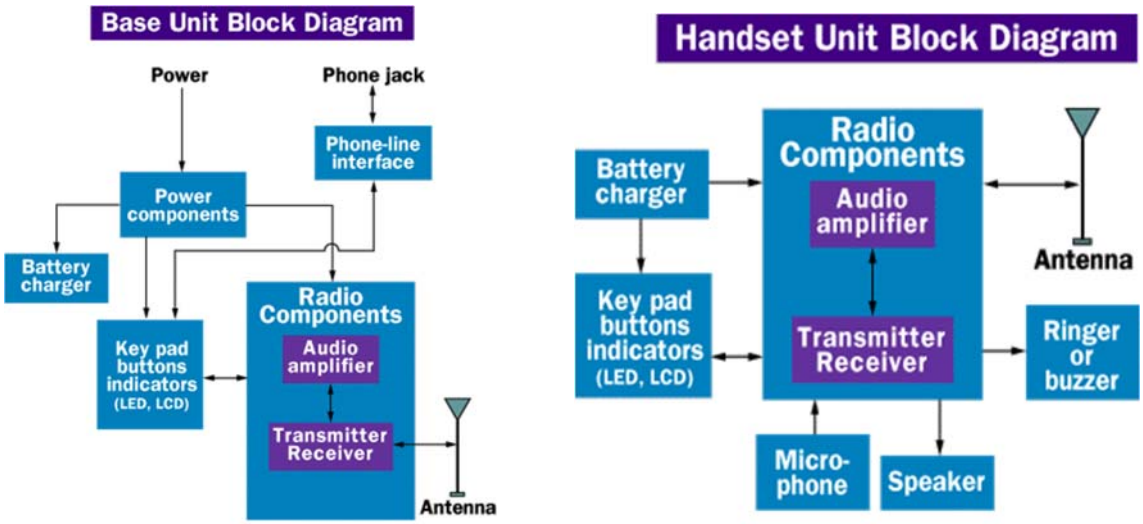
composes of a cavity and a tiny metal ball that rolls around inside. When the shock switch is placed upright, the ball rolls onto the two conductive contacts sticking out of the cavity, creating a conductive path (Figure 2b). If the sensor tilts towards another direction, the contacts are disconnected, making a simple means for detecting motion or orientation. When used as a security sensor, the shock switch is connected between the two terminals of the antenna and placed upright, so that shorts them in its passive position. The resulting short breaks the impedance matching between the RFID chip and the antenna, preventing the RFID tag from radiating a signal. If the shock sensor is tilted, the metal ball moves off the contacts, enabling the RFID tag to receive power and to radiate a signal, which is then read by RFID reader.

Motion sensor

The motion sensor system shown in Figure 2d consists of an RFID chip, an antenna, a reed switch, and a magnet. A reed switch is comprised of two ferromagnetic flexible metal reed contacts in a sealed glass cavity. The switch's two contacts are normally open, until the presence of a magnetic field causes them to close (Figure 2e). When the senor is moved out of proximity of the magnet, its contacts return to the original open condition as in Figure 2f, thereby enabling the RFID chip and alerting the reader that the tag has been moved. This is illustrated in Figure 1 where, for example, the RFID tag with the reed switch is affixed on the window, and the magnet is attached on the wall near the RFID tag. When the window is closed, the magnet keeps the reed switch in a closed position thereby shunting the antenna and keeping the chip inactive. When the window is moved up or down, the magnet is no longer close enough to keep the reed switch closed. At this point, the reed switch reverts to its open position and the RFID tag becomes active.

Unit V Communication Systems - Cordless Telephones, Fax Machines, PDAs- Tablets, Smart Phones and Smart Watches. Introduction to Smart OS- Android and iOS. Video Conferencing Systems- Web/IP Camera, Video security, Internet Enabled Systems, Wi-Fi, IoT, Li-Fi, GPS and Tracking Systems, Contemporary Topics.

Cordless phone



A cordless telephone is basically a combination telephone and radio transmitter/receiver A cordless phone has two major parts: base and handset.

The base is attached to the phone jack through a standard phone wire connection, and as far as the phone system is concerned it looks just like a normal phone. The base receives the incoming call (as an electrical signal) through the phone line, converts it to an FM radio signal and then broadcasts that signal.

The handset receives the radio signal from the base, converts it to an electrical signal and sends that signal to the speaker, where it is converted into the sound you hear. When you talk, the handset broadcasts your voice through a second FM radio signal back to the base. The base receives your voice signal, converts it to an electrical signal and sends that signal through the phone line to the other party.

Advantage

1. Console operators, to be able to take calls when they step away from their desk for functions such as making copies. 2. Warehouse employees
3. Retail store personnel who can take calls from anywhere in the store.
4. Call centre agents 5. People who work at home

Generation

CT1 : The *first generation* of cordless telephone is designed to serve the domestic environment with a *range* of 100 m. The base station transmits on one of eight frequencies between 1.6 MHz and1.8 MHz, and the handset one of eight frequencies in the 47 MHz band. Frequency modulation with a deviation of ±*4* kHz at the base station and 2.5 kHz at the handset. Permitted effective radiated power at the base station and the handset is 10mW.

CT2 : The second generation of cordless telephone. The services, under various names, telepoint, phone zone, etc., were planned to provide for the general public a *lower cost alternative* to the cellular radio telephone networks which were seen at the time as a businessman's preserve.

The operational frequencies are in the band 864.1 to 868.1 MHz and employ time division multiple access (TDMA). Speech is digitised at 32 kbit/s, stored, and then transmitted at 64 kbits/s in 1 ms slots.it leaves the alternate 1 ms slots available for the digitised and stored speech of a reply. Duplex operation achieved in this way on a single radio frequency.

CT3 : The third generation of cordless telephone, *Digital European Cordless Telephone* (DECT) is pan-European system. DECT operates in the 1880 to 1900 MHz band. It offers data handling facilities and the ability for a subscriber to receive calls while away from the local base station. The techniques are used for GSM (Global System for Mobile Communications) although, because the mobile is virtually stationary, the constraints on data transmission are less severe and no hand-off is required.

Fax machine (Facsimile automatic Xerox)

Essentially, a fax machine scans original documents, converts the scanned images into electrical signals, and transmits them over telephone lines to a receiving fax machine. The receiving fax machine in turn converts the received signals back into the graphical images of the original document and prints them.

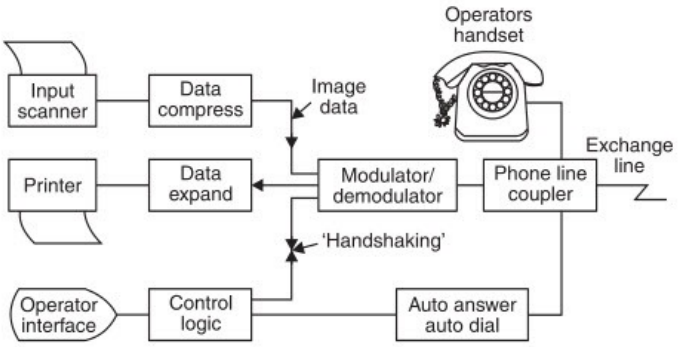
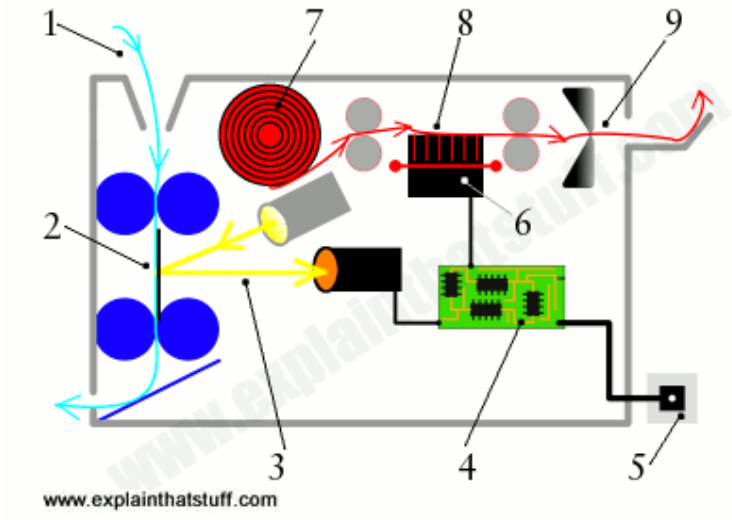


