

BE 8251-BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK WITH ANSWERS

UNIT-1 ELECTRICAL CIRCUITS & MEASUREMENTS

PART-A:

1. State ohm's law.(N/D-2016)

The potential difference across any two ends of a conductor is directly proportional to the current flowing between the two ends provided the temperature of the conductor remains constant.

2. Compare moving coil and moving iron instruments.(N/D-2016)

S.No	M.C Instruments	M.I Instruments
1	More accurate	Less accurate
2	Uniform scale	Non-uniform scale (scale cramped at beginning and finishing)
3	Eddy current damping is used	Air friction damping is used
4	Controlling torque is provided by spring	Controlling torque is provided by gravity or spring

3. List the operating forces present in indicating instruments.(M/J-2016)

In an indicating instrument, it is essential that the moving system is acted upon by three distinct torque (or forces) for satisfactory working. There torques are:

1. A deflecting or operating torque, T_d
2. A controlling torque, T_c
3. A damping torque, T_v .

4. State ohm's law and its limitations.(N/D-2015)

Ohm's law:

The potential difference across any two ends of a conductor is directly proportional to the current flowing between the two ends provided the temperature of the conductor remains constant.

Limitation of Ohm's Law:

The limitations of Ohm's law are explained as follows: This law cannot be applied to unilateral networks. A unilateral network has unilateral elements like diode, transistors, etc., which do not have same voltage current relation for both directions of current.

5. Mention the errors in moving coil instruments.(N/D-2015)

The errors that usually occur in PMMC instruments are

1. The frictional error.
2. Temperature error.

3. The error owing weakening of permanent magnet.
4. Stray magnetic field error.
5. Thermo-electric error.
6. Observational error.

6. Mention the errors in moving iron instruments. (A/M-2015)

- Hysteresis error
- Temperature error
- Stray magnetic field error
- Frequency error
- Eddy current error

7. State kirchoff's voltage law. (A/M-2015)

KVL states that the algebraic sum of voltages in a closed path is zero.

8. Define power factor.(A/M-2017)

The ratio of the actual electrical power dissipated by an AC circuit to the product of the r.m.s. values of current and voltage.

9. What is the main difference between moving coil and moving iron instruments?(N/D-2016-2008 reg)

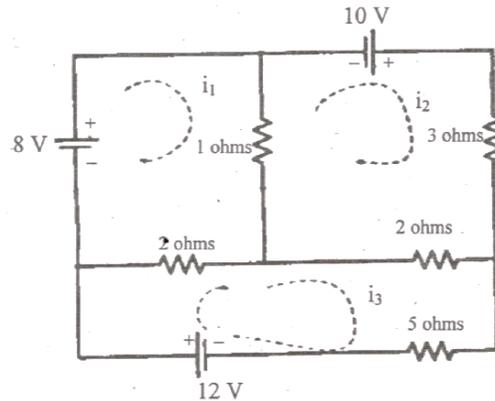
M.C Instruments	M.I Instruments
1. MC type instruments are more accurate.	1. MI type are less accurate than MC type.
2. Manufacturing cost is high.	2. Cheap in cost.
3. Reading scale is uniformly distributed.	3. Non-uniform scale (scale cramped at beginning and finishing)
4. Very sensitive in construction & for input.	4. Robust in construction.
5. Low power consumption	5. Slightly high power consumption.
6. Eddy current damping is used.	6. Air friction damping is used.
7. Can be used only for D.C measurements.	7. Can be used for A.C as well as for D.C measurements

10. Define RMS value.(M/J-16)

The effective value of an alternating current is that value of steady ,direct current which produces the same heat as that produced by the alternating current when passed which produces the same heat as that produced by the alternating current when passed through the same resistance for the same interval of time.

PART-B:

1. For the given circuit, determine the current in 5Ω resistor.(N/D-16)



SOLUTION:

Applying KVL, at loop 1

$$3I_1 - I_2 - 2I_3 = 8$$

Applying KVL, at loop 2

$$-I_1 + 6I_2 + 2I_3 = 10$$

Applying KVL, at loop 3

$$-2I_1 - 2I_2 + 9I_3 = 12$$

Current through the 5ohm resistor is 3.38A

2. Explain the construction and working of an energy meter. (N/D-16),(M/J-2016)

Energy meters are the basic part to measure the power consumption. It is used everywhere, no matter how big or small consumption it is. It is also known as watt-hour meter. Here we discuss the construction and working principle of induction type energy meter. To understand the structure of watt-hour meter, we must understand the four essential components of the meter. These components are as follows:

1. Driving system
2. Moving system
3. Braking system
4. Registering system

1. Driving System:

- The components of this system are two silicon steel laminated electromagnets. The upper electromagnet is called shunt magnet and it carries a voltage coil consisting of many turns of thin wire. The lower electromagnet is called series magnet and it carries the two current coils consisting of a few turns of thick wire.

- Current coils are connected in series with the circuit and load current passes through it. Where as voltage coil is connected to the supply mains and produce a high ratio of inductance to resistance. There is copper bands in the lower part of shunt magnet which provides frictional compensation so that the phase angle between shunt magnetic flux and the supply voltage is exactly 90° .

2. Moving System

- As you can see in the figure, there is a thin aluminum disk placed in the gap between the two electromagnets and mounted on a vertical shaft. The eddy currents are induced in the aluminum disk when it cuts the flux produced by both the magnets.
- As a result of interference of eddy currents and two magnetic fields constitute a deflecting torque in the disk. As you start consuming power the disk slowly starts rotating and the several rotation of the disk displays the power consumption, in the particular interval of time. Normally it is measured in kilowatt-hours.

3. Braking System

The main part of this system is a permanent magnet called brake magnet. It is located near the disk so that eddy currents are induced in it due to movement of rotating disk through the magnetic field. This eddy current reacts with the flux and exerts a braking torque which opposes the motion of the disk. The speed of the disk can be controlled by changing flux.

4. Registering System

As its name suggest, it registers the number of rotation of the disk which is proportional to the energy consumed directly in kilowatt-hour. There is a disk spindle which is driven by a gear on the disk shaft and indicates the number of times the disk has turned.

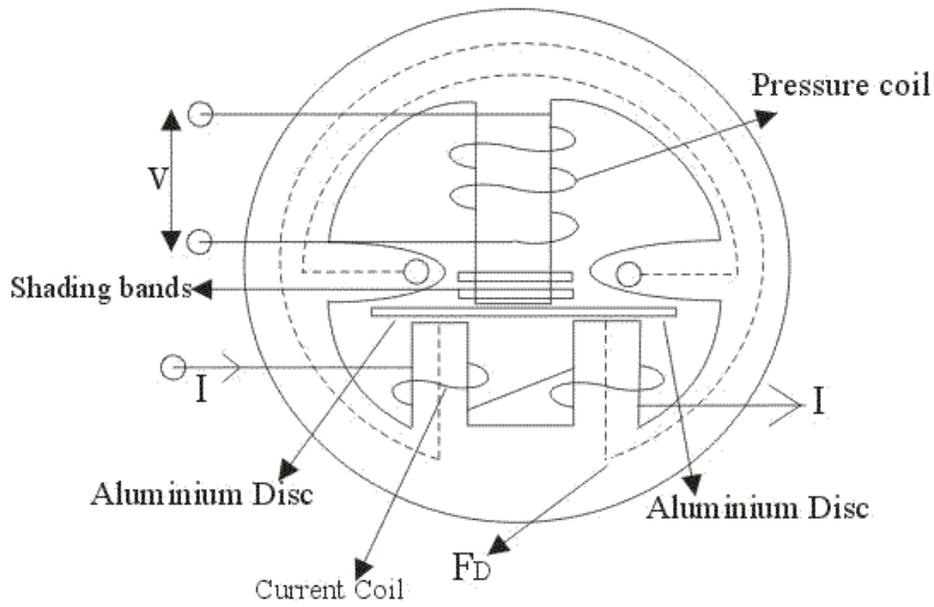
Working Principle of Energy Meter

The working of single phase induction type energy meters are based on two main fundamentals:

1. Rotation of aluminum disk.
2. Arrangement of counting and displaying the amount of energy consumed.

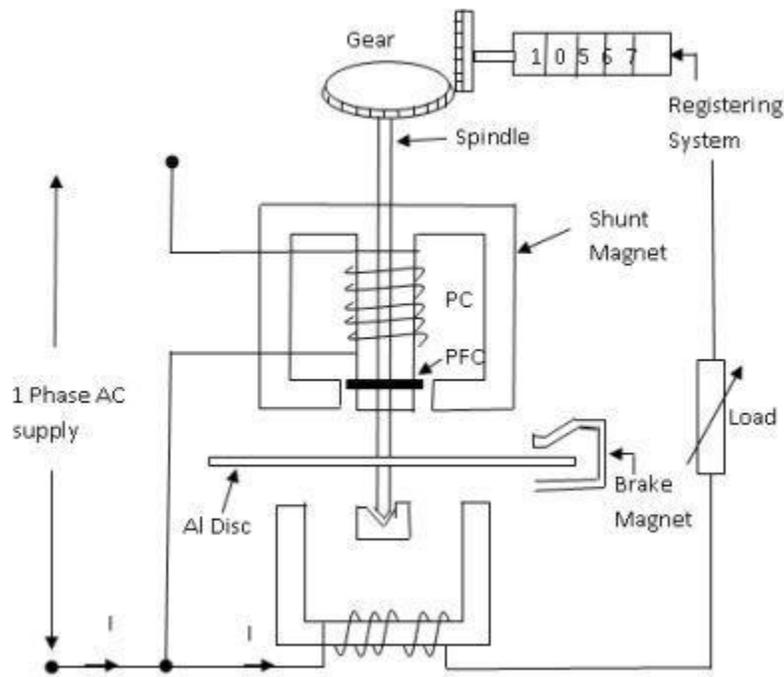
1. Rotation of an Aluminum Disk

- The rotation of metallic disk is operated by two coils. Both the coils are arranged in such way that one coil produces a magnetic field in proportion to voltage and the other coil creates a magnetic field proportion to current.
- The field produced by voltage coil is delayed by 90° so that eddy current is induced in the disk. The force exerted on the disk by the two fields is proportional to the product of the immediate current and voltage in the coils.
- As a result of it, a lite weight aluminum disk rotates in an air gap. But there is a need to stop a disk when there is no power supply. A permanent magnet works as a brake which opposes the rotation of the disk and balances the speed of rotation with respect to power consumption.



Arrangement of Counting and Displaying the Energy Consumed

- In this system, the rotation of the floating disk has been counted and then displayed on the meter window. The aluminum disk is connected to a spindle which has a gear.
- This gear drives the register and the revolution of the disk has been counted and displayed on the register which has series of dials and each dial represent a single digit.



- In this type of meter, a non-magnetic and electrically conductive aluminum metal disc is made to revolve in a magnetic field. The rotation is made possible with the power passing through it. The rotation speed is proportional to the power flow through the meter.
- Gear trains and counter mechanisms are incorporated to integrate this power. This meter works by counting the total number of revolutions and it is relative to the usage of energy. A series magnet is connected in series with the line and that comprises of a coil of few turns with thick wire. A shunt magnet is connected in shunt with the supply and comprises of a coil of large number of turns with thin wire.
- A braking magnet which is a permanent magnet is included for stopping the disc at the time of power failure and to place the disc in position. This is done by applying a force opposite to the rotation of the disc.
- A flux is produced by the series magnet that is directly proportional to the current flow and another flux is produced by the shunt magnet corresponding to the voltage. Because of the inductive nature, these two fluxes lag each other by 90° .
- An eddy current is developed in the disc which is the interface of the two fields. This current is produced by a force that is corresponding to the product of instantaneous current, voltage and the phase angle among them. A break torque is developed on the disc by the braking magnet positioned over one side of the disc.
- The speed of the disc becomes constant when the following condition is achieved, Braking torque = Driving torque. The gear arrangement linked with the shaft of the disc is implemented for recording the number of revolution. This is for single phase AC measurement. Additional number of coils can be implemented for different phase configuration.

$$Power = \frac{3600.Kh}{time\ in\ sec\ for\ one\ revolution\ of\ the\ disc}$$

3. A series has $R=5\Omega$, $L=0.15mH$, and $C=100\mu F$ and is supplied with 230V,50Hz single phase. Find impedance, current, power, power factor of the circuit. (M/J-2016).

Solution:

Impedance: Z

Inductive Reactance, X_L .

$$X_L = 2\pi fL = 2\pi \times 50 \times 0.15 = 47.13\Omega$$

Capacitive Reactance, X_C .

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}} = 31.83 \Omega$$

Circuit Impedance, Z.

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

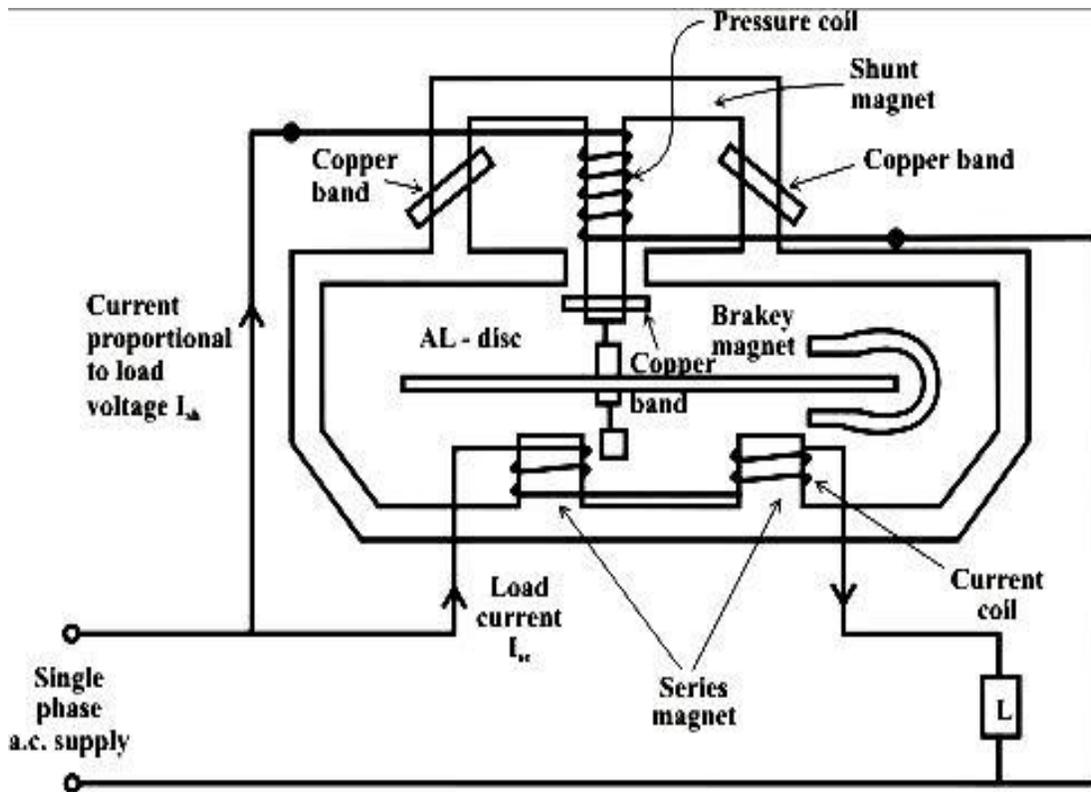
$$Z = \sqrt{12^2 + (47.13 - 31.83)^2}$$

$$Z = \sqrt{144 + 234} = 19.4 \Omega$$

4. Explain the construction and principle of operating single phase energy meter.(M/J-2016).

Construction of AC Energy Meter:

- Energy meters are the basic part to measure the power consumption. It is used everywhere, no matter how big or small consumption it is. It is also known as watt-hour meter.
- Here we discuss the construction and working principle of induction type energy meter. To understand the structure of watt-hour meter, we must understand the four essential components of the meter. These components are as follows:
 1. Driving system
 2. Moving system
 3. Braking system
 4. Registering system
- The components of this system are two silicon steel laminated electromagnets. The upper electromagnet is called shunt magnet and it carries a voltage coil consisting of many turns of thin wire.
- Where as voltage coil is connected to the supply mains and produce a high ratio of inductance to resistance. There is copper bands in the lower part of shunt magnet which provides frictional compensation so that the phase angle between shunt magnet flux and the supply voltage is exactly 90° .