Fig. 44.2 *Block diagram of a typical facsimile machine*

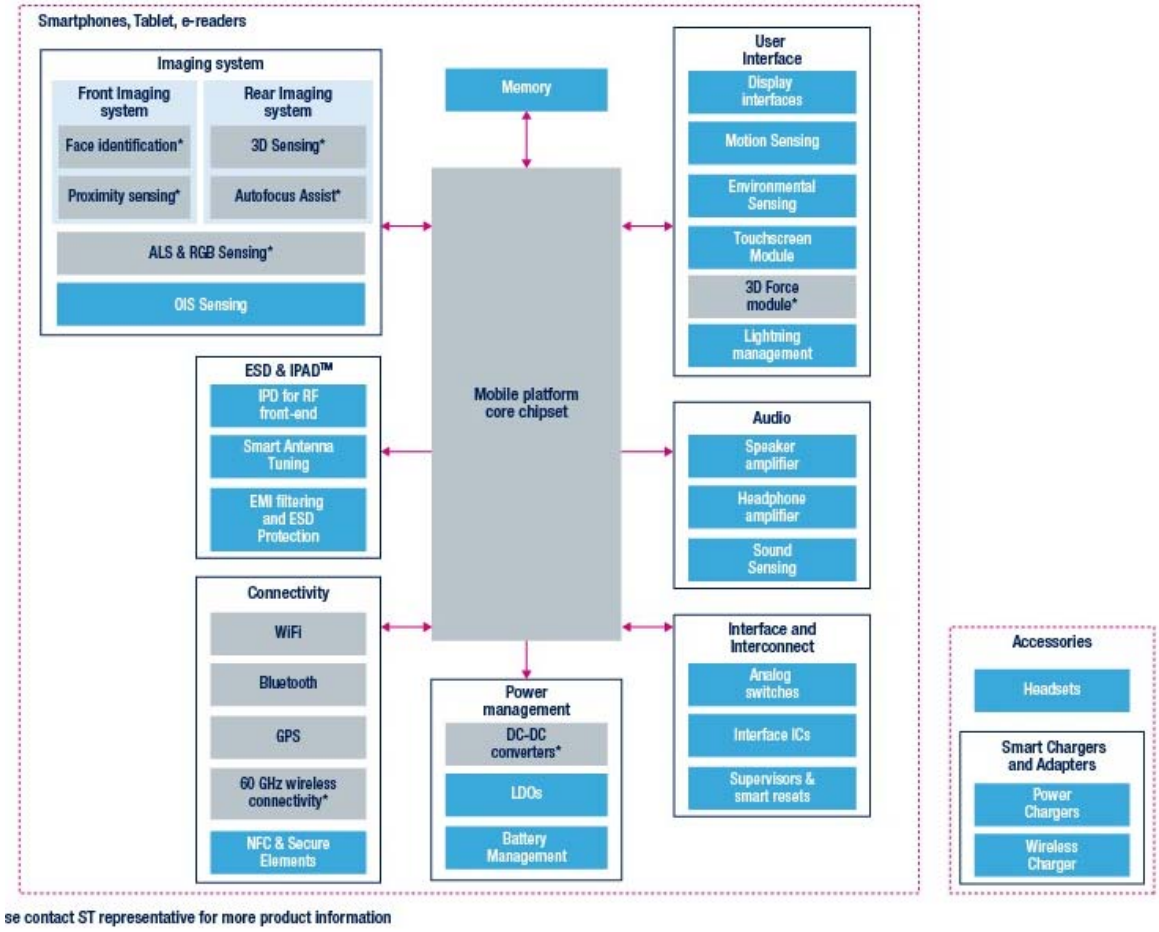
The essential parts of a fax system are the transmitting devices that translate the graphic material into electrical impulses according to a set pattern, and a synchronized receiving device that retranslates these impulses and prints that. In a typical system, the fax scanner consists of a rotating cylinder, a source projecting a narrow beam of light and a photoelectric cell. The copy to be transmitted is wrapped around the cylinder and is scanned by the light beam, which moves along the cylinder as it revolves.

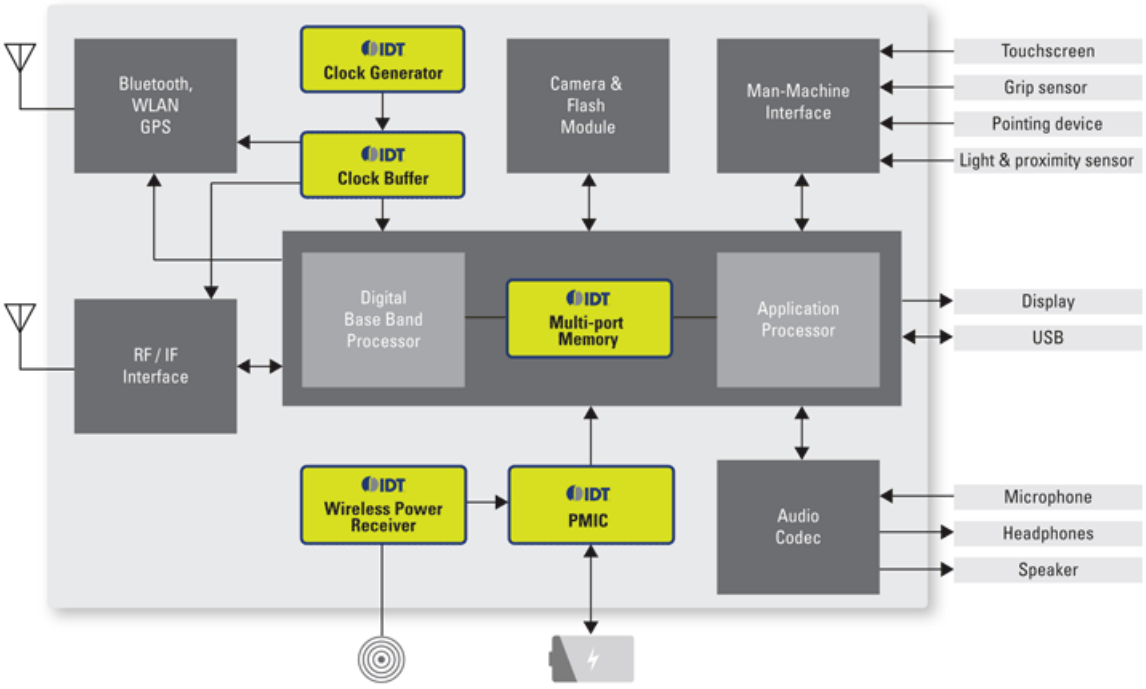


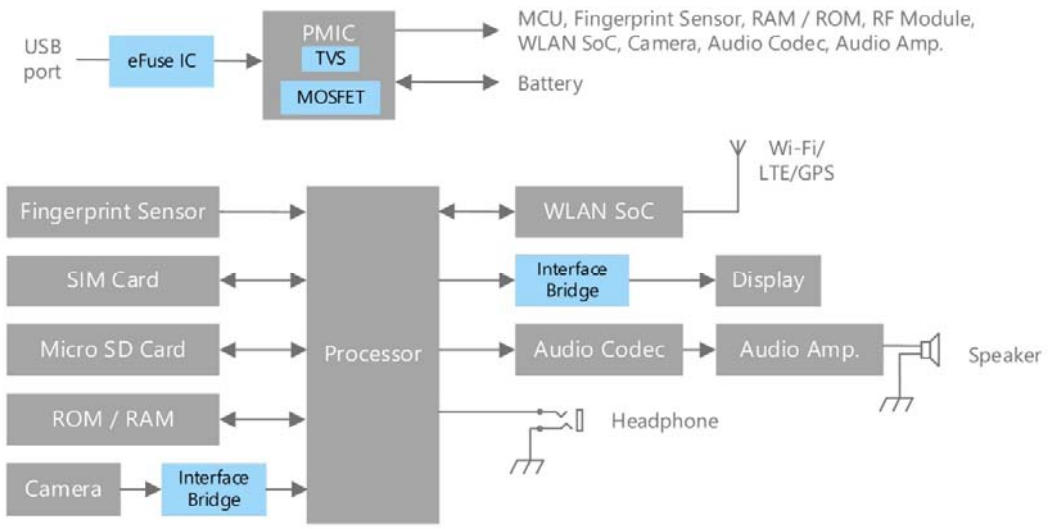
The output of the photoelectric cell is amplified and transmitted to the receiving end, where a similar cylinder, covered with specially impregnated paper, revolves in synchronism with the transmitting cylinder. A light of varying

intensity moves along the rotation cylinder and darkens the paper by chemically reproducing the pattern of the original. When the fax is done, it pops out as a blue print of what the other person sent.

Smart phone







(Refer any one figure for smart phone)

A smartphone is a mobile phone built on a mobile operating system, with more advanced computing capability connectivity. In addition to voice communication, most smartphones function as portable media players, digital cameras, and GPS navigation units. Typically supporting touch screen interaction and peripheral, smartphones are smaller and less powerful than both tablets and laptops.

The major subsystem of smart phone is processor subsystem, RF subsystem, display subsystem, peripherals subsystem (camera, audio, GPS etc), power management subsystem, charger subsystem

At the core is the processor sub-system that coordinates everything in the phone as well as runs the User Interface and applications. The RF sub-system contains the RF front-end, antennas and modem, and is the section responsible for all wireless functionalities.

The display sub-system is what the user initially notices about the smartphone since it is such a visibly large part of the entire device. The peripheral sub-system is what users would consider to be features of the phone. It includes such things as cameras, fingerprint scanner, audio, GPS, accelerometer and other similar components.

Finally, there is the battery and power management sub-system. It is, of course, responsible for storing and then providing power to the entire phone. Runtime is one of the key aspects a typical user considers when buying a smartphone.

Display

Perhaps the most obvious components of a modern smartphone is its display, and while every detail you see is on the outside, it is actually an internal component of the device. Display technologies in smartphones of today come in two main types:

- Those based on LCDs (IPS technology and its variations)
- Those based on LEDs (AMOLED or Super AMOLED and its variations)

System-on-a-chip' or SoC

The SoC is perhaps the most important component present in a smartphone, and some users might confuse it as being the processor of the device. However, it is far more than that; the SoC not only comprises up of the smartphone's CPU, but GPU, LTE modem, display processor, video processor, and other bits of silicon that turn it into a functional 'system' in a phone.

Memory and storage

No smartphone can function without the use of RAM and memory (system storage). First, let's talk about the RAM; most mobile devices are shipped with LPDDR3 or LPDDR4, while some high-end smartphones are shipped with LPDDR4X RAM. 'LP' stands for 'Low-Power,' and it reduces the total voltage of these chips, making them highly efficient and giving mobile phones the extended battery life.

Modems

Since smartphones are just phones at the end of the day, they need communication components to receive and send text messages and calls. That's where modems come in, and every SoC manufacturer has their own brand of modems, and this includes Qualcomm, Samsung, Huawei and several others.

camera

All smartphones come with a rear-facing and front-shooting camera. A smartphone comprises up of three main parts:

- The sensor (which detects light)
- The lens (the component in which light comes through)
- The image processor

While the megapixels on the smartphone are still an important part of the camera, it carries less importance than it did a while back. Instead, the primary limiting factor is the camera sensor of the phone and how sensitive it is when light passes through the lens.

Sensors

There are five main sensors in a smartphone that allow it to give you that functionality of a 'touch-enabled smart device'. The names of all these sensors and their importance have been detailed below:

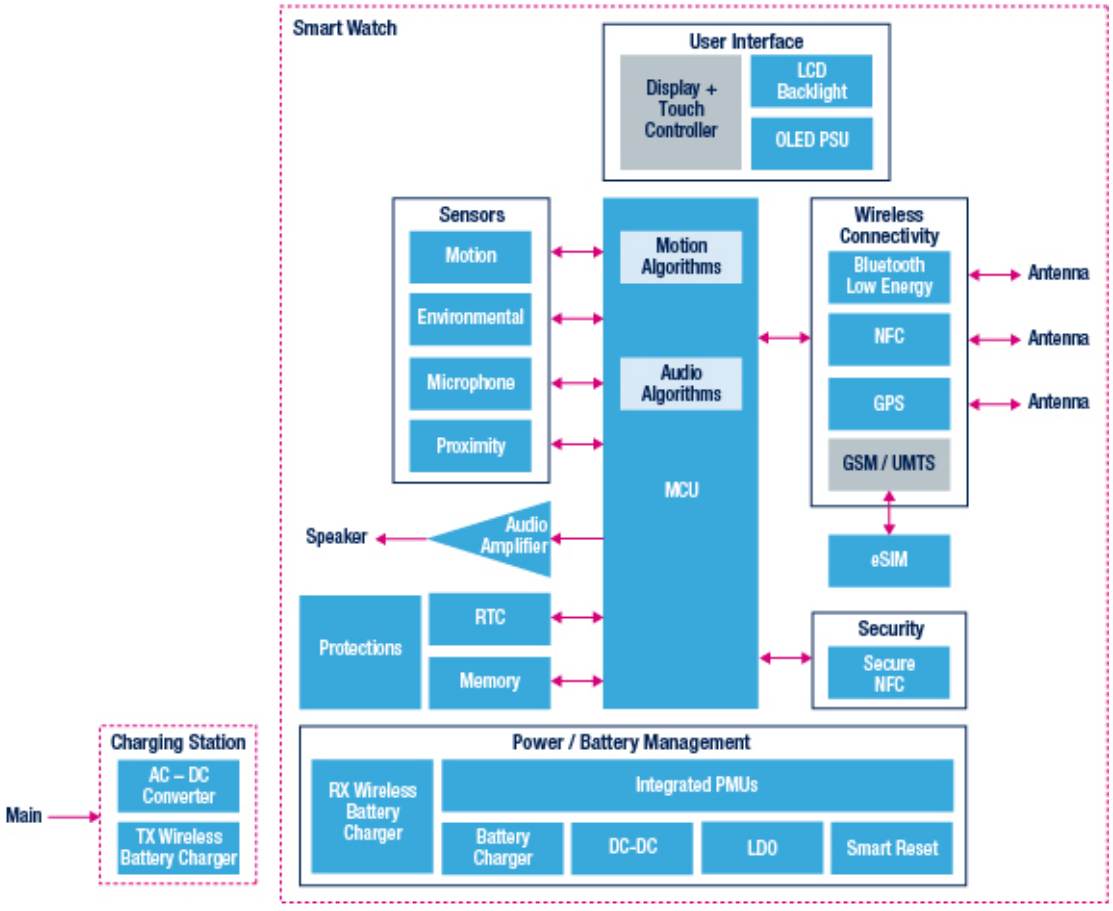
1. **Accelerometer**: Used by apps to detect the orientation of the device and its movements, as well as allow features like shaking the phone to change music.
2. **Gyroscope**: Works with the Accelerometer to detect the rotation of your phone, for features like tilting phone to play racing games or to watch a movie.
3. **Digital Compass**: Helps the phone to find the North direction, for map/navigation purposes.
4. **Ambient Light Sensor**: This sensor is automatically able to set the screen brightness based on the surrounding light, and helps conserve battery life. This would also explain why your smartphone's brightness is reduced in low-light environments, so it helps to reduce the strain on your eyes.
5. **Proximity Sensor**: During a call, if the device is brought near your ears, it automatically locks the screen to prevent unwanted touch commands.

Tablet (For Block diagram refer figure 1 of the smart phone)

A tablet electronic device is generally capable of playing audio and video content, running games, allowing the creation of text and other types of documents, providing social media tools, and reading and writing email, among other functions. These capabilities are available through downloadable applications, with the application downloaded from a data center (the cloud). To enable these capabilities, the device must have network capability usually available through Wi-Fi and often from cellular networks as well (generally as a paid service). Tablets, along with smartphone.

also contain sophisticated environmental sensors, such as accelerometers and GPS radios, that can provide new ways to interact with the machine and location-based services (such as navigation systems). With increasing bandwidth available through Wi-Fi and cellular networks (4G and soon 5G), the size of content and interactivity available in these devices will increase considerably. This will be important with higher-resolution video, 4 K now and 8 K in the future, and with 360 degree video (which will be particularly important for smartphones and stand-alone VR headsets). In addition, with the improvements in voice recognition, enabled by artificial intelligence capabilities, these devices, along with smartphones, are becoming important devices for automotive entertainment as well as home automation control.

Smart watch



A **smartwatch** is a wearable computer in the form of a watch; modern smartwatches provide a local touchscreen interface for daily use, while an associated smartphone app provides for management and telemetry (such as long-term biomonitoring). While early models could perform basic tasks, such as calculations, digital time telling, translations, and game-playing, 2010s smartwatches have more general functionality closer to smartphones, including mobile apps, a mobile operating system and WiFi/Bluetooth connectivity. Some smartwatches function as portable media players, with FM radio and playback of digital audio and video files via

a Bluetooth headset. Some models, called watch phones (or vice versa), have mobile cellular functionality like making calls

Sensors

It is the core element of a smartwatch and is where data is being stored. This type of sensor differs from other mobile electronics as it offers distinct features like heart rate monitoring, UV test, pedometer, humidity test, temperature test. Generally, sensors are divided into three different categories:

- Biosensors - These are blood pressure, EMG, ECG, glucose, brain waves, and temperature sensors.
- Environmental sensors - Examples of these sensors are ultraviolet, ambient light, PH, gas, pressure, and dust particles.
- Motion sensors - These are gyroscope, acceleration, atmospheric pressure, and geomagnetic sensors.

A sensor gathers and transmits data to the display processor or CPU. Sensors will surely become smarter, more precise, smaller, consume less energy as technology continues to evolve day by day.