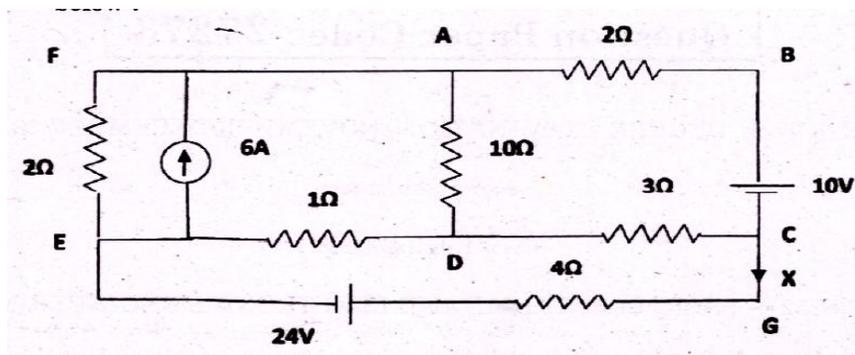


Types of Watt Hour Meter

Basically, the watt-hour meter is classified into three different types as follows:

- Electromechanical type induction meter
- Electronic energy meter
- Smart energy meters

5. Determine the current, power 'X' in the 4ohm resistance of the circuit shown in below. (N/D-2015)



Solution: i) total current = 4.5A, ii) Power in the 4ohm resistance is 81W.

6. Draw and explain the working principle of attraction type, repulsion type moving iron instruments and derive its deflecting torque.(N/D-2015,A/M-2015,M/J-2016)

CLASSIFICATION OF MOVING IRON INSTRUMENTS:

Moving iron instruments are of two types

- i. Attraction type.
- ii. Repulsion type

Attraction type:

- The coil is flat and has a narrow slot like opening.
- The moving iron is a flat disc or a sector eccentrically mounted.
- When the current flows through the coil, a magnetic field is produced and the moving iron moves from the weaker field outside the coil to the stronger field inside it or in other words the moving iron is attracted in.
- The controlling torque is provide by springs hut gravity control can be used for panel type of instruments which are vertically mounted.
- Damping is provided by air friction with the help of a light aluminium piston (attached to the moving system) which move in a fixed chamber closed at one end as shown in Fig. or with the help of a vane (attached to the moving system) which moves in a fixed sector shaped chamber.

Repulsion Type:

- In the repulsion type, there are two vanes inside the coil one fixed and other movable.
- These are similarly magnetized when the current flows through the coil and there is a force of
- repulsion between the two vanes resulting in the movement of the moving vane. Two different
- designs are in common use

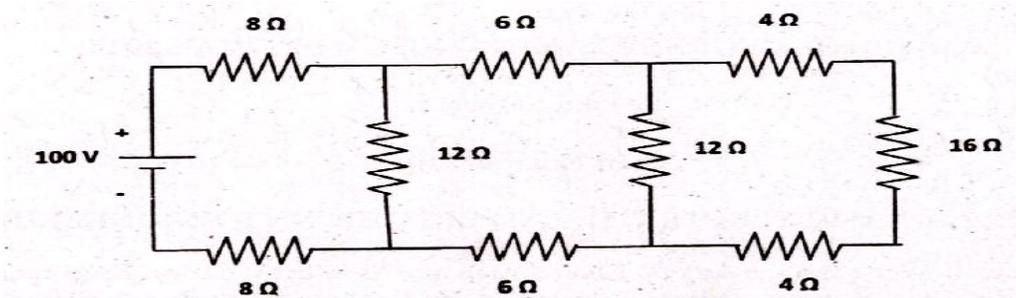
Radial Vane Type

In this type, the vanes are radial strips of iron .The fixed vane is attached to the coil and the movable one to the spindle of the instrument

Co-axial Vane Type

- In this type of instrument, the fixed and moving vanes are sections of co axial cylinders. The controlling torque is provided by springs. Gravity control can also be used in vertically mounted instruments. The damping torque is produced by air friction as in attraction type instruments
- The operating magnetic field in moving iron instruments is very weak and therefore eddy current damping is not used in them as introduction of a permanent magnet required for eddy current damping would destroy the operating magnetic field.

7. Calculate (i) equivalent resistance across the terminal of the supply (ii) total current supplied by the source, (iii) power delivered to the 100V battery of the circuit shown in below. (A/M-2015)

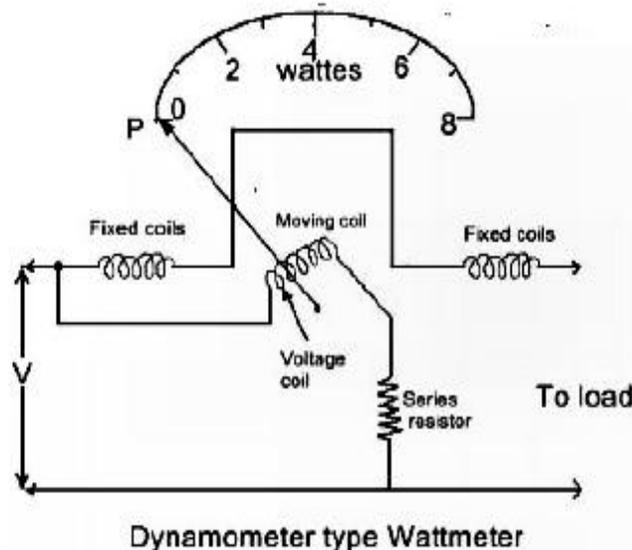


Solution:

- i) Equivalent resistance $R_t = V / I$
 $= 100/4.25$
 $= 23.5\text{Ohm}$
- ii) Total current $I = V / R = 100/23.5$
 $= 4.25\text{A}$
- iii) Power delivered to the 16ohm resistor $P = V \cdot I = 425\text{Watts}$

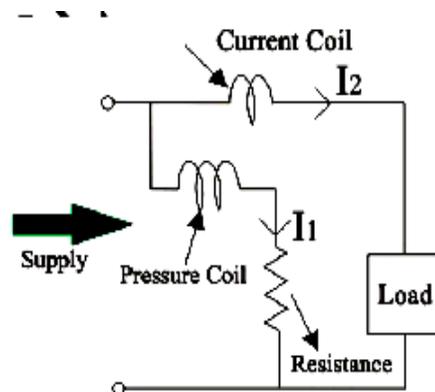
8. Explain the construction and working of dynamometer type wattmeter. Mention its merits and demerits. (A/M-2017, N/D-2016, N/D-2015, M/J-2016)

- It very essential to know the principle of working of electro-dynamometer type wattmeter. Dynamometer type wattmeter works on very simple principle and this principle can be stated as "when any current carrying conductor is placed inside a magnetic field, it experiences a mechanical force and due this mechanical force deflection of conductor takes place".



Construction and Working Principle of Electrodynamometer Type Wattmeter:

- Now let us look at constructional details of electro-dynamometer. It consists of following parts there are two types of coils present in the electro-dynamometer. They are moving coil moves the pointer with the help of spring control instrument.
- A limited amount of current flows through the moving coil so as to avoid heating. So in order to limit the current we have connect the high value resistor in series with the moving coil. The moving is air cored and is mounted on a pivoted spindle and can moves freely.
- In electro-dynamometer type wattmeter, moving coil works as pressure coil. Hence moving coil is connected across the voltage and thus the current flowing through this coil is always proportional to the voltage.
- Fixed Coil The fixed coil is divided into two equal parts and these are connected in series with the load, therefore the load current will flow through these coils. Now the reason is very obvious of using two fixed coils instead of one, so that it can be constructed to carry considerable amount of electric current.
- These coils are called the current coils of electro-dynamometer type wattmeter. Earlier these fixed coils are designed to carry the current of about 100 amperes but now the modern wattmeter are designed to carry current of about 20 amperes in order to save power. Control System Out of two controlling systems i.e.
 - i. Gravity control
 - ii. Spring control
- Damping System Air friction damping is used, as eddy current damping will distort the weak operating magnetic field and thus it may leads to error. Scale there is uniform scale is used in these types of instrument as moving coil moves linearly over a range of 40 degrees to 50 degrees on either sides.
- Now let us derive the expressions for the controlling torque and deflecting torques. In order to derive these expressions let us consider the circuit diagram given below:



Advantages of Electrodynamometer Type Wattmeter

Following are the advantages of electro-dynamometer type wattmeter and they are written as follows:

1. Scale is uniform upto certain limit.
2. They can be used for both to measure ac as well dc quantities as scale is calibrated for both.

Disadvantages of Electrodynamometer Type Wattmeter

1. Errors in the pressure coil inductance.
2. Errors may be due to pressure coil capacitance.
3. Errors may be due to mutual inductance effects.
4. Errors may be due connections.(i.e. pressure coil is connected after current coil)
5. Error due to Eddy currents.

9. An alternating voltage is given by $V=230\sin 314t$. Calculate i) frequency, ii) maximum value, iii) average value, iv) RMS value. (N/D-2016)

Solution:

- i) Frequency $F = 1/T = 43.5 \text{ Hz}$
- ii) Maximum value $V_m = V_{rms}/\sqrt{2} = 230/\sqrt{2} = 115 \text{ V}$
- iii) Average value: 35.6 V
- iv) RMS value = Avg value / form factor = $35.6 / 1.11 = 32.07 \text{ V}$

10. With the help of diagrams, explain the construction and working principle of permanent magnet moving coil instruments. obtain the expression for its deflecting torque.(N/D-2015)

Several electrical machines and panels are fitted onboard so that the ship can sail from one port to another, safely and efficiently. The electrical machinery and system require scheduled maintenance and checks to avoid any kind of breakdown during sailing.

Permanent Magnet Moving Coil: Principle of Working:

When a current carrying conductor is placed in a magnetic field, it experiences a force and tends to move in the direction as per Fleming's left hand rule.

Fleming left hand rule:

If the first and the second finger and the thumb of the left hand are held so that they are at right angle to each other, then the thumb shows the direction of the force on the conductor, the first finger points towards the direction of the magnetic field and the second finger shows the direction of the current in the wire.

Equation involved

The interaction between the induced field and the field produced by the permanent magnet causes a deflecting torque, which results in rotation. The three important torque involved in this instrument are:

Deflecting torque

The force F which will be perpendicular to both the direction of the current flow and the direction

of magnetic field as per the Fleming's left hand rule can be written as

$$F = NBIL$$

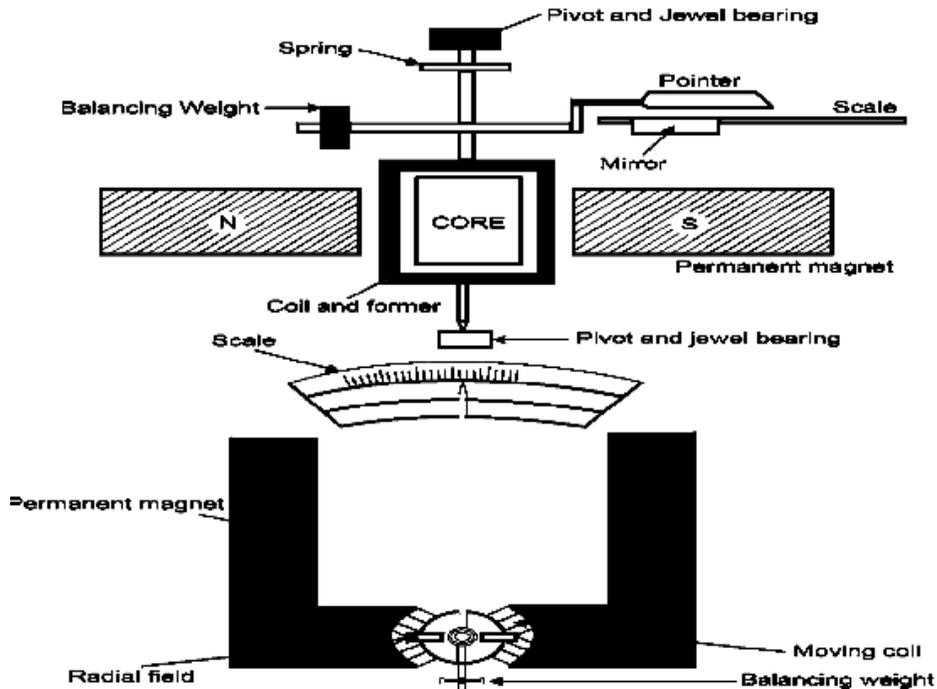
Where,

N: turns of wire on the coil

B: flux density in the air gap

I: current in the movable coil

L: vertical length of the coil



Theoretically the torque (here electro-magnetically torque) is equal to the multiplication of force with distance to the point of suspension. Hence Torque on left side of the cylinder

$$TL = NBIL \times W/2 \text{ and torque on right side of the cylinder } TR = NBIL \times W/2$$

Therefore the total torque will be = $TL + TR$

$$T = NBILW \text{ or } NBIA \text{ where } A \text{ is effective area } (A = L \times W)$$

Controlling Torque:

- This torque is produced by the spring action and opposes the deflection torque so as the pointer can come to rest at the point where these two torques are equal (Electromagnetic torque = control spring torque).
- The value of control torque depends on the mechanical design of spiral springs and strip suspensions. The controlling torque is directly proportional to the angle of deflection of the coil.

Control torque $C_t = C\theta$ where, θ = deflection angle in radians and C = spring constant Nm / rad .

Damping torque:

This torque ensures the pointer comes to an equilibrium position i.e. at rest in the scale without oscillating to give accurate reading. In PMMC as the coil moves in the magnetic field, eddy current sets up in a metal former or core on which the coil is wound or in the circuit of the coil itself which opposes the motion of the coil resulting in slow swing of pointer and then come to rest quickly with very little oscillation

Construction:

- A coil of thin wire is mounted on an aluminum frame (spindle) positioned between the poles of a U shaped permanent magnet which is made up of magnetic alloys like alnico.

The coil is pivoted on the jeweled bearing and thus the coil is free to rotate.

- The current is fed to the coil through spiral springs which are two in numbers. The coil which carries current, which is to be measured, moves in a strong magnetic field produced by a permanent and a pointer is attached to the spindle which shows the measured value

Working:

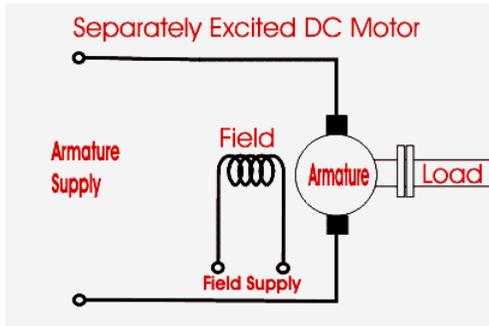
- When a current flow through the coil, it generates a magnetic field which is proportional to the current in case of an ammeter. The deflecting torque is produced by the electromagnetic action of the current in the coil and the magnetic field.
- When the torques are balanced the moving coil will stopped and its angular deflection represent the amount of electrical current to be measured against a fixed reference, called a scale. If the permanent magnet field is uniform and the spring linear, then the pointer deflection is also linear.
- Torque is provided by two phosphorous bronze flat coiled helical springs. These springs serve as a flexible connection to the coil conductors. Damping is caused by the eddy current set up in the aluminum coil which prevents the oscillation of the coil.

UNIT-2 ELECTRICAL MACHINES

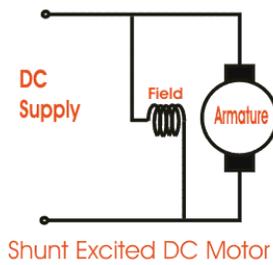
PART-A:

1. Draw the circuit for various types of d.c motor. (N/D-2016)

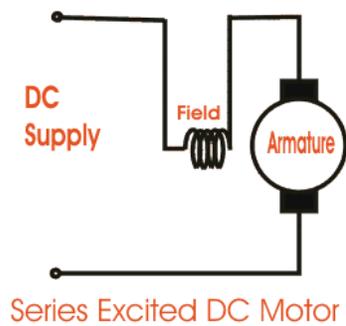
Separately Excited DC Motor



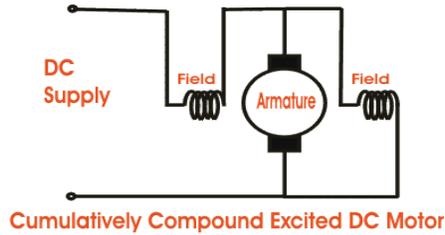
DC Shunt Motor



DC Series Motor



DC Compound Motor



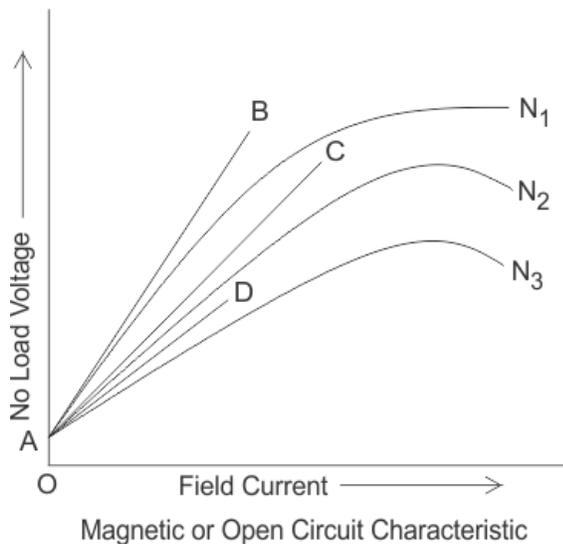
2. Define voltage regulation of transformer. (N/D-2016, M/J-2016)

The voltage regulation of the transformer is the percentage change in the output voltage from no-load to full-load.

3. Sketch the O.C.C of dc shunt generator. (M/J-2016)

Critical Load Resistance of Shunt Wound DC Generator

This is the minimum external load resistance which is required to excite the shunt wound generator



4. Write down the EMF equation of a transformer. (M/J-2016)

$$E_1 = 4.44 \cdot N_1 \cdot f \cdot B_m \cdot A \text{ and } E_2 = 4.44 \cdot N_2 \cdot f \cdot B_m \cdot A$$

5. List out the types of induction motor. (N/D-2015)

Induction motor types:

- Polyphase cage rotor.
- Polyphase wound rotor.
- Two-phase servo motor.
- Single-phase induction motor.
- Polyphase synchronous motor.

- Single-phase synchronous motor.
- Hysteresis synchronous motor.

6. Give some application of D.C motor. (A/M-2015,N/D-2016)

Shunt : driving constant speed, lathes, centrifugal pumps, machine tools, blowers and fans, reciprocating pumps

Series : electric locomotives, rapid transit systems, trolley cars, cranes and hoists, conveyors

Compound : elevators, air compressors, rolling mills, heavy planners

7. Why a single phase induction motor does not self -start? (A/M-2015, A/M-2017,N/D-2016)

When a single phase supply is fed to the single phase induction motor. Its stator winding produces a flux which only alternates along one space axis. It is not a synchronously revolving field, as in the case of a 2 or 3phase stator winding, fed from 2 or 3 phase supply.

8. Mention the application of DC generator? (A/M-2017)

- general lighting.
- Used to charge battery because they can be made to give constant output voltage.
- They are used for giving the excitation to the alternators.
- used for small power supply.

9. What is the significance of back EMF? (A/M-2017)

- When the motor is running on no load, small torque is required to overcome the friction and windage losses. Therefore, the armature current I_a is small and the back emf is nearly equal to the applied voltage.
- If the motor is suddenly loaded, the first effect is to cause the armature to slow down. Therefore, the speed at which the armature conductors move through the field is reduced and hence the back emf E_b falls. The decreased back emf allows a larger current to flow through the armature and larger current means increased driving torque. Thus, the driving torque increases as the motor slows down. The motor will stop slowing down when the armature current is just sufficient to produce the increased torque required by the load.
- If the load on the motor is decreased, the driving torque is momentarily in excess of the requirement so that armature is accelerated. As the armature speed increases, the back emf E_b also increases and causes the armature current I_a to decrease. The motor will stop accelerating when the armature current is just sufficient to produce the reduced torque required by the load.

10. Write the principle of DC Motor?(N/D-2015)

Fleming's left hand rule to determine the direction of force acting on the armature conductors of DC motor. If a current carrying conductor is placed in a magnetic field perpendicularly, then the conductor experiences a force in the direction mutually perpendicular to both the direction of field and the current carrying conductor. Fleming's left hand rule says that if

we extend the index finger, middle finger and thumb of our left hand perpendicular to each other, in such a way that the middle finger is along the direction of current in the conductor, and index finger is along the direction of magnetic field i.e. north to south pole, then thumb indicates the direction of created mechanical force

PART-B

1. With a neat circuit diagram Explain the construction and principle of operation of DC Motor. (N/D-2016, N/D-2015, M/J-2017)

DC MOTOR – INTRODUCTION:

A machine that converts dc power into mechanical energy is known as dc motor. Its operation is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. The direction of the force is given by Fleming's left hand rule.

WORKING OF DC MOTOR:

- There are different kinds of D.C. motors, but they all work on the same principles. When a permanent magnet is positioned around a loop of wire that is hooked up to a D.C. power source, we have the basics of a D.C. motor.
- In order to make the loop of wire spin, we have to connect a battery or DC power supply between its ends, and support it so it can spin about its axis.
- To allow the rotor to turn without twisting the wires, the ends of the wire loop are connected to a set of contacts called the commutator, which rubs against a set of conductors called the brushes.
- The brushes make electrical contact with the commutator as it spins, and are connected to the positive and negative leads of the power source, allowing electricity to flow through the loop. The electricity flowing through the loop creates a magnetic field that interacts with the magnetic field of the permanent magnet to make the loop spin

PRINCIPLES OF OPERATION:

It is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's Left- hand rule and whose magnitude is given by

$$\text{Force, } F = B I l \text{ newton}$$

Where,

B is the magnetic field in weber/m²

I is the current in amperes and

l is the length of the coil in meter

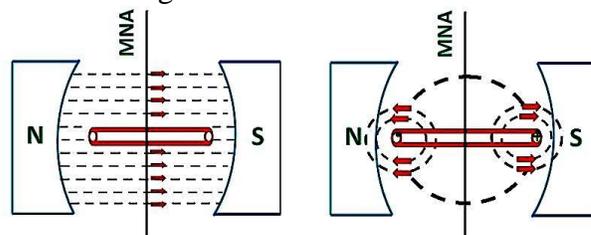


Figure A

Figure B

The force, current and the magnetic field are all in different directions. If an Electric current flows through two copper wires that are between the poles of a magnet, an upward force will move one wire up and a downward force will move the other wire down.

2.Explain the construction, working principle of single phase Induction motor.(N/D-2016)

Single phase motors are very widely used in home, offices, workshops etc. as power delivered to most of the houses and offices is single phase. In addition to this, single phase motors are reliable, cheap in cost, simple in construction and easy to repair.

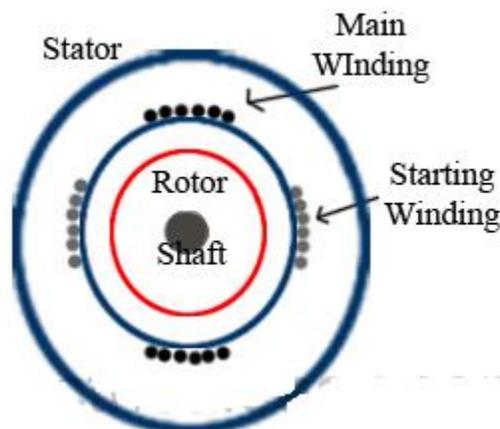
Single phase electric motors can be classified as:

1. Single phase induction motor (Split phase, Capacitor and shaded pole etc)
2. Single phase synchronous motor
3. Repulsion motor etc.

Single Phase Induction Motor

CONSTRUCTION:

Construction of a single phase induction motor is similar to the construction of three phase induction motor having squirrel cage rotor, except that the stator is wound for single phase supply. Stator is also provided with a 'starting winding' which is used only for starting purpose. This can be understood from the schematic of single phase induction motor at the left.



Working Principle Of Single Phase Induction Motor:

- When the stator of a single phase motor is fed with single phase supply, it produces alternating flux in the stator winding. The alternating current flowing through stator winding causes induced current in the rotor bars (of the squirrel cage rotor) according to Faraday's law of electromagnetic induction.

- This induced current in the rotor will also produce alternating flux. Even after both alternating fluxes are set up, the motor fails to start. However, if the rotor is given an initial start by external force in either direction, then the motor accelerates to its final speed and keeps running with its rated speed. This behavior of a single phase motor can be explained by double-field revolving theory.

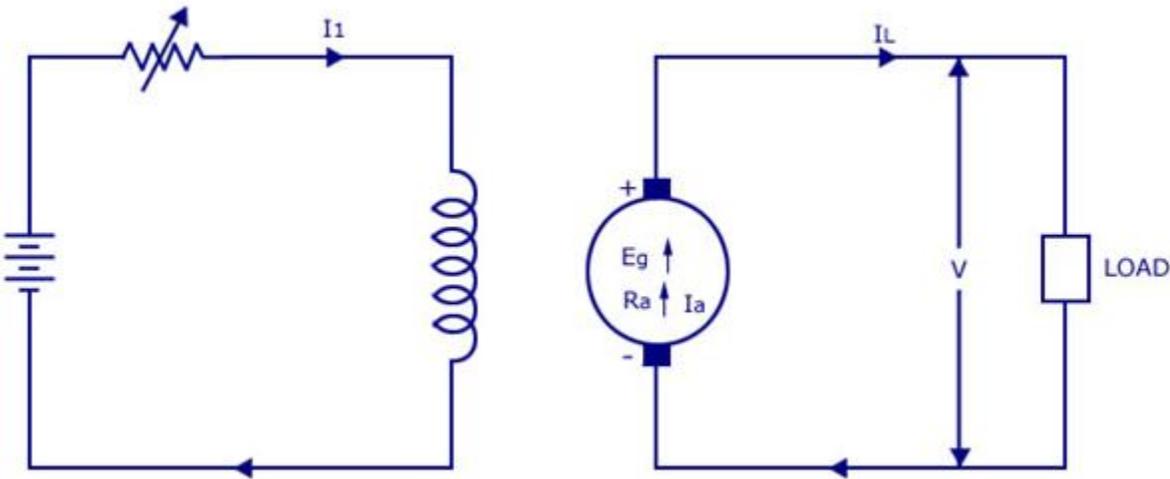
3. Describe various types self-excited DC generator with their circuit layout. (M/J-2016)

DC generators are classified based on their method of excitation. So on this basis there are two types of DC generators:-

Self-excited DC generator can again be classified as 1) DC Series generator 2) DC Shunt generator and 3) DC Compound generator.

1. Separately excited DC generator

As you can guess from the name itself, this DC generator has a field magnet winding which is excited using a separate voltage source (like a battery). You can see the representation in the below image. The output voltage depends on the speed of rotation of the armature and the field current. The higher the speed of rotation and current, the higher the output e.m.f.