Wireless Chipset

This is another essential component of a smartwatch. The majority of these watches' data transmission is done through wireless performance, such as GPS, WiFi, Bluetooth, and NFC. Most manufacturers opt for chipsets that incorporate these functions since smartwatches are small. Hence, they need components that will fit into a narrow frame.

Apart from the chipset size, the consumption of electricity is another important thing to consider. Most smartwatches have a synchronization feature that needs a chipset to be activated all the time. Therefore, the power control of this aspect must be a significant consideration

Screen

A smartwatch screen is the major output and input element of the entire setup. The screen can be divided into two parts: the inductive touch panel and the smart display. Generally, there are four screen types used in every smartwatch OLED, E-ink, Traditional LCD, and Sharp memory LCD. Some companies even introduced a smartwatch screen with MEMS technology and "soft screen". Widely used screens are currently LED and E-ink because they take less power consumption.

Battery

There are two main batteries used in smartwatches: Lithium polymer and Li-ion. When it comes to power capacity, lithium batteries can support higher. Making them an ideal battery choice for smartwatches.

Typical wristwatches can last up to 2-3 years, whilst smartwatches need regular power charging. Some may find it difficult to use a watch that does not last an entire day of use.

Although there are modern charging technologies available for smartwatches like solar power and wireless charging, these are not available for worldwide consumers. That's why for now, battery capacities are being used even though it is one limiting factor.

Processor

Advanced RISC Machines (ARM) are what most smartwatches use as licensed processors. Even if others offer competing choices. Smartwatches application processors contain lower power consumption compared to processors found in desktops or laptops. They also take up less board space. There are definitely a lot of good chipset applications available in the consumer market. Just do some research or you can ask an expert on what processor works best for your smartwatch needs.

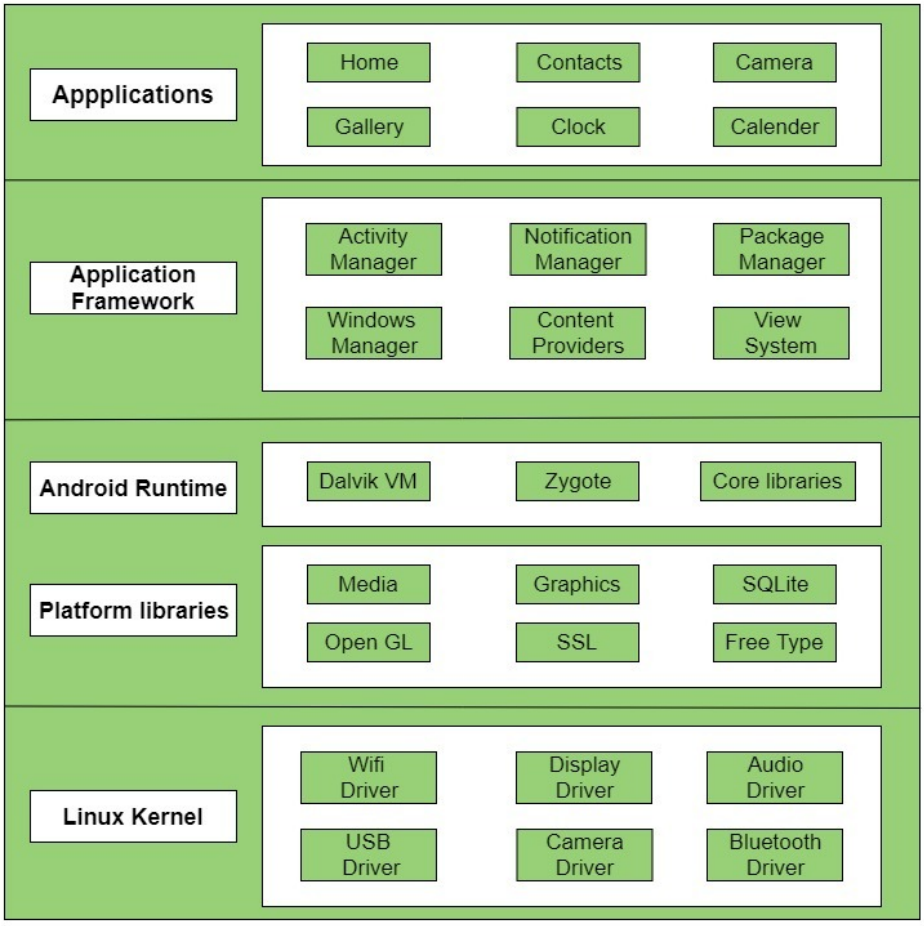
Smart OS

ANDROID

Android is an open source and Linux-based **Operating System** for mobile devices such as smartphones and tablet computers. Android was developed by the *Open Handset Alliance*, led by Google, and other companies.

Android offers a unified approach to application development for mobile devices which means developers need only develop for Android, and their applications should be able to run on different devices powered by Android.

Android Architecture



The main components of android architecture are following: -

- Applications
- Application Framework
- Android Runtime
- Platform Libraries
- Linux Kernel

Applications
Applications is the top layer of android architecture. The pre-installed applications like home, contacts, camera, gallery etc and third-party applications downloaded from the play store like chat applications, games etc, will be installed on this layer only. It runs within the Android run time with the help of the classes and services provided by the application framework.

Application framework
Application Framework provides several important classes which are used to create an Android application. It provides a generic abstraction for hardware access and also helps in managing the user interface with application resources. Generally, it provides the services with the help of which we can create a particular class and make that class helpful for the Applications creation.

It includes different types of services activity manager, notification manager, view system, package manager etc. which are helpful for the development of our application according to the prerequisite.

Application runtime
Android Runtime environment is one of the most important part of Android. It contains components like core libraries and the Dalvik virtual machine (DVM). Mainly, it provides the base for the application framework and powers our application with the help of the core libraries.

Like Java Virtual Machine (JVM), **Dalvik Virtual Machine (DVM)** is a register-based virtual machine and specially designed and optimized for android to ensure that a device can run multiple instances efficiently. It depends on the layer Linux kernel for threading and low-level memory management. The core libraries enable us to implement android applications using the standard JAVA or Kotlin programming languages.

Platform libraries

The Platform Libraries includes various C/C++ core libraries and Java based libraries such as Media, Graphics, Surface Manager, OpenGL etc. to provide a support for android development.

- **Media** library provides support to play and record an audio and video formats.
- **Surface manager** responsible for managing access to the display subsystem.
- **SGL** and **OpenGL** both cross-language, cross-platform application program interface (API) is used for 2D and 3D computer graphics.
- **SQLite** provides database support and **Free Type** provides font support.
- **Web-Kit** This open-source web browser engine provides all the functionality to display web content and to simplify page loading.
- **SSL (Secure Sockets Layer)** is security technology to establish an encrypted link between a web server and a web browser.

Linux Kernel–
Linux Kernel is heart of the android architecture. It manages all the available drivers such as display drivers, camera drivers, Bluetooth drivers, audio drivers, memory drivers, etc. which are required during the runtime.
The Linux Kernel will provide an abstraction layer between the device hardware and the other components of android architecture. It is responsible for management of memory, power, devices etc.
The features of Linux kernel are:

- **Security:** The Linux kernel handles the security between the application and the system.
- **Memory Management:** It efficiently handles the memory management thereby providing the freedom to develop our apps.
- **Process Management:** It manages the process well, allocates resources to processes whenever they need them.
- **Network Stack:** It effectively handles the network communication.
- **Driver Model:** It ensures that the application works properly on the device and hardware manufacturers responsible for building their drivers into the Linux build

Features of Android

Android is a powerful operating system competing with Apple 4GS and supports great features. Few of them are listed below −

Beautiful UI: Android OS basic screen provides a beautiful and intuitive user interface.

Connectivity: GSM/EDGE, IDEN, CDMA, EV-DO, UMTS, Bluetooth, Wi-Fi, LTE, NFC and WiMAX.

Storage: SQLite, a lightweight relational database, is used for data storage purposes.

Media support: H.263, H.264, MPEG-4 SP, AMR, AMR-WB, AAC, HE-AAC, AAC 5.1, MP3, MIDI, Ogg Vorbis, WAV, JPEG, PNG, GIF, and BMP.

Messaging: SMS and MMS

Web browser: Based on the open-source Web Kit layout engine, coupled with Chrome's V8 JavaScript engine supporting HTML5 and CSS3.

Multi-touch: Android has native support for multi-touch which was initially made available in handsets such as the HTC Hero.

Multi-tasking: User can jump from one task to another and same time various application can run simultaneously.

Resizable widgets: Widgets are resizable, so users can expand them to show more content or shrink them to save space.

Multi-Language: Supports single direction and bi-directional text.

GCM: Google Cloud Messaging (GCM) is a service that lets developers send short message data to their users on Android devices, without needing a proprietary sync solution.

Wi-Fi Direct: A technology that lets apps discover and pair directly, over a high-bandwidth peer-to-peer connection.