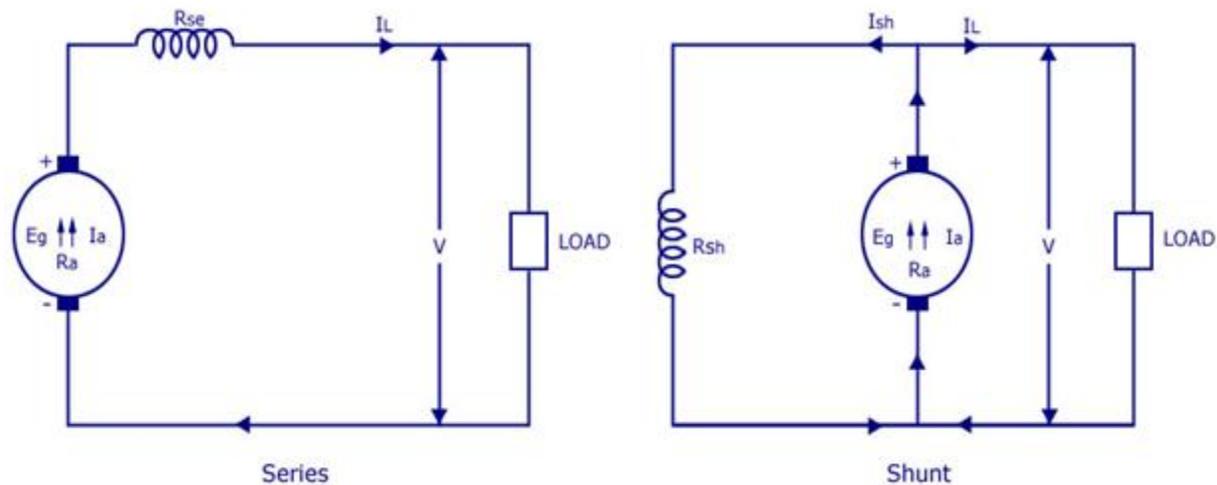


2. Self Excited DC Generator

- These are generators in which the field winding is excited by the output of the generator itself. As described before – there are three types of self-excited DC generators, they are 1) Series 2) Shunt and 3) Compound.

A **series DC generator** is shown below in fig. in which the armature winding is connected in series with the field winding so that the field current flows through the load as well as the field winding. Field winding is a low resistance, thick wire of few turns. Series generators are also rarely used.

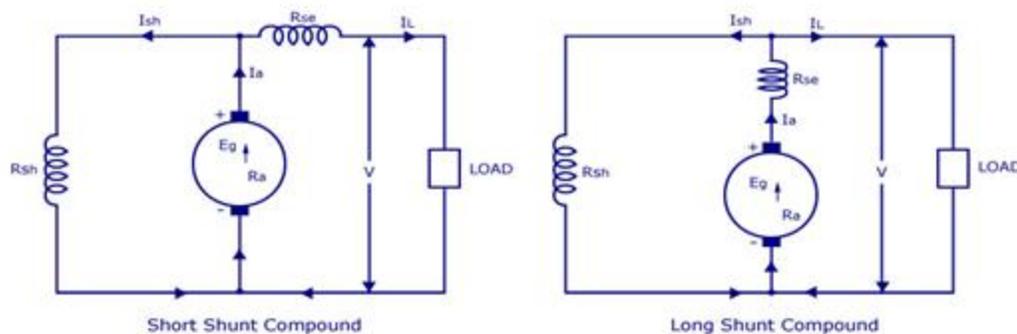
A **shunt DC generator** is shown in figure (b), in which the field winding is wired parallel to armature winding so that the voltage across both are same. The field winding has high resistance and more number of turns so that only a part of armature current passes through field winding and the rest passes through load.



A **compound generator** is shown in figure below. It has two field windings namely R_{sh} and R_{se} . They are basically shunt winding (R_{sh}) and series winding (R_{se}). Compound generator is of two types – 1) Short shunt and 2) Long shunt

Short shunt:- Here the shunt field winding is wired parallel to armature and series field winding is connected in series to the load. It is shown in fig (1)

Long shunt:- Here the shunt field winding is parallel to both armature and series field winding (R_{se} is wired in series to the armature). It is shown in figure (2)

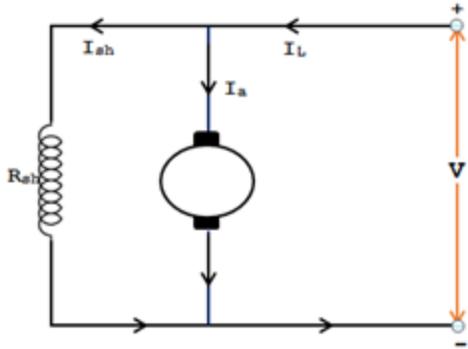


4.Explain the characteristics of dc shunt motor.(M/J-2016)

Characteristics of DC Shunt Motor:

The three important shunt characteristic curves are

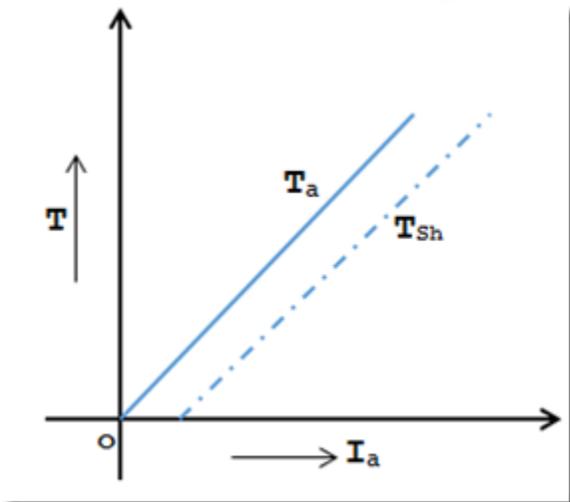
1. Torque V_s Armature current characteristic (T_a/I_a)
2. Speed V_s Armature current characteristic (N/I_a)
3. Speed V_s Torque characteristic (N/T_a)



The fig above shows the circuit diagram of shunt motor. In this circuit the field winding is directly connected to the source voltage, so the field current I_{sh} and the flux in a shunt motor are constant.

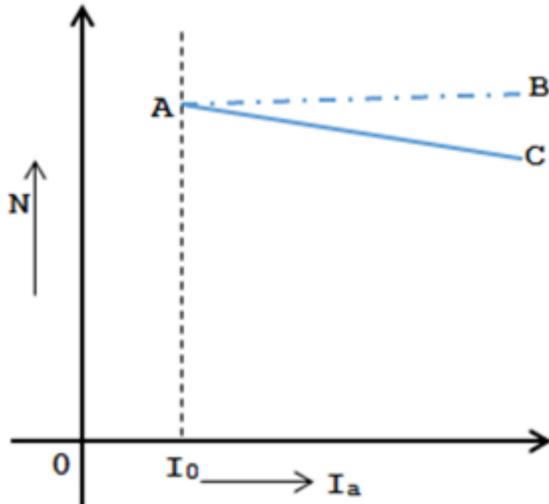
1. Torque V_s Armature current characteristic (T_a/I_a)

We know that in a DC Motor $T_a \propto \Phi I_a$. In this the flux Φ is continuous by ignoring the armature reaction, since the motor is working from a continual source voltage.



Therefore the curve drawn between torque V_s armature current is a straight line transitory through the origin which is shown in fig. The shaft torque (T_{sh}) is a smaller amount than armature torque and is shown in the fig by a dotted line. From this curve it is proved that to start a heavy load very large current is requisite. Hence the shunt DC motor should not be started at full load.

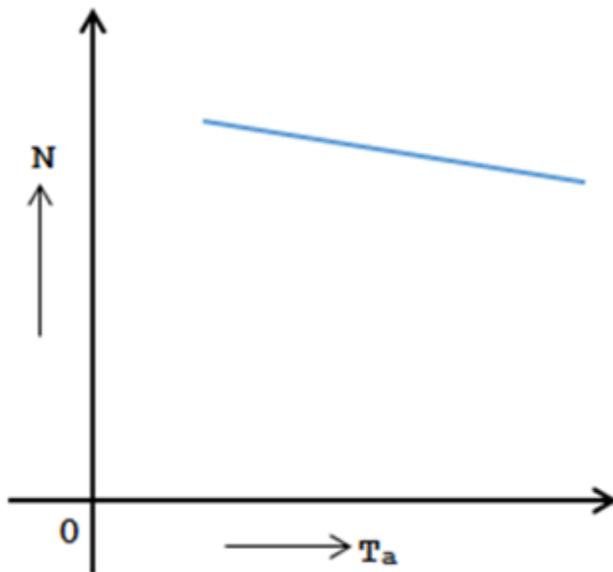
2. Speed V_s Armature current characteristic (N/I_a)



At normal condition the back EMF E_b and Flux Φ both are constant in a DC Shunt motor. Hence the armature current differs and the speed of a DC Shunt motor will continue constant which is shown in the fig (dotted Line AB).

Whenever the shunt motor load is increased $E_b = V - I_a R_a$ and flux reduces as a result drop in the armature resistance and armature reaction. On the other hand, back EMF reduces marginally more than that the speed of the shunt motor decreases to some extent with load.

3. Speed V_s Torque characteristic (N/T_a)



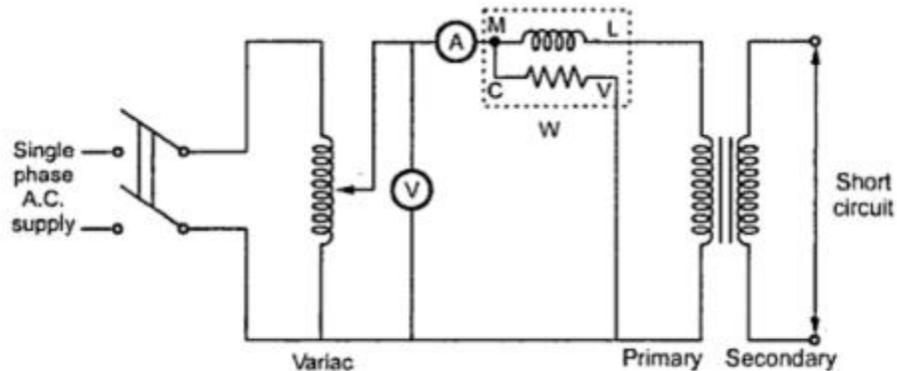
- This curve is drawn between the speed of the motor and armature current with various amps as shown in the fig. From the curve it is understood that the speed reduces when the load torque increases.
- With the above three characteristic it is clearly understood that when the shunt motor runs from no load to full load there is slight change in speed. Thus, it is essentially a constant speed motor. Since the armature torque is directly proportional to the armature current, the starting torque is not high

5.Explain the tests on a single phase transformer and develop an equivalent from the above tests.(M/J-2016)

1.Open Circuit Test on Transformer:

- The connection diagram for open circuit test on transformer is shown in the figure. A voltmeter, wattmeter, and an ammeter are connected in LV side of the transformer as shown. The voltage at rated frequency is applied to that LV side with the help of a variac of variable ratio auto transformer.
- The HV side of the transformer is kept open. Now with the help of variac, applied voltage gets slowly increased until the voltmeter gives reading equal to the rated voltage of the LV side. After reaching at rated LV side voltage, all three instruments reading (Voltmeter, Ammeter and Wattmeter readings) are recorded.
- The ammeter reading gives the no load current I_e . As no load current I_e is quite small compared to rated current of the transformer, the voltage drops due to this current that can be taken as negligible. Since, voltmeter reading V_1 can be considered equal to secondary induced voltage of the transformer, the input power during test is indicated by watt-meter reading.
- As the transformer is open circuited, there is no output, hence the input power here consists of core losses in transformer and copper loss in transformer during no load condition. But as said earlier, the no load current in the transformer is quite small compared to full load current, so copper loss due to the small no load current can be neglected. Hence, the wattmeter reading can be taken as equal to core losses in transformer. Let us consider wattmeter reading is P_o .

$$P_o = \frac{V_1}{R_m^2}$$

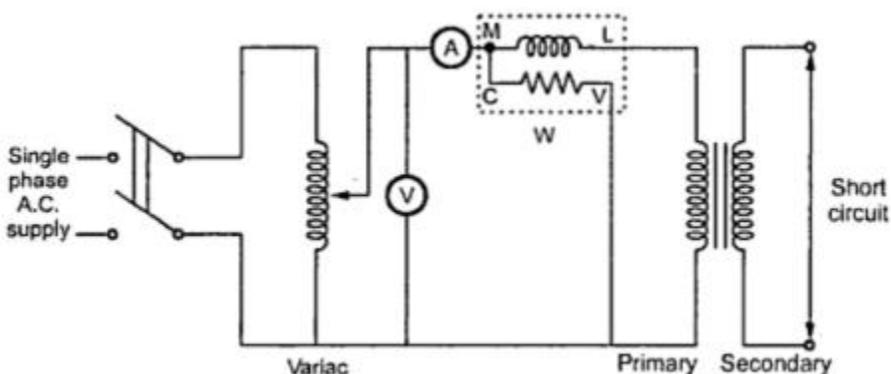


Therefore, if shunt branch reactance of transformer is X_m ,

$$\text{Then, } \left(\frac{1}{X_m}\right)^2 = \left(\frac{1}{Z_m}\right)^2 - \left(\frac{1}{R_m}\right)^2$$

2. Short Circuit Test on Transformer:

- The connection diagram for short circuit test on transformer is shown in the figure. A voltmeter, wattmeter, and an ammeter are connected in HV side of the transformer as shown. The voltage at rated frequency is applied to that HV side with the help of a variac of variable ratio auto transformer.
- The LV side of the transformer is short circuited. Now with the help of variac applied voltage is slowly increased until the ammeter gives reading equal to the rated current of the HV side.
- After reaching at rated current of HV side, all three instruments reading (Voltmeter, Ammeter and Watt-meter readings) are recorded. The ammeter reading gives the primary equivalent of full load current I_L . As the voltage applied for full load current in short circuit test on transformer is quite small compared to the rated primary voltage of the transformer, the core losses in transformer can be taken as negligible here.



- Let's say, voltmeter reading is V_{sc} . The input power during test is indicated by watt-meter reading. As the transformer is short circuited, there is no output; hence the input power here consists of copper losses in transformer.
- Since, the applied voltage V_{sc} is short circuit voltage in the transformer and hence it is quite small compared to rated voltage, so core loss due to the small applied voltage can be neglected. Hence the wattmeter reading can be taken as equal to copper losses in transformer. Let us consider wattmeter reading is P_{sc} .

$$P_{sc} = R_e I_L^2$$

- These values are referred to the HV side of transformer as because the test is conducted on HV side of transformer. These values could easily be referred to LV side by dividing these values with square of transformation ratio.
- Therefore it is seen that the short circuit test on transformer is used to determine copper loss in transformer at full load and parameters of approximate equivalent circuit of transformer

6. Describe the construction details of single phase transformer.(A/M-2017,M/J-2017,N/D-2015,A/M-2015)

TRANSFORMER – INTRODUCTION

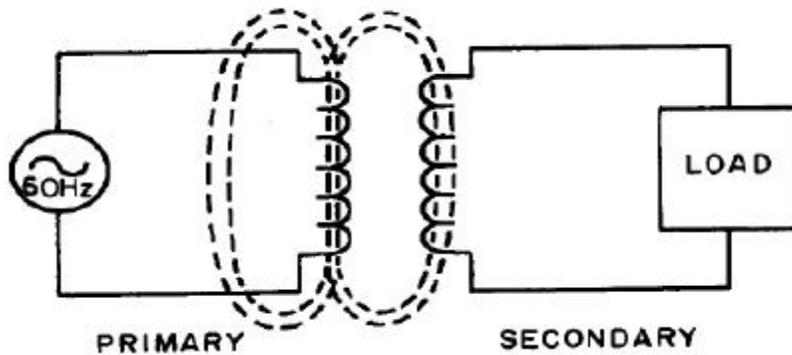
- A TRANSFORMER is a device that transfers electrical energy from one circuit to another by electromagnetic induction (transformer action). The electrical energy is always transferred without a change in frequency, but may involve changes in magnitudes of voltage and current.
- Because a transformer works on the principle of electromagnetic induction, it must be used with an input source voltage that varies in amplitude. There are many types of power that fit this description; for ease of explanation and understanding, transformer action will be explained using an ac voltage as the input source.

BASIC OPERATION OF A TRANSFORMER:

Its most basic form a transformer consists of: A primary

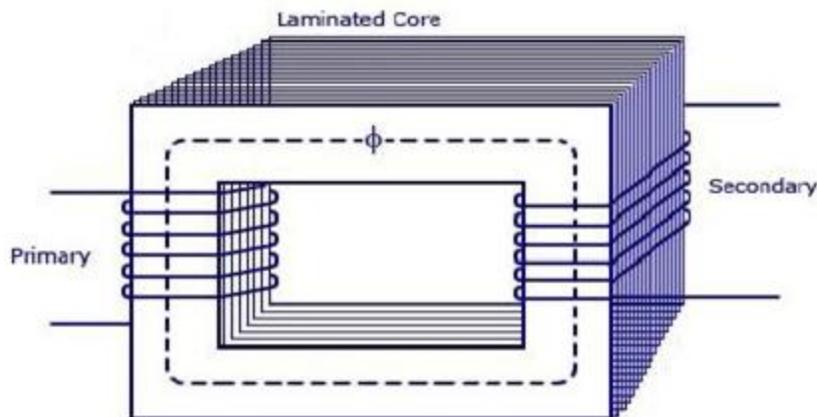
- Coil or winding.
- A secondary coil or winding.
- A core that supports the coils or windings

The primary winding is connected to a 60 hertz ac voltage source. The magnetic field (flux) builds up (expands) and collapses (contracts) about the primary winding. The expanding and contracting magnetic field around the primary winding cuts the secondary winding and induces an alternating voltage into the winding. This voltage causes alternating current to flow through the load. The voltage may be stepped up or down depending on the design of the primary and secondary windings.



BASIC WORKING PRINCIPLE OF TRANSFORMER:

- A transformer can be defined as a static device which helps in the transformation of electric power in one circuit to electric power of the same frequency in another circuit. The voltage can be raised or lowered in a circuit, but with a proportional increase or decrease in the current ratings.
- The main principle of operation of a transformer is mutual inductance between two circuits which is linked by a common magnetic flux. A basic transformer consists of two coils that are electrically separate and inductive, but are magnetically linked through a path of reluctance. The working principle of the transformer can be understood from the figure below



- As shown above the transformer has primary and secondary windings. The core laminations are joined in the form of strips in between the strips you can see that there are some narrow gaps right through the cross-section of the core. These staggered joints are said to be ‘imbricated’. Both the coils have high mutual inductance

Faraday’s laws of Electromagnetic Induction as

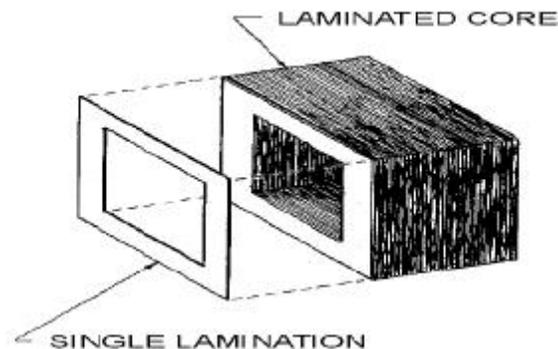
$$e=M \cdot dI/dt$$

TRANSFORMER CONSTRUCTION:

- Two coils of wire (called windings) are wound on some type of core material. In some cases the coils of wire are wound on a cylindrical or rectangular cardboard form. In effect, the core material is air and the transformer is called an air-core transformer.
- Transformers used at low frequencies, such as 60 hertz and 400 hertz, require a core of low-reluctance magnetic material, usually iron. This type of transformer is called an iron-core transformer. Most power transformers are of the iron-core type.

The principle parts of a transformer and their functions are:

- The core, which provides a path for the magnetic lines of flux.
- The primary winding, which receives energy from the ac source.
- The secondary winding, which receives energy from the primary winding and delivers it to the load.
- The enclosure, which protects the above components from dirt, moisture



CORE

There are two main shapes of cores used in laminated-steel-core transformers. One is the HOLLOWCORE, so named because the core is shaped with a hollow square through the center. This shape of core. Notice that the core is made up of many laminations of steel it shows how the transformer windings are wrapped around both sides of the core.

WINDINGS

- As stated above, the transformer consists of two coils called WINDINGS which are wrapped around a core. The transformer operates when a source of ac voltage is connected to one of the windings and a load device is connected to the other.
- The winding that is connected to the source is called the PRIMARY WINDING. The winding that is connected to the load is called the secondary winding. The primary is wound in layers directly on a rectangular cardboard form.

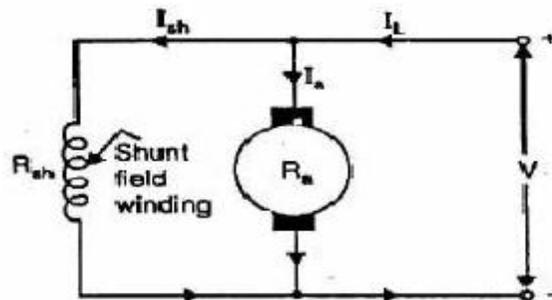
7. Explain the different types of dc motor with neat sketch.(N/D-2016)

❖ DC MOTOR TYPES

- Shunt Wound
- Series Wound
- Compound wound

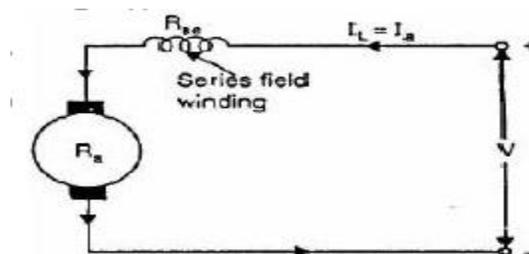
1. Shunt Motor

- In shunt wound motor the field winding is connected in parallel with armature. The current through the shunt field winding is not the same as the armature current.
- Shunt field windings are designed to produce the necessary m.m.f. by means of a relatively large number of turns of wire having high resistance. Therefore, shunt field current is relatively small compared with the armature current



2. Series Motor:

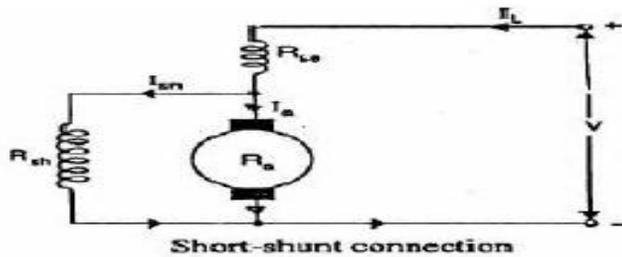
- In series wound motor the field winding is connected in series with the armature. Therefore, series field winding carries the armature current. Since the current passing through a series field winding is the same as the armature current, series field windings must be designed with much fewer turns than shunt field windings for the same mmf. Therefore, a series field winding has a relatively small number of turns of thick wire and, therefore, will possess a low resistance.



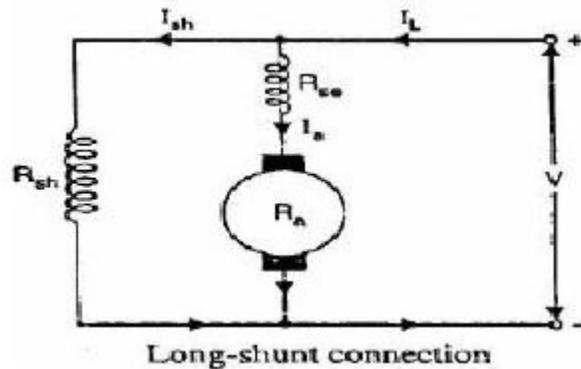
3. Compound Wound Motor: Compound wound motor has two field windings; one connected in parallel with the armature and the other in series with it. There are two types of compound motor connections

1. Short-shunt connection
2. Long shunt connection

When the shunt field winding is directly connected across the armature terminals it is called short-shunt connection.



When the shunt winding is so connected that it shunts the series combination of armature and series field it is called long-shunt connection.



8. Explain the working principle of various types of single phase induction motor with neat circuit diagram.(M/J-2016)

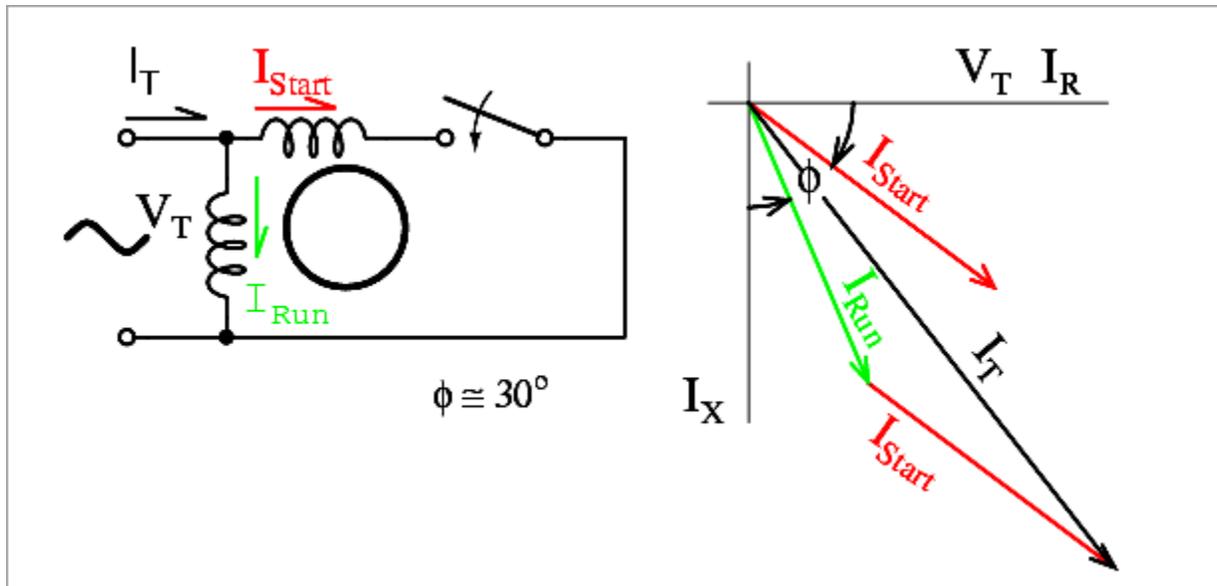
The single phase induction motors are made self- starting by providing an additional flux by some additional means. Now depending upon these additional means the single phase induction motors are classified as:

1. Split phase induction motor.
2. Capacitor start inductor motor.
3. Capacitor start capacitor run induction motor (two value capacitor method).
4. Permanent split capacitor (PSC) motor .
5. Shaded pole induction motor.

1.Split Phase Induction Motor :

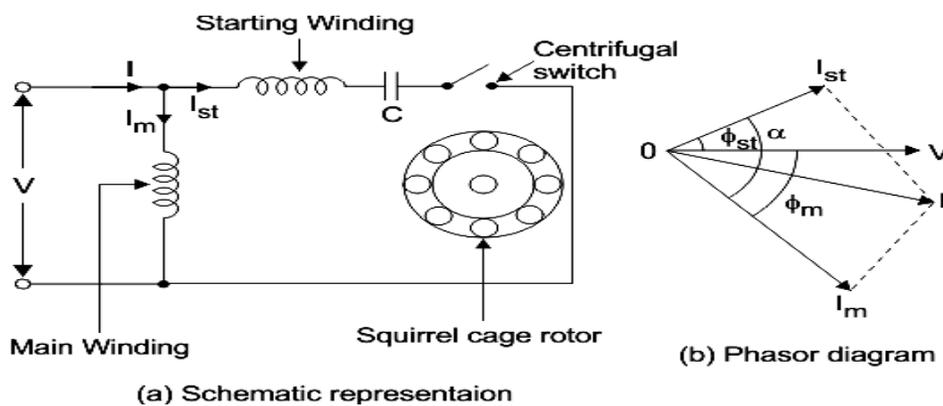
- In addition to the main winding or running winding, the stator of single phase induction motor carries another winding called auxiliary winding or starting winding. A centrifugal switch is connected in series with auxiliary winding. The purpose of this switch is to disconnect the auxiliary winding from the main circuit when the motor attains a speed up to 75 to 80% of the synchronous speed.

We know that the running winding is inductive in nature. Our aim is to create the phase difference between the two winding and this is possible if the starting winding carries high resistance.