Android Beam: A popular NFC-based technology that lets users instantly share, just by touching two NFC-enabled phones together.

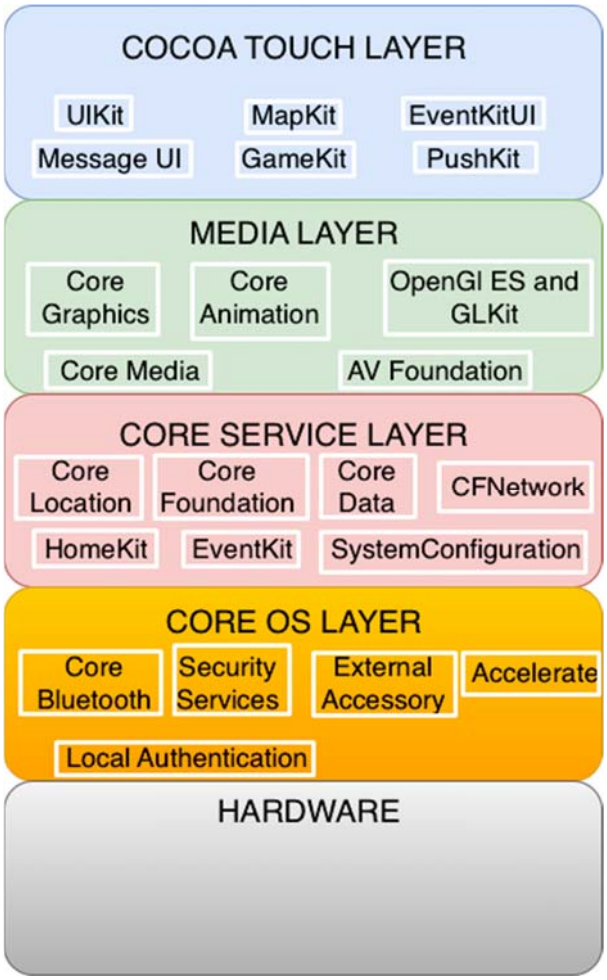
Android Applications

Android applications are usually developed in the Java language using the Android Software Development Kit.
Once developed, Android applications can be packaged easily and sold out either through a store such as **Google Play**, **SlideME**, **Opera Mobile Store**, **Mobango**, **F-droid** and the **Amazon Appstore**.

Android powers hundreds of millions of mobile devices in more than 190 countries around the world. It's the largest installed base of any mobile platform and growing fast. Every day more than 1 million new Android devices are activated worldwide.

iOS

The iOS is the operating system created by Apple Inc. for mobile devices. The iOS is used in many of the mobile devices for apple such as iPhone, iPod, iPad etc. The iOS is used a lot and only lags behind Android in terms of popularity.



The iOS architecture is layered. It contains an intermediate layer between the applications and the hardware so they do not communicate directly. The lower layers in iOS provide the basic services and the higher layers provide the user interface and sophisticated graphics.

Layers in iOS Architecture

The different layers as shown in the above diagram are given as follows −

Core OS

This is the bottom layer of the hierarchy and is responsible for the foundation of the operating system. The important layer responsible to managing memory allocating and releasing memory once the application has finished with it, taking care of the file system tasks, handling networking and other operating system tasks. It also interacts directly with the hardware.

These technologies include Core Bluetooth Framework, External Accessory Framework, Accelerate Framework, Security Services Framework, Local Authorization Framework etc.

Core Services

It is the third layer from the top of stack. The iPhone core service layer provides much of the foundation on which the above layers are built. It provides peer to peer services, iCloud storage, block objects, data protection, file sharing support, grand central dispatch, In app purchase, SQlite, XML support features.

Cloud kit Framework: The data can be moved between the app the iCloud using the Cloud kit Framework.

Core Foundation Framework: This provides the data management and service features for the iOS apps.

Core Data Framework: The data model of the model view controller app is handled using the Core Data Framework.

Address Book Framework: The address book framework provides access to the contacts database of the user.

Core Motion Framework: All the motion-based data on the device is accessed using core motion framework.

Health kit Framework: The health-related information of the user can be handled by this new framework.

Core Location Framework: This framework provides the location and heading information to the various apps.

Media layer

It is the second layer from the top of the stack. It provides the iphone OS with audio, video, animation and graphics capabilities. As with the other layers of the iPhone stack, the media layer comprises a number of frameworks that can be utilised when developing iPhone apps.

UI Kit Graphics: This provides support for designing images and animating the view content.
Core Graphics Framework: This provides support for 2-D vector and image based rendering and is the native drawing engine for iOS apps.
Core Animation: The Core Animation technology optimizes the animation experience of the apps.
Media Player Framework: This framework provides support for playing playlists and enables the user to use their iTunes library.

AV Kit: This provides various easy to use interfaces for video presentation.

Cocoa Touch

The cocoa touch layer contains key frameworks for building iOS. These frameworks define the appearance of your app. They also provide the basic app infrastructure and support for key technologies such as multitasking, touch-based input, push notifications and many high-level system services. When designing our apps, we should investigate the technologies in this layer first to see if they meet our needs
The cocoa touch layer provides the following frameworks −
Event Kit Framework: This shows the standard system interfaces using view controllers for viewing and changing calendar related events.
Game Kit Framework: This provides support for users to share their game related data online using Game center.
MapIt Framework: This provides a scrollable map which can be included into the app user interface.

Features of iOS operating System:

1. Highly Securer than other operating systems.
2. iOS provides multitasking features like while working in one application we can switch to another application easily.
3. iOS's user interface includes multiple gestures like swipe, tap, pinch, Reverse pinch.
4. iBooks, iStore, iTunes, Game Center, and Email are user-friendly.
5. It provides Safari as a default Web Browser.
6. It has a powerful API and a Camera.
7. It has deep hardware and software integration

Applications of IOS Operating System:

1. iOS Operating System is the Commercial Operating system of Apple Inc. and is popular for its security.
2. iOS operating system comes with pre-installed apps which were developed by Apple like Mail, Map, TV, Music, Wallet, Health, and Many More.
3. Swift Programming language is used for Developing Apps that would run on IOS Operating System.
4. In iOS Operating System we can perform Multitask like Chatting along with Surfing on the Internet.

Advantages of IOS Operating System:

The iOS operating system has some advantages over other operating systems available in the market especially the Android operating system. Here are some of them-

1. More secure than other operating systems.
2. Excellent UI and fluid responsive
3. Suits best for Business and Professionals

4. Generate Less Heat as compared to Android.

Disadvantages of IOS Operating System:

1. More Costly.
2. Less User Friendly as Compared to Android Operating System.
3. Not Flexible as it supports only IOS devices.
4. Battery Performance is poor.

Video conference

Video conferencing is a technology that allows users in different locations to hold face-to-face meetings without having to move to a single location together. This technology is particularly convenient for business users in different cities or even different countries because it saves the time, expense and hassle associated with business travel. Uses for video conferencing include holding routine meetings, negotiating business deals and interviewing job candidates.

Video conferencing may also involve sharing documents, various presentation materials, whiteboards, flip charts and similar group presentation visual aids. Video conferencing is differentiated from video phone calls, which serve individuals as opposed to a conference.

Components of a Generic Video Conferencing System:

Video Input: Webcams connected to computers or video cameras to capture the motion of participants.
Audio Input: Microphones to convert the voice of participants into an electrical signal which is then converted into a digital signal during processing.

Processing Unit: A data processing unit performs the function of converting the data into a packet stream for transmission on the transmitting end, and for receiving the network data and converting it into a presentable format on the receiving end.

Transmission Medium: The communication channel over which the data is transmitted from one place to another. It can be a telephone network or a digital internet broadband network. The network also might contain firewalls which are designed to block any kind of unwanted network traffic. Appropriate modules like Session Border Controllers are usually used on the network to detect various kinds of packets and to allow the videoconference packets to pass.

Output Unit: The output terminals are connected to the receiver unit to present the output in a suitable format. These are usually a monitor or screen for displaying the video and speakers to deliver the sound from the other end. Usually, all the components are present both in the transmission location and the receiving location as communication is bidirectional.