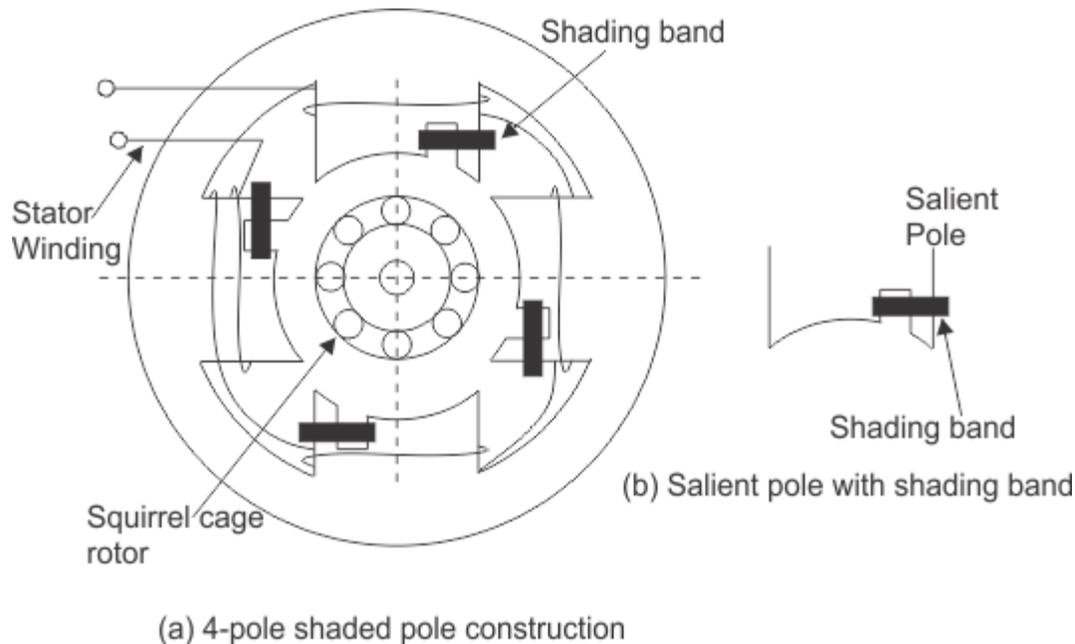


2.Capacitor Start IM and Capacitor Start Capacitor Run IM

- The working principle and construction of Capacitor start inductor motors and capacitor start capacitor run induction motors are almost the same. We already know that single phase induction motor is not self-starting because the magnetic field produced is not rotating type. In order to produce rotating magnetic field there must be some phase difference.
- In case of split phase induction motor we use resistance for creating phase difference but here we use capacitor for this purpose. We are familiar with this fact that the current flowing through the capacitor leads the voltage. So, in capacitor start inductor motor and capacitor start capacitor run induction motor



3. Shaded Pole Single Phase Induction Motors



- The stator of the shaded pole single phase induction motor has salient or projected poles. These poles are shaded by copper band or ring which is inductive in nature. The poles are divided into two unequal halves. The smaller portion carries the copper band and is called as shaded portion of the pole.
- When a single phase supply is given to the stator of shaded pole induction motor an alternating flux is produced. This change of flux induces emf in the shaded coil. Since this shaded portion is short circuited, the current is produced in it in such a direction to oppose the main flux. The flux in shaded pole lags behind the flux in the unshaded pole.
- The phase difference between these two fluxes produces resultant rotating flux. We know that the stator winding current is alternating in nature and so is the flux produced by the stator current. In order to clearly understand the working of shaded pole induction motor consider three regions-

1. When the flux changes its value from zero to nearly maximum positive value.
2. When the flux remains almost constant at its maximum value.
3. When the flux decreases from maximum positive value to zero.

9. Write short notes on the types of dc machines. (N/D-2015)

TYPES OF DC MACHINES:

- i) DC generator
- ii) DC motor

i) DC generator

- An electrical generator is a rotating machine which usually converts mechanical energy into electrical energy for doing work. The energy changing is based on the principle of electromagnetic induction.
- According to Faraday's laws of electromagnetic induction, Whenever a conductor is feel motion in a magnetic field, emf induced dynamically in the conductor. When an external load is connected to the conductor this induced emf make a current flow in the load.
- Thus the mechanical energy which is given in the form of movement to the conductor is converted into electrical energy.
- Dc generators can be classified as per their methods of field excitation. There are two types of dc generators on the basis of excitation.

Power delivered to the source is $V \cdot I(a)$.

Separately excited Dc generators:-

If the field winding is excited by a separate dc supply from the external source, then the generator is called separately excited dc generators.

Self -excited Dc generators:-

If the field winding energy is supplied from the armature of the generator itself, then it is called self- excited dc generators. Self -excited dc generators are further classified as

Series generator:-

In series generator field winding is connected series to the armature itself.

The voltage generated in series field generator is $E(\text{generated}) = V(\text{terminal voltage}) + I(a) \cdot R(a) + I(\text{se}) \cdot R(\text{se}) + V(\text{brush})$.

Power generated is $E(g) \cdot I(a)$.

Shunt generator:

In shunt generator field winding is connected across the armature or parallel to the armature.

The generated emf in shunt field generator is $E(\text{generated}) = V(\text{terminal voltage}) + I(a) \cdot R(a)$.

Power generated is $E(g) \cdot I(a)$.

Power delivered to the source is $V \cdot I(a)$.

Compound generator

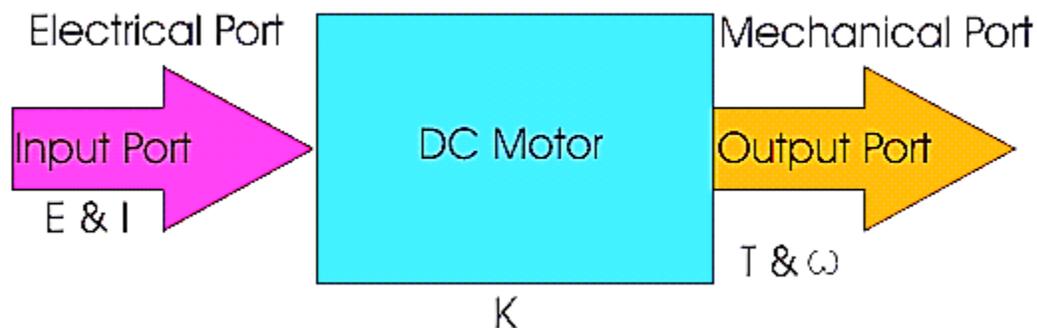
The compound generator consists of both shunt field and series field winding on its structure. One winding is series and other is in parallel with the armature of the generator.

ii) DC Motor:

Electric motors are everywhere around us. Almost all the electro-mechanical movements we see around us are caused either by a AC or a DC motor. Here we will be exploring DC motors. This is a device that converts DC electrical energy to a mechanical energy.

Principle of DC Motor

- This DC or direct current motor works on the principle, when a current carrying conductor is placed in a magnetic field, it experiences a torque and has a tendency to move. This is known as motoring action.
- If the direction of current in the wire is reversed, the direction of rotation also reverses. When magnetic field and electric field interact they produce a mechanical force, and based on that the working principle of DC motor is established.
- The direction of rotation of a this motor is given by Fleming's left hand rule, which states that if the index finger, middle finger and thumb of your left hand are extended mutually perpendicular to each other and if the index finger represents the direction of magnetic field, middle finger indicates the direction of current, then the thumb represents the direction in which force is experienced by the shaft of the DC motor.
- Structurally and construction wise a direct current motor is exactly similar to a DC generator, but electrically it is just the opposite. Here we unlike a generator we supply electrical energy to the input port and derive mechanical energy from the output port. We can represent it by the block diagram shown below.



Here in a DC motor, the supply voltage E and current I is given to the electrical port or the input port and we derive the mechanical output i.e. torque T and speed ω from the mechanical port or output port.

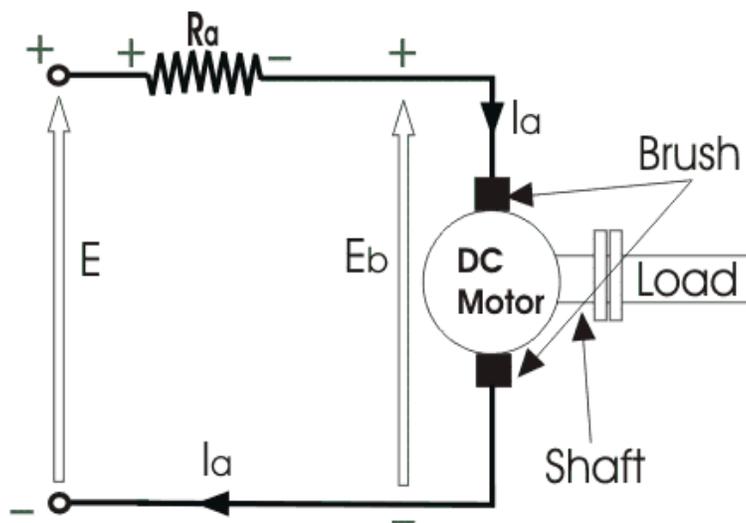
The input and output port variables of the direct current motor are related by the parameter K .

$$T = KI \text{ and } E = K\omega$$

So from the picture above we can well understand that motor is just the opposite phenomena of a DC generator, and we can derive both motoring and generating operation from the same machine by simply reversing the ports.

Detailed Description of a DC Motor

- The direct current motor is represented by the circle in the center, on which is mounted the brushes, where we connect the external terminals, from where supply voltage is given.
- On the mechanical terminal we have a shaft coming out of the Motor, and connected to the armature, and the armature-shaft is coupled to the mechanical load. On the supply terminals we represent the armature resistance R_a in series.



10. With a neat circuit diagram Explain the construction and principle of operation of DC Generator(N/D-2015)

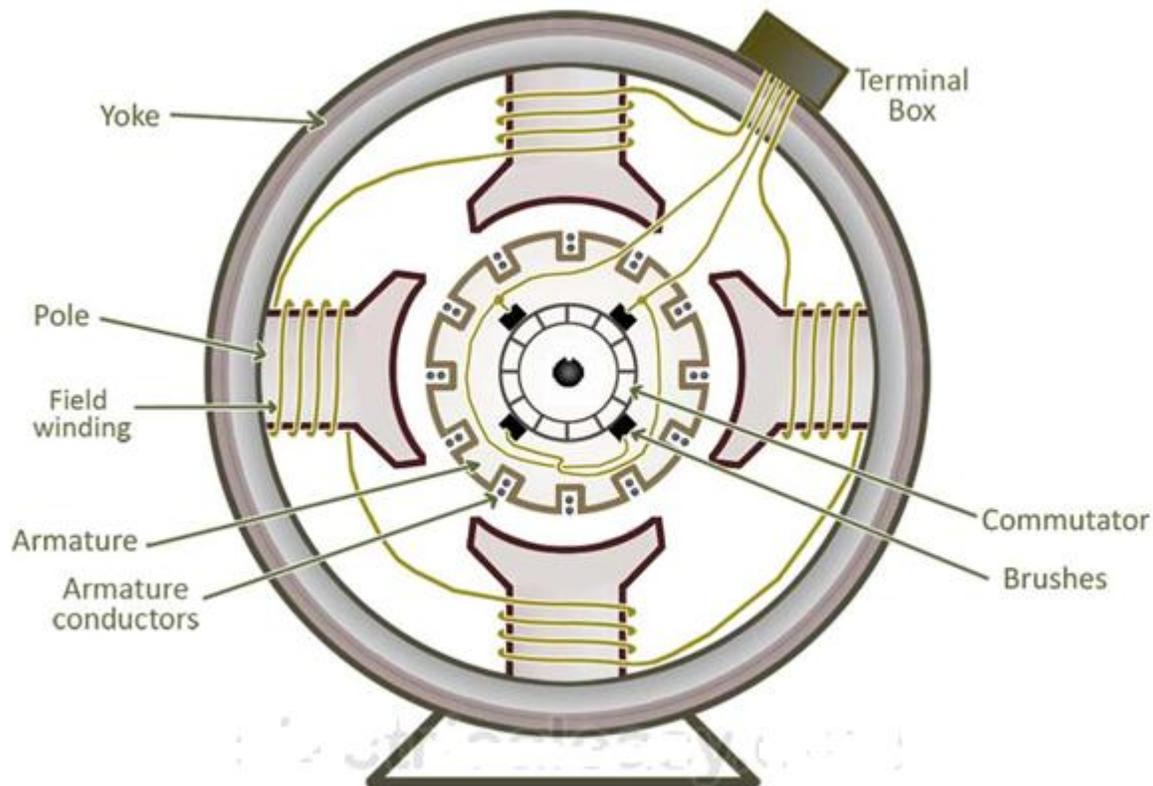
DC Generator:

A dc generator is an electrical machine which converts mechanical energy into direct current electricity. This energy conversion is based on the principle of production of dynamically induced emf. This article outlines basic construction and working of a DC generator.

Construction of a DC generator:

- A DC generator can be used as a DC motor without any constructional changes and vice versa is also possible. Thus, a DC generator or a DC motor can be broadly termed as a DC machine. These basic constructional details are also valid for the construction of a DC

motor. Hence, let's call this point as construction of a DC machine instead of just 'construction of a dc generator'.



The above figure shows the constructional details of a simple 4-pole DC machine. A DC machine consists two basic parts; stator and rotor. Basic constructional parts of a DC machine are described below.

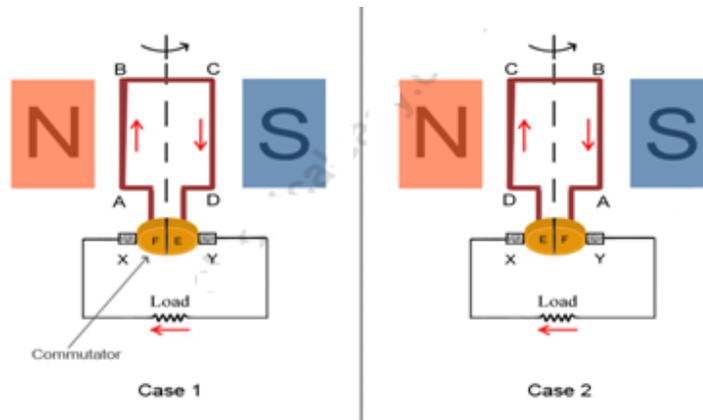
1. **Yoke:** The outer frame of a dc machine is called as yoke. It is made up of cast iron or steel. It not only provides mechanical strength to the whole assembly but also carries the magnetic flux produced by the field winding.
2. **Poles and pole shoes:** Poles are joined to the yoke with the help of bolts or welding. They carry field winding and pole shoes are fastened to them. Pole shoes serve two purposes; (i) they support field coils and (ii) spread out the flux in air gap uniformly.
3. **Field winding:** They are usually made of copper. Field coils are former wound and placed on each pole and are connected in series. They are wound in such a way that, when energized, they form alternate North and South poles.
4. **Armature core:** Armature core is the rotor of the machine. It is cylindrical in shape with slots to carry armature winding. The armature is built up of thin laminated circular steel

disks for reducing eddy current losses. It may be provided with air ducts for the axial air flow for cooling purposes. Armature is keyed to the shaft.