Classification of Video Conferencing Systems:

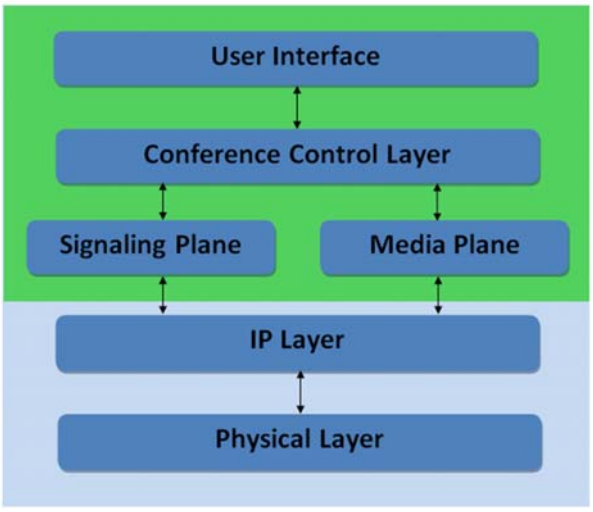
There can be two broad classifications of video conferencing equipment:

1. Standalone dedicated systems.
2. Desktop Systems.

Standalone Dedicated Systems: These are devices specially made for the sole purpose of video conferencing with every necessary component packaged into a single board or console which is connected to a high-quality camera, wired or wireless.

Desktop Systems: Web-cameras and microphones can be connected to desktop systems and software built for the purpose of videoconferencing installed on it to use a normal desktop system for video conferencing. The codec needs to be installed as a part of the software to support the transmission and reception of the data.

Architecture of Video Conferencing System:



The handling of the video conferencing process happens in a layered form with each layer interacting with the layer immediately below and above it and performing a certain essential function. These layers can be termed as (from top to bottom) User Interface, Conference Control Layer, Signalling Plane and Media Plane. We can always draw a comparison of these layers with the seven layers of the OSI.

User Interface: It acts as a bridge between the inner, complex world of bits and bytes and the external, world of the humans. These interfaces may be graphical, or voice interactive.. This layer is used for scheduling and setting up the call. Every configurable option of the system is presented to the user using this interface which ultimately affects the operation of the other lower layers of the console.

Conference Control Layer: The resource allocation, management and routing of the packets is performed at this layer. The creation, scheduling, session management, addition and removal of participants, and tear down of a conference take place at this layer.

Signalling Plane: This is a main part of the entire layered structure as the protocols responsible for having a successful video call run at this layer. The protocols are in the form of a code stack that signals the various endpoints to connect or tear down. The major protocols that have been used or are being used for video conferencing are the H.323 protocol and the Session Initiation Protocol (SIP). The session parameters and control of incoming and outgoing signals is done at this layer.

Media Plane: The mixing and streaming of audio and video streams takes place at this layer. It is analogous to the 4^{th} layer of the OSI i.e. the Transport layer (or let us say, it is resident in the 4^{th} layer itself). The protocols running at this layer are the User Datagram Protocol (UDP), Real-Time Transport Protocol (RTP) and Real-Time Transport Control Protocol (RTCP). The RTP and UDP carry payload parameter information like the type of codec, frame rate, size of the video etc. to the receiving end, while the RTCP is more of a quality control Protocol for error detection.

Advantages of Video Conferencing System: -

1. No time constraint: Video conferencing can be conducted at any time of the day. Time differences between countries do not matter when people use this method of communication because they do not actually need to travel to attend meetings.

2. Dramatic travel saving: Not only is video conferencing a direct replacement for many in-person business trip, but also there is virtually no cost for people to be involved in a virtual meeting, you can easily bring the right them together.

3. Easy communication: People can use video conferencing to communicate with anyone with HD video and other collaboration tools such as whiteboard, text exchange, file sharing, media sharing, screen sharing, remote control, electronic voting, conference recording etc.

4. Increased productivity: By eliminating time and district barriers, meetings can be hold anytime, anywhere with anyone. In this way, meetings are shorter and more effective. And also with the rich collaboration tools, decisions can be made faster.

Disadvantages of Video Conferencing System: -

1. Lack of personal interaction: Some meetings require a personal touch to be successful. Video conferencing can be less personal than meeting face to face, and it can be possible to miss out on vital body language when you're struggling with a pixelated image or stuttering video.

2.Technical problems: The major disadvantages are the technical difficulties associated with smooth transmissions that could result from software, hardware or network failure. Remote connections are sometimes known to be hampered by environmental changes. On some occasions, the absence of technical support personnel creates difficulty for participants who are unfamiliar with the videoconferencing technological concepts.

3. International time zones: One of the very real disadvantages of using video conferencing is that if you communicate regularly with people in other countries you will be available at different times to them. Unfortunately, without the skills of a time lord there's not really a practical way to overcome this.

4. High cost of setup: Setting up video conferencing in an office can be a bit expensive for small-sized companies. Simple features can fit into the budget, but if advanced features are required, then a substantial amount of expenditure must be done.

besides, many people argue that the following three issues hinder video conferencing from becoming an everyday technology.

1. **Eye Contact:** Eye contact is a prime essential of building a one-to-one conversation when video is available. However, the video conferencing systems may give an impression that the person is avoiding eye contact by looking elsewhere, while he had been looking in the screen all the time. This problem is partially resolved by having the camera in the screen itself. Much research is going on and image processing going on to achieve stereo reconstruction of the image to remove any such parallax effect.

2. **Camera Consciousness:** Being aware of being on camera has a psychological effect on people and many a times, also impairs communication rather than making it clear.

3. **Latency:** Apart from large bandwidth requirements, a small round trip time is required for reduced delays between frames. Any delay beyond 150-300ms becomes noticeable and distracting.

Other than these, mass adoption of videoconferencing is low because of the following probable causes:

1. **Complexity:** Most users are not technical and look forward for a simple interface.

2. **Lack of interoperability:** Many of the video conferencing systems cannot interconnect without an intervening gateway. The software solutions can seldom connect to hardware solutions. Different standards are being used by different people and hence additional configuration is required when connecting dissimilar systems.

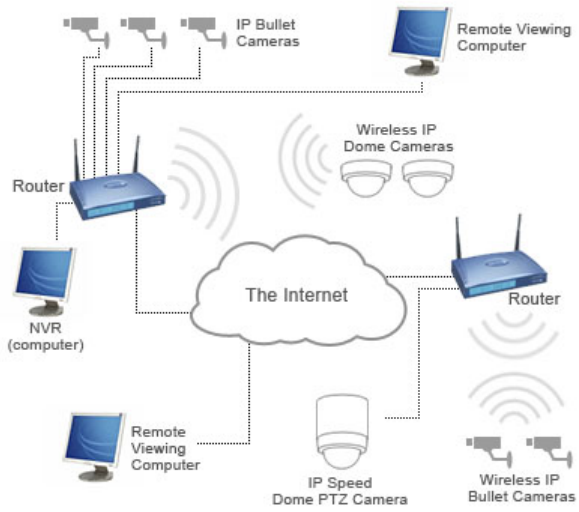
3. **Bandwidth and quality of service:** Most broadband connections being offered have dissimilar upload and download speeds. Upload speeds are often very less as compared to the download speeds and hence poses a bottleneck to the success of videoconferencing.

4. **Expense:** Dedicated videoconferencing systems have special considerations regarding the architecture of the rooms in which they will be installed like the acoustics and reverberations, and hence are not the only thing which incurs initial cost for setting up a conferencing system.

Webcam

webcam is a compact digital camera you can hook up to your computer to broadcast video images in real time (as they happen). Just like a digital camera, it captures light through a small lens at the front using a tiny grid of microscopic light-detectors built into an image-sensing microchip (either a **charge-coupled device (CCD)** or, more likely these days, a **CMOS image sensor**). As we'll see in a moment, the image sensor and its circuitry convert the picture in front of the camera into digital format a string of zeros and ones that a computer knows how to handle. Unlike a digital camera, a webcam has no built-in memory chip or flash memory card: it doesn't need to "remember" pictures because it's designed to capture and transmit them immediately to a computer. That's why webcams have USB cables coming out of the back. The USB cable supplies power to the webcam from the computer and takes the digital information captured by the webcam's image sensor back to the computer from where it travels on to the Internet. Some cams work wirelessly and don't need to be connected to a computer: typically, they use Wi-Fi to transmit their pictures to your Internet router, which can then make them available to other machines on your home network or, using the Internet, to anyone, anywhere in the world.

IP camera



An IP Camera (Internet Protocol) is one that sends and receives data via a computer network and the Internet (hence its name). These types of cameras are typically used for surveillance monitoring and are either “centralized” (meaning they require a central network video recorder to handle the recording, video and alarm management) or “decentralized” (meaning no NVR is necessary and the footage can be recorded and managed from any local or remote storage media). Though a webcam is essentially an internet-based camera, the term “IP” is typically reserved for surveillance equipment

WLAN or Wi-Fi

Wireless LANs refer to LANs (Local Area Networks) that use high frequency radio waves instead of cables for connecting the devices. It can be conceived as a set of laptops and other wireless devices communicating by radio signals. Users connected by WLANs can move around within the area of network coverage. Most WLANs are based upon the standard IEEE 802.11 or WiFi.

Configuration of Wireless LANs

Each station in a Wireless LAN has a wireless network interface controller. A station can be of two categories −

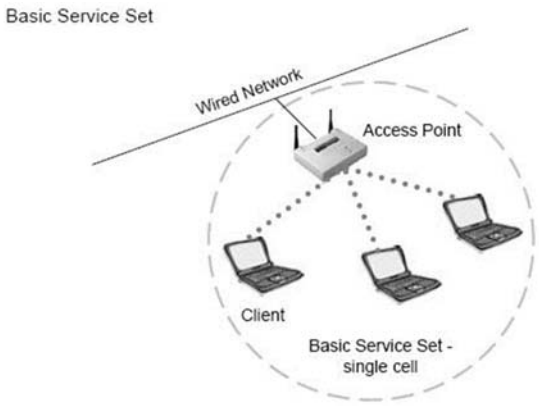
- **Wireless Access Point (WAP)** − WAPs or simply access points (AP) are generally wireless routers that form the base stations or access points. The APs are wired together using fiber or copper wires, through the distribution system.
- **Client** − Clients are workstations, computers, laptops, printers, smart phones etc. They are around tens of metres within the range of an AP.

IEEE 802.11 Architecture (WLAN-Wireless Local area network)

The IEEE 802.11 standard defines two kinds of service: the basic service(BSS) and the extended service set(ESS)

Basic service set:

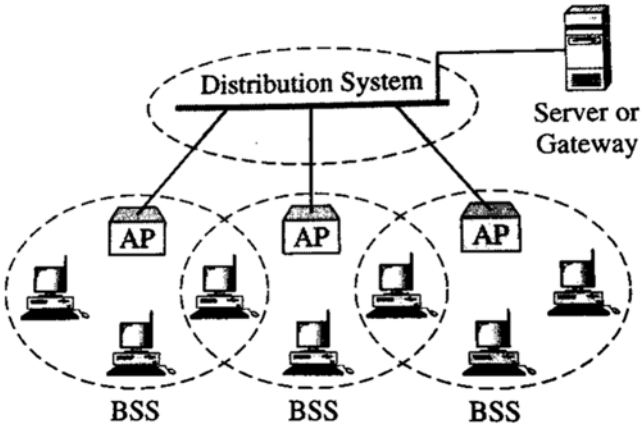
IEEE 802.11 defines the basic service set(BSS) as the building block of a wireless LAN. A basic service set is made of stationary or mobile wireless stations and a possible central base station, known as the access point(AP)



The BSS without an AP is a stand- alone network and cannot send data to other BSSs. It is what is called ad hoc architecture In this architecture, stations can form a network without the need of an AP; they can locate Each other and agree to be part of a BSS.

Extended Service set (ESS)

An ESS is made up of two or more BSSs with APs. In this case, the BSSs are connected through a distribution system, which is usually a wired LAN. The distribution system connects the APs in the BSSs. IEEE 802.11 does not restrict the distribution system; it can be any IEEE LAN such as Ethernet. Note that the ESS uses two types of stations: mobile and stationary. The mobile stations are normal stations inside a BSS. The stationary stations are AP stations that are part of a wired LAN



When BSSs are connected, we have what is called an infrastructure network. In this network, the stations within reach of one another can communicate without use of an AP. However, communication between two stations in two different BSSs usually occurs via two APs. The idea is similar communication in a cellular network if we consider each BSS to be a cell

and each AP to be a base station. Note that a mobile station can be belong to more than one BSS at the same time.

Types of WLAN Protocols

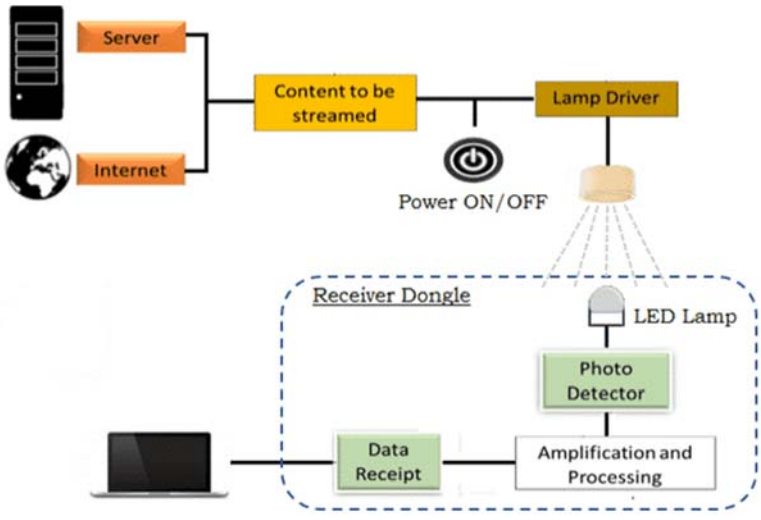
IEEE 802.11 or WiFi has a number of variations, the main among which are −

- **802.11a Protocol**− This protocol supports very high transmission speeds of 54Mbps. It has a high frequency of 5GHz range, due to which signals have difficulty in penetrating walls and other obstructions. It employs Orthogonal Frequency Division Multiplexing (OFDM).
- **802.11b Protocol** − This protocol operates within the frequency range of 2.4GHz and supports 11Mbps speed. It facilitates path sharing and is less vulnerable to obstructions. It uses Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) with Ethernet protocol.
- **802.11g Protocol** − This protocol combines the features of 802.11a and 802.11b protocols. It supports both the frequency ranges 5GHz (as in 802.11a standard) and 2.4GHz (as in 802.11b standard). Owing to its dual features, 802.11g is backward compatible with 802.11b devices. 802.11g provides high speeds, varying signal range, and resilience to obstruction. However, it is more expensive for implementation.
- **802.11n Protocol** − Popularly known as Wireless N, this is an upgraded version of 802.11g. It provides very high bandwidth up to 600Mbps and provides signal coverage. It uses Multiple Input/Multiple Output (MIMO), having multiple antennas at both the transmitter end and receiver ends. In case of signal obstructions, alternative routes are used. However, the implementation is highly expensive.

Lifi

Li-Fi-light fidelity is similar to Wi-Fi technology and it is one of the future wireless communication technologies. The main feature of this technology includes fully networked, bidirectional and high-speed wireless. Nowadays, the most trending domain in wireless communication is Wi-Fi and internet users are also being increased every year. For obtaining better speed, efficiency, bandwidth, Li-Fi technology has evolved. The data transmission in this technology can be done using light because the light intensity changes quicker than the human eye for capturing. The range of data transmission in L-Fi is faster 100 times than Wi-Fi.

The block diagram of Li-Fi system is shown below, and the transmitter section includes the input, timer circuit, an LED bulb. The input of the transmitter can be any kind of data like text, voice, etc. The timer circuit in this section is used to provide the necessary time intervals among every bit, and these are transmitted to the receiver end in the form of LED flashes.



The receiver section includes photodiode as well as amplifier. Here, photodiode receives the LED bulb flashes then changes the flashes into electrical signals. Finally, the amplifier receives the signals from the photodiode and amplifies to provide the output. Li-Fi uses normal LEDs to allow the data to transfer and increase the speed up to 224 Gigabits/sec.

Advantages of Li-Fi

- Ultra-fast data communication – no limit for data rate
- No interference like traditional radio waves
- Cost effective solutions – much cheaper than other wireless technologies
- High security data transmission – light can't penetrate through wall, wooden doors and metallic blocks
- Multiple device support – many devices without any limit and no network overloading
- Highly energy efficient solutions – energy spending for wireless data communication can be significantly reduced using Li-Fi implementation
- Scalable network for enterprise and home applications
- Highly reliable network – chances of device malfunctioning, interference from other sources are lesser compared to conventional network using radio waves
- Simple implementation – no need for expensive spectrum, equipment and antenna system

Limitations of Li-Fi

- Device must be compatible – Li-Fi enabled devices are required to configure network
- Any distraction could stop connection (requires line of sight communication)
- Integration and coordination of device manufacturers is required for standardization

Future applications of Li-Fi

- Smart home application for various appliances
- Wireless solutions for enterprise and offices
- Smart city applications
- Smart transport
- Hospitals and healthcare
- Security applications
- Most important data communication option for future 5G and IoT networks