5. **Armature winding:** It is usually a former wound copper coil which rests in armature slots. The armature conductors are insulated from each other and also from the armature core. Armature winding can be wound by one of the two methods; lap winding or wave winding. Double layer lap or wave windings are generally used. A double layer winding means that each armature slot will carry two different coils.
6. **Commutator and brushes:** Physical connection to the armature winding is made through a commutator-brush arrangement. The function of a commutator, in a dc generator, is to collect the current generated in armature conductors. Whereas, in case of a dc motor, commutator helps in providing current to the armature conductors. A commutator consists of a set of copper segments which are insulated from each other. The number of segments is equal to the number of armature coils. Each segment is connected to an armature coil and the commutator is keyed to the shaft. Brushes are usually made from carbon or graphite. They rest on commutator segments and slide on the segments when the commutator rotates keeping the physical contact to collect or supply the current.

Working principle of a DC generator:

- According to Faraday's laws of electromagnetic induction, whenever a conductor is placed in a varying magnetic field (OR a conductor is moved in a magnetic field), an emf (electromotive force) gets induced in the conductor.
- The magnitude of induced emf can be calculated from the emf equation of dc generator. If the conductor is provided with the closed path, the induced current will circulate within the path.
- In a DC generator, field coils produce an electromagnetic field and the armature conductors are rotated into the field. Thus, an electromagnetically induced emf is generated in the armature conductors. The direction of induced current is given by Fleming's right hand rule.
- according to Fleming's right hand rule, the direction of induced current changes whenever the direction of motion of the conductor changes. Let's consider an armature rotating clockwise and a conductor at the left is moving upward.
- When the armature completes a half rotation, the direction of motion of that particular conductor will be reversed to downward.
- Hence, the direction of current in every armature conductor will be alternating. If you look at the a figure, you will know how the direction of the induced current is alternating in an armature conductor



.But with a split ring commutator, connections of the armature conductors also gets reversed when the current reversal occurs. And therefore, we get unidirectional current at the terminals.

UNIT-3 SEMICONDUCTOR DEVICES AND APPLICATIONS

PART-A:

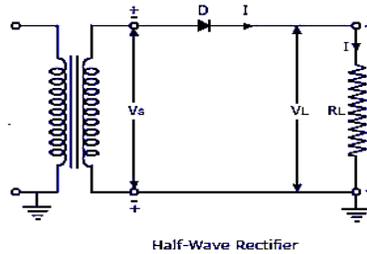
1. What is the difference between Zener and avalanche breakdown? (N/D-2016)

Avalanche Breakdown	Zener Breakdown
The avalanche breakdown is a phenomena of increasing the free electrons or electric current in semiconductor and insulating material by applying the higher voltage.	The process in which the electrons are moving across the barrier from the valence band of the p-type material to the conduction band of the lightly filled n-material is known as the Zener breakdown.

2. Define ripple factor.(N/D-2016)

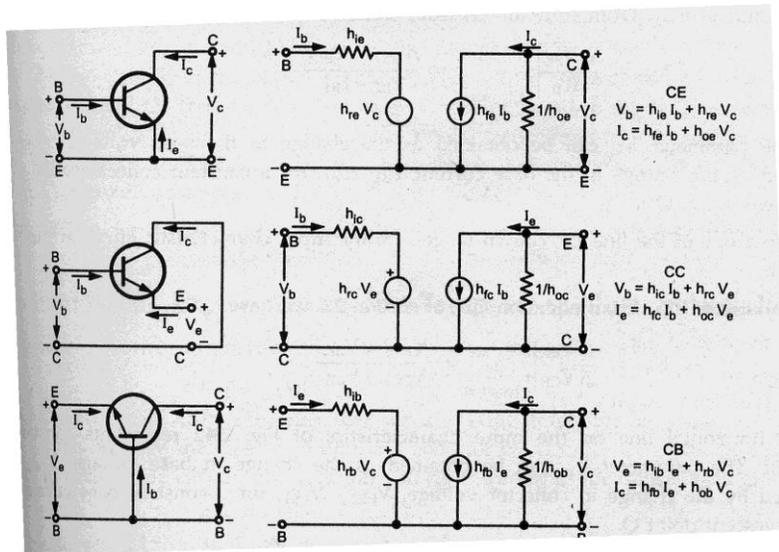
The ripple factor for a Full Wave Rectifier is given by. The average voltage or the dc voltage available across the load resistance is and RMS value of the voltage at the load resistance is called ripple factor.

3. Draw the circuit diagram of half wave rectifier. (M/J-2016)



4. List various hybrid parameters of transistor. (M/J-2016)

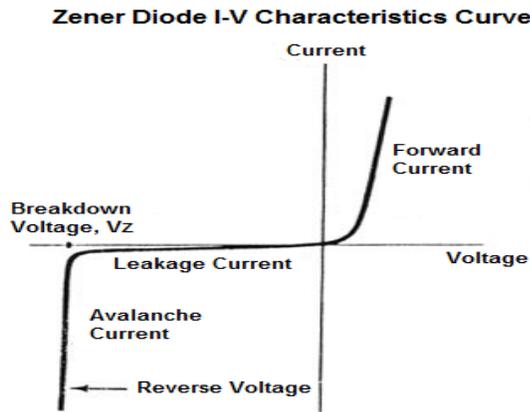
Hybrid Model and Equations for the transistor in three different configurations are given below



5. What is the total current at the junction of PN junction diode? (A/M-2015)

Current flow in a pn-junction diode under forward bias. Under the forward bias (p-side is more positive w.r.t. n-side, or n-side is more negative w.r.t. p-side), holes are injected from the p-side , across the depletion region (around the junction, a region depleted of mobile carriers) into the n-side .

6. Draw the characteristics of Zener diode. (A/M-2015)



7. What do you mean by biasing? (A/M-2017)

When voltage is applied across a **diode** in such a way that the **diode** prohibits current, the **diode** is said to be reverse-**biased**. The voltage dropped across a conducting, forward-**biased diode** is called the forward voltage.

8. Give the application of Zener diode. (A/M-2017)

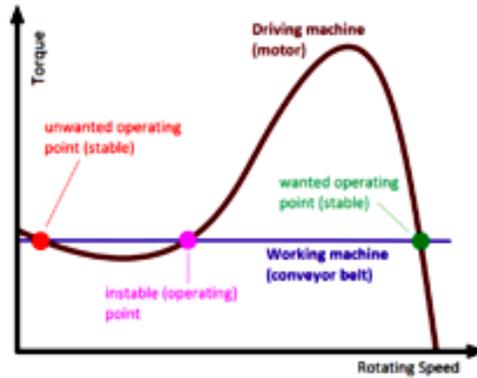
- Zener diodes are used in Voltage stabilizers (or) shunt regulators
- Used in Surge suppression circuitry for device protection
- Used in Over voltage protection circuits.
- Zener diodes are used in clipping and clamping circuits especially peak clippers .
- They are used as Reference elements.
- Used in switching applications.

9. How do you define voltage regulation? (N/D-2016)

A voltage regulator is a circuit that is connected between the power source and a load, that provides a constant voltage despite variations in input voltage or output load.

10. Define operating point. (N/D-2015)

The operating point is a specific point within the operation characteristic of a technical device. This point will be engaged because of the properties of the system and the outside influences and parameters. In electronic engineering establishing an operating point is called biasing.



PART-B

1. Explain the working of Zener diode and mention its applications. (N/D-2015,N/D-2016)

Symbol of Zener Diode



- We can identify the terminals of zener diode by observing a black color ring at cathode terminal (refer the first figure in this post). If it is a SMD component, then a band will be available for cathode terminal.
- A Zener diode is a silicon semiconductor device that permits current to flow in either a forward or reverse direction. The diode consists of a special, heavily doped p-n junction, designed to conduct in the reverse direction when a certain specified voltage is reached.
- The Zener diode has a well-defined reverse-breakdown voltage, at which it starts conducting current, and continues operating continuously in the reverse-bias mode without getting damaged. Additionally, the voltage drop across the diode remains constant over a wide range of voltages, a feature that makes Zener diodes suitable for use in voltage regulation.

Operation of Zener Diode:

- Zener diodes are normally used only in the reverse bias direction.
- It means that the anode must be connected to the negative side of the voltage source and the cathode must be connected to the positive side.
- A main difference between zener diodes and regular silicon diodes is the way they are used in the circuits.
- It is primarily used to regulate the circuit voltage as it has constant V_Z .

- A large change in I_R will cause only a small change in V_Z . It means that a zener diode can be used as an alternate current path. The constant V_Z developed across the diode can then be applied to a load.
- Thus the load voltage remains at constant by altering the current flow through the zener diode.

Zener diode applications:

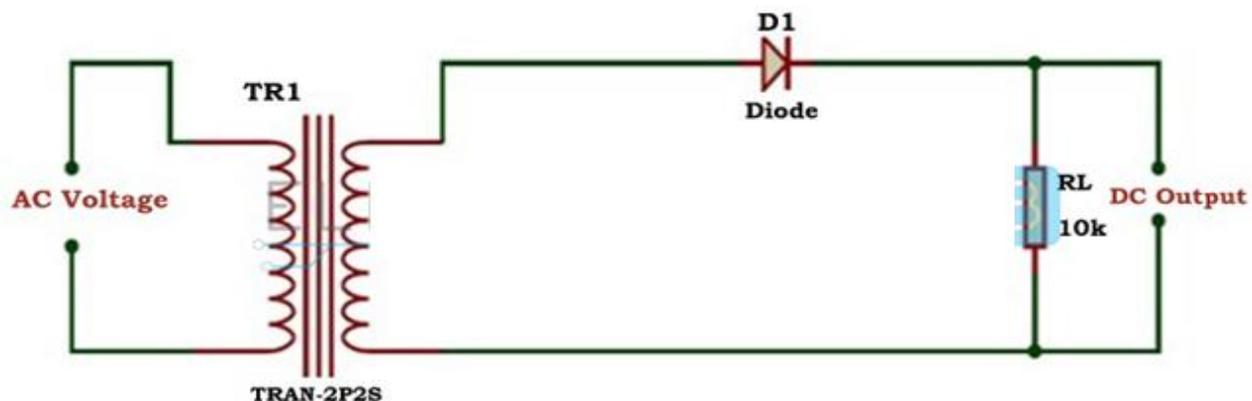
Zener diodes are used for voltage regulation, as reference elements, surge suppressors, and in switching applications and clipper circuits.

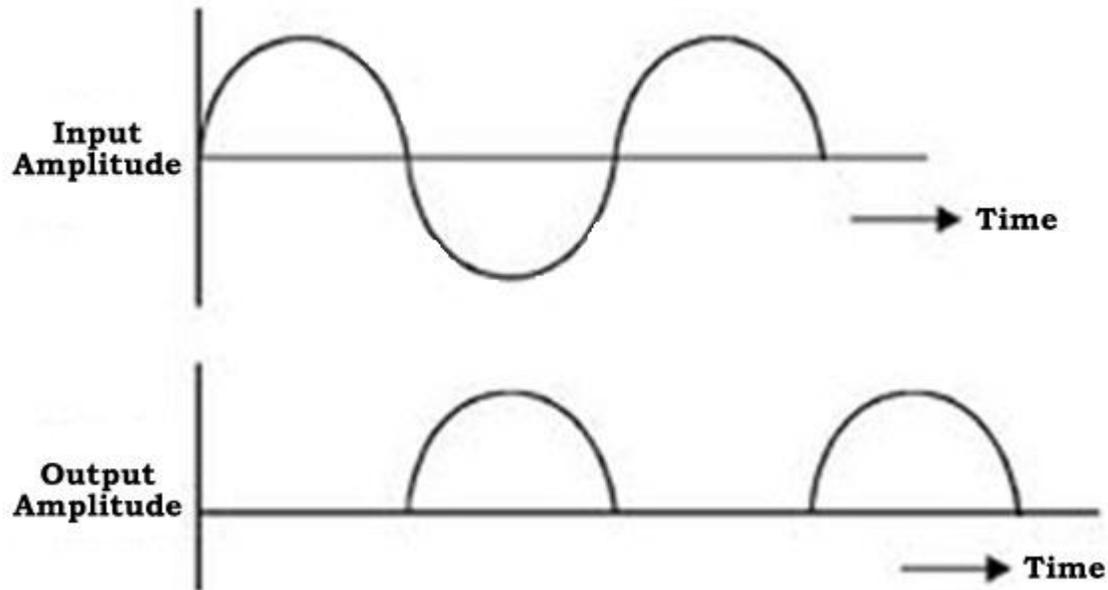
2. Draw the circuit diagram for half-wave rectifier and explain its working.(N/D-2016,N/D-2015)

Rectifier is an electronic device which converts the alternating current to unidirectional current, in other words rectifier converts the AC voltage to DC voltage. We use rectifier in almost all the electronic devices mostly in the power supply section to convert the main voltage into DC voltage. Every electronic device will work on the DC voltage supply only.

Half Wave Rectifier:

- The half wave rectifier is a type of rectifier that rectifies only half cycle of the waveform. This article describes the half wave rectifier circuit working. The half rectifier consist a step down transformer, a diode connected to the transformer and a load resistance connected to the cathode end of the diode. The circuit diagram of half wave transformer is shown below:
- The main supply voltage is given to the transformer which will increase or decrease the voltage and give to the diode. In most of the cases we will decrease the supply voltage by using the step down transformer here also the output of the step down transformer will be in AC.
- This decreased AC voltage is given to the diode which is connected serial to the secondary winding of the transformer, diode is electronic component which will allow only the forward bias current and will not allow the reverse bias current. From the diode we will get the pulsating DC and give to the load resistance R_L .





Working of Half Wave Rectifier:

The input given to the rectifier will have both positive and negative cycles. The half rectifier will allow only the positive half cycles and omit the negative half cycles. So first we will see how half wave rectifier works in the positive half cycles.

Positive Half Cycle:

- In the positive half cycles when the input AC power is given to the primary winding of the step down transformer, we will get the decreased voltage at the secondary winding which is given to the diode.
- The diode will allow current flowing in clock wise direction from anode to cathode in the forward bias (diode conduction will take place in forward bias) which will generate only the positive half cycle of the AC.
- The diode will eliminate the variations in the supply and give the pulsating DC voltage to the load resistance R_L . We can get the pulsating DC at the Load resistance.