Difference

Features	Li Fi	Wi Fi
Full name	Light Fidelity	IEEE (Institute of Electrical and Electronic Engineering) 802.11x
Work of operation	Transmission of data using light via LED bulbs	Transmission of data using radio waves via Wi Fi router
Technology	Present IrDA (Infrared Data Association) compliant devices	WLAN (Wireless Local Area Network) 802.a/b/g/n/ac/ad standard compliant devices
Practical Applications	Underwater communications, Security, Hospital, Industrial automation, Airplanes, Military, Retail, Museums, Trains, Car to Car communications, GPS, Augmented Reality, Virtual Reality	Security, Hospital, Vehicles, Industrial automation, Military, Retail, Museums, Trains, GPS, Augmented Reality, Virtual Reality
Interference	No interference issues	Interference issues from nearby access points
Transmission Security	Light cannot go through walls and therefore will provide a more secure data transfer	RF can go through walls and therefore need to employ techniques for secure data transfer
Data Transfer Speed	Can reach transfer speed between 1Gpbs to 20Gpbs	150Mpbs with WLAN 11n, 1Gbps to 2Gpbs with WiGig/Giga-IR
Frequency of operation	10,000 times frequency spectrum of radio waves	2.4GHz, 4.9GHz and 5GHz
Data Density	Work in High dense environments	Work in Less dense environments
Distance coverage	10 meters	Can reach 32 meters
System components	Lamp driver, LED bulb and photo detector	Installation of routers

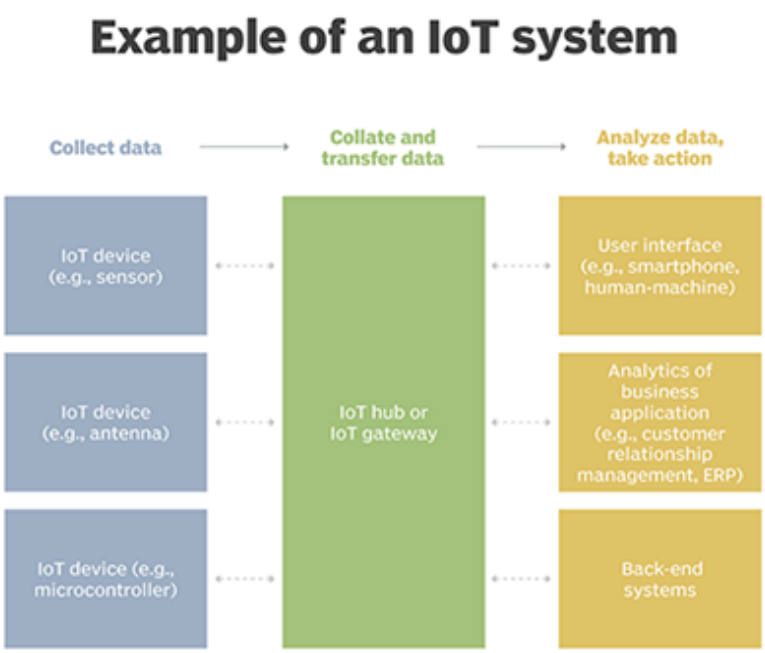
Internet of things (IoT)

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

A *thing* in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network.

Increasingly, organizations in a variety of industries are using IoT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business.

Working principle



An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed.
IoT can also make use of artificial intelligence (AI) and machine learning to aid in making data collecting processes easier and more dynamic.

Some of the advantages of IoT include the following:

- ability to access information from anywhere at any time on any device;
- improved communication between connected electronic devices;
- transferring data packets over a connected network saving time and money; and

- automating tasks helping to improve the quality of a business's services and reducing the need for human intervention.
-

Some disadvantages of IoT include the following:

- As the number of connected devices increases and more information is shared between devices, the potential that a hacker could steal confidential information also increases.
- Enterprises may eventually have to deal with massive numbers -- maybe even millions -- of IoT devices, and collecting and managing the data from all those devices will be challenging.
- If there's a bug in the system, it's likely that every connected device will become corrupted.
- Since there's no international standard of compatibility for IoT, it's difficult for devices from different manufacturers to communicate with each other.

IoT standards and frameworks

There are several emerging IoT standards, including the following:

- IPv6 over Low-Power Wireless Personal Area Networks (*6LoWPAN)* is an open standard defined by the Internet Engineering Task Force (IETF). The 6LoWPAN standard enables any low-power radio to communicate to the internet, including 804.15.4, Bluetooth Low Energy (BLE) and Z-Wave (for home automation).
- ZigBee is a low-power, low-data rate wireless network used mainly in industrial settings. ZigBee is based on the Institute of Electrical and Electronics Engineers (IEEE) 802.15.4 standard. The ZigBee Alliance created Dotdot, the universal language for IoT that enables smart objects to work securely on any network and understand each other.
- LiteOS is a Unix-like operating system (OS) for wireless sensor networks. LiteOS supports smartphones, wearables, intelligent manufacturing applications, smart homes and the internet of vehicles (IoV). The OS also serves as a smart device development platform.
- OneM2M is a machine-to-machine service layer that can be embedded in software and hardware to connect devices. The global standardization body, OneM2M, was created to develop reusable standards to enable IoT applications across different verticals to communicate.
- Data Distribution Service (DDS) was developed by the Object Management Group (OMG) and is an IoT standard for real-time, scalable and high-performance M2M communication.
- Advanced Message Queuing Protocol (AMQP) is an open source published standard for asynchronous messaging by wire. AMQP enables encrypted and interoperable messaging between organizations and applications. The protocol is used in client-server messaging and in IoT device management.
- Constrained Application Protocol (CoAP) is a protocol designed by the IETF that specifies how low-power, compute-constrained devices can operate in the internet of things.
- Long Range Wide Area Network (LoRaWAN) is a protocol for WANs designed to support huge networks, such as smart cities, with millions of low-power devices.

Global Positioning System (GPS)

Global Positioning System **(GPS)** is a navigation system based on satellite. It has created the revolution in navigation and position location. It is mainly used in positioning, navigation, monitoring and surveying applications.

A GPS system consists of a network of 24 orbiting satellites, called **NAVSTAR** (Navigation System with Time and Ranging), and placed in space in six different orbital paths with four satellites in each orbital plane and covering the entire earth under their signal beams.

GPS elements are divided into three segments

- space segment
- control segments
- user segment

Space segment:

GPS satellites fly in circular orbits at an altitude of twenty thousand and two hundred kilometer and with a period of 12 hours powered by solar cells. The satellites continuously orient themselves to point the solar panels toward the Sun and the antenna towards the earth. Orbital planes are centered on the earth orbits are designed so that at least six satellites are always within line of sight from any location on the planet.

Control segment:

The control segment consists of three entities the control segment

- master control system
- monitor stations
- ground antennas
-

Master control station:

The master control station located at Falcon Air Force Base in Colorado Springs. It is responsible for overall management of the remote monitoring and transmission sites. Checkup is performed twice a day by each of six stations as the satellites complete their journeys around the earth can reposition satellites to maintain an optimal GPS constellation.

Monitor station:

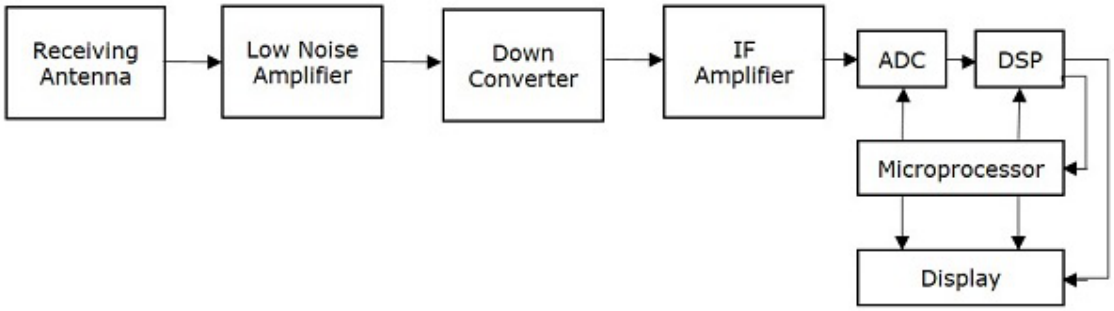
Monitor stations checks the exact altitude position speed and overall health of orbiting satellites. The control segment ensures that the GPS satellite orbits and clock remains within acceptable limits. A station can track up to 11 satellites at a time. This checkup is performed twice a day by each station.

Ground antennas:

Ground antennas monitor and track the satellite from horizon– to horizon. They also transmit correction information. They also transmit correct information to individual satellites and communicate with the GPS satellites for command and control purposes.

User Segment:

GPS receivers are generally composed of



The function of each block present in GPS receiver is mentioned below.

- **Receiving Antenna** receives the satellite signals. It is mainly, a circularly polarized antenna.
- **Low Noise Amplifier** (LNA) amplifies the weak received signal
- **Down converter** converts the frequency of received signal to an Intermediate Frequency (IF) signal.
- **IF Amplifier** amplifies the Intermediate Frequency (IF) signal.
- **ADC** performs the conversion of analog signal, which is obtained from IF amplifier to digital. Assume, the sampling & quantization blocks are also present in ADC (Analog to Digital Converter).
- **DSP** (Digital Signal Processor) generates the C/A code.
- **Microprocessor** performs the calculation of position and provides the timing signals in order to control the operation of other digital blocks. It sends the useful information to Display unit in order to display it on the screen.