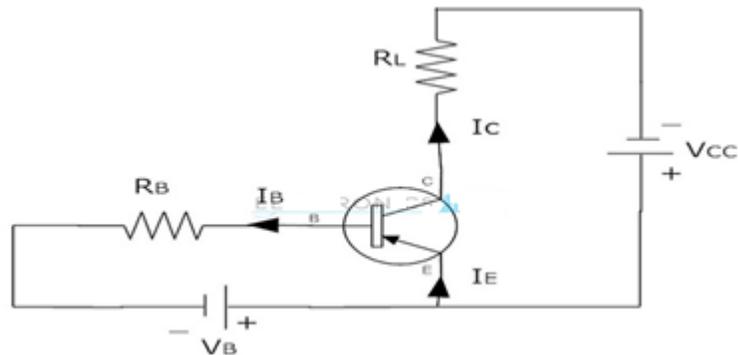
Negative Half Cycle:

- In the negative half cycle the current will flow in the anti-clockwise direction and the diode will go in to the reverse bias. In the reverse bias the diode will not conduct so, no current in flown from anode to cathode, and we cannot get any power at the load resistance.
- Only small amount of reverse current is flown from the diode but this current is almost negligible. And voltage across the load resistance is also zero.

3.Explain the operation of PNP and NPN transistors.(N/D-2016)

PNP Transistor Working

- The circuit connection of PNP transistor with supply voltages is given below. Here the base terminal has negative bias with respect to emitter and the emitter terminal has positive bias voltage with respect to both base and collector because of PNP transistor.



- The polarities and current directions are reversed here compared to NPN transistor. If the transistor is connected to all the voltage sources as shown above then the base current flows through the transistor but here the base voltage needs to be more negative with respect to the emitter to operate transistor.
- Here the base- emitter junction acts as a diode. The small amount of current in the base controls the flowing of large current through emitter to collector region. The base voltage is generally 0.7V for Si and 0.3V for Germanium devices.
- Here the base terminal acts as input and the emitter- collector region acts as output. The supply voltage V_{CC} is connected to the emitter terminal and a load resistor (R_L) is connected to the collector terminal.
- This load resistor (R_L) is used to limits the maximum current flow through the device. One more resistor (R_B) is connected to the base terminal which is used to limit the maximum current flow through the base terminal and also a negative voltage is applied to the base terminal.
- Here the collector current is always equal to the subtraction of base current from emitter current. Like NPN transistor, the PNP transistor also has the current gain value β . Now let us see the relation between the currents and current gain β .

The collector current (I_C) is given by,

$$I_C = I_E - I_B$$

The DC current gain (β) for the PNP transistor is same as the NPN transistor.

DC current gain = β = Output current/Input current

Here output current is collector current and input current is base current.

$$\beta = I_C/I_B$$

From this equation we get,

$$I_B = I_C/\beta$$

$$I_C = \beta I_B$$

And also we define the current gain as,

Current gain = Collector current/ Emitter current (In common base transistor)

$$\alpha = I_C/I_E$$

The relation between α and β is given by,

$$\beta = \alpha / (1 - \alpha) \text{ and } \alpha = \beta / (\beta + 1)$$

The collector current in PNP transistor is given by,

$I_C = -\alpha I_E + I_{CBO}$ where I_{CBO} is the saturation current.

$$\text{Since } I_E = -(I_C + I_B)$$

$$I_C = -\alpha (-(I_C + I_B)) + I_{CBO}$$

$$I_C - \alpha I_C = \alpha I_B + I_{CBO}$$

$$I_C (1 - \alpha) = \alpha I_B + I_{CBO}$$

$$I_C = (\alpha / (1 - \alpha)) I_B + I_{CBO} / (1 - \alpha)$$

$$\text{Since } \beta = \alpha / (1 - \alpha)$$

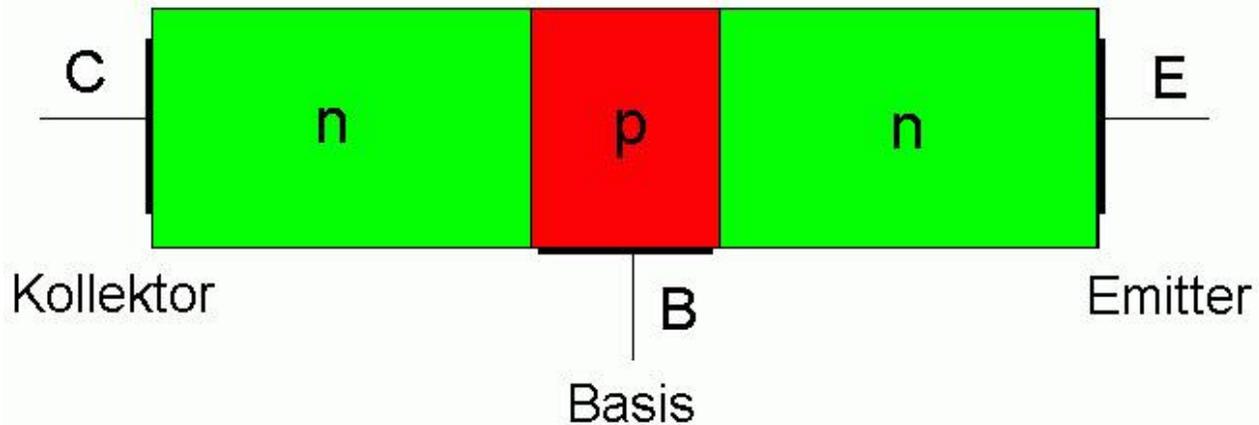
Now we get the equation for collector current

$$I_C = \beta I_B + (1 + \beta) I_{CBO}$$

- The output characteristics of PNP transistor are same as NPN transistor characteristics. The small difference is that the PNP transistor characteristic curve rotates 180° to calculate the reverse polarity voltages and current values. The dynamic load line also exists on the characteristic curve to calculate the Q-point value. The PNP transistors are also used in switching and amplifying circuits like NPN transistors.

NPN TRANSISTOR WORKING:

- The NPN transistor is a bipolar junction transistor, In an NPN transistor, the first letter N indicates a negatively charged layer of material and a P indicates a positively charged layer. These transistors have a positive layer, which is located in-between two negative layers.
- NPN transistors are generally used in circuits for switching, amplifying the electrical signals that pass through them. These transistors comprise three terminals namely, base, collector and emitter and these terminals connect the transistor to the circuit board.
- When the current flows through the NPN transistor, the transistor base terminal receives the electrical signal, the collector makes a stronger electric current than the one passing through the base, and the emitter passes this stronger current on to the rest of the circuit. In this transistor, the current flows through the collector terminal to the emitter.



- Generally, this transistor is used because it is so easy to produce. For an NPN transistor to work properly, it needs to be formed from a semiconductor material, which carries some electric current, but not the maximum amount as very conductive materials like metal. “Si” is one of the most commonly used semiconductor, and NPN transistors are the easiest transistors to make out of silicon.
- The application of an NPN transistor is on a computer circuit board. Computers need all their information to be translated into binary code, and this process is accomplished through a plethora of small switches flipping on and off on the computers circuit boards. NPN transistors can be used for these switches. A powerful electric signal turns the switch on, whereas a lack of a signal turns the switch off.

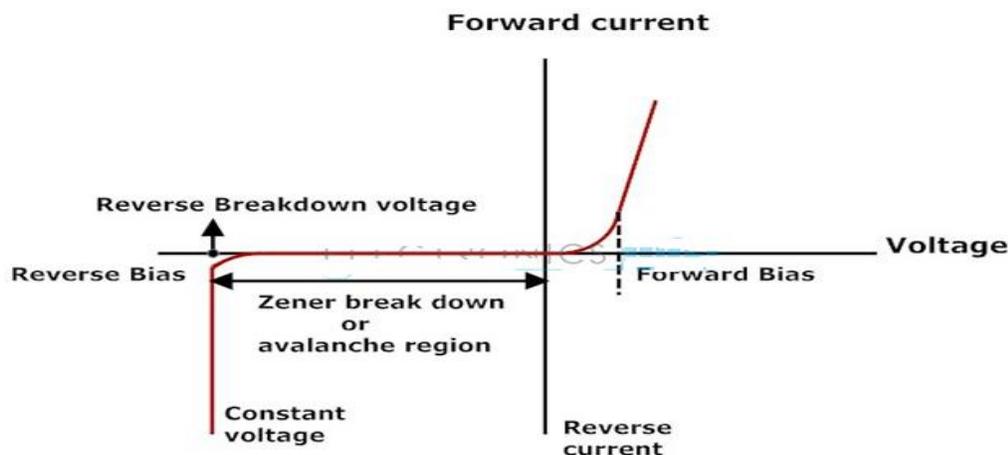
4. Explain the operation of zener diode with required circuit and characteristics.(M/J-2016)

Operation of Zener Diode:

- Zener diodes are normally used only in the reverse bias direction.
- It means that the anode must be connected to the negative side of the voltage source and the cathode must be connected to the positive side.
- A main difference between zener diodes and regular silicon diodes is the way they are used in the circuits.
- It is primarily used to regulate the circuit voltage as it has constant V_Z .
- A large change in I_R will cause only a small change in V_Z . It means that a zener diode can be used as an alternate current path. The constant V_Z developed across the diode can then be applied to a load.
- Thus the load voltage remains at constant by altering the current flow through the zener diode.

Zener Diode V-I Characteristics:

- In the forward bias condition, the zener diode behaves like an ideal diode within specified current and power limits, but it differs in reverse bias condition where the zener diode has very steep avalanche characteristic at the breakdown voltage in reverse bias condition.
- Zener operates mainly in the reverse bias mode by connecting anode to the negative terminal of the power supply. Zener diodes are categorized and rated by the voltage at which they will turn on or start to conduct the reverse bias current.
- The maximum power intended for a zener diode is specified as $P_Z = V_Z I_{Z\text{ max}}$ and it is a function of the plan and structure of the diode. The knee of the curve is generally approximated as 10% of $I_{Z\text{ max}}$.



- Generally these zener diodes are used to regulate the voltage. In reverse bias condition after the break down zener diode provides a constant output voltage even if we increase the input voltage. There are specifically two separate mechanisms that might cause a breakdown in a zener diode:

Avalanche Breakdown

- It is predominant above approximately 5.5 volts. This mechanism is also referred to as impact ionization or avalanche multiplication. For reverse conduction it is necessary to visualize the phenomenon of avalanche breakdown.
- This process begins when a large negative bias is applied to the PN junction, sufficient energy is imparted to thermally generated minority charge carriers in the semiconductors.

Zener Breakdown

- It is predominant below approximately 5.5 volts. This mechanism is also referred to as a high field emission mechanism. The phenomenon of zener breakdown is related to the concept of avalanche breakdown. Zener breakdown is achieved by heavily doped regions in the neighborhood of ohmic contact.

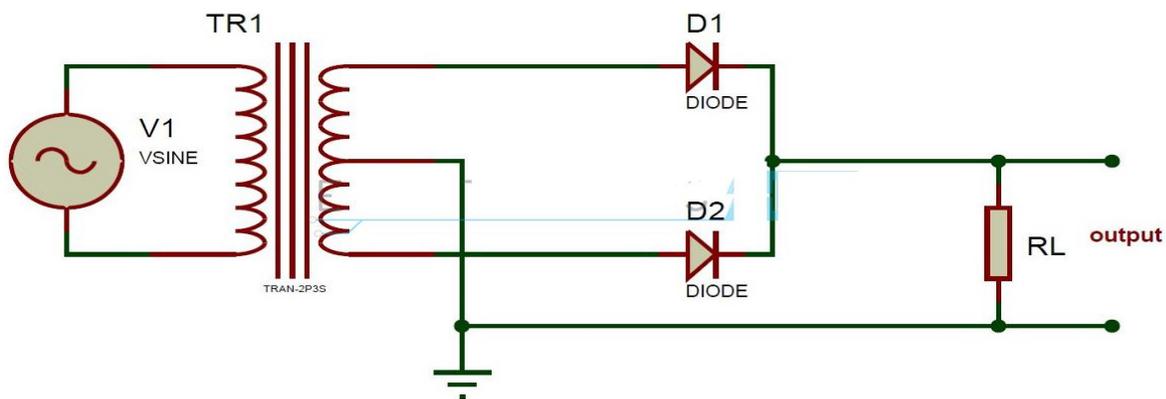
5. Explain the operation of full wave rectifiers with relevant waveforms.(M/J-2016,A/M-17,N/D-2015)

The full wave rectifier can be further divided mainly into following types.

1. Center Tapped Full Wave Rectifier
2. Full Wave Bridge Rectifier

1.Center Tapped Full Wave Rectifier

Center tap is the contact made at the middle of the winding of the transformer.



- In the center tapped full wave rectifier two diodes were used. These are connected to the center tapped secondary winding of the transformer. Above circuit diagram shows the center tapped full wave rectifier. It has two diodes. The positive terminal of two diodes is connected to the two ends of the transformer. Center tap divides the total secondary voltage into equal parts.

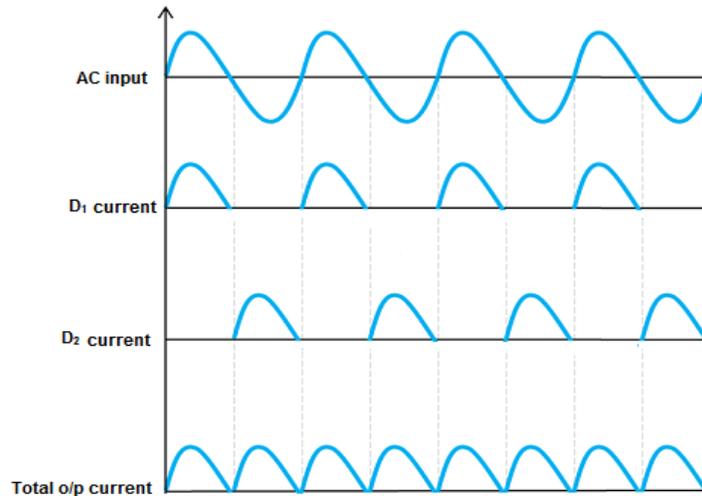
Full Wave Rectifier Working:

- The primary winding of the center tap transformer is applied with the Ac voltage. Thus the two diodes connected to the secondary of the transformer conducts alternatively. For the positive half cycle of the input diode D1 is connected to the positive terminal and D2 is connected to the negative terminal.
- Thus diode D1 is in forward bias and the diode D2 is reverse biased. Only diode D1 starts conducting and thus current flows from diode and it appears across the load RL. So positive cycle of the input is appeared at the load.
- During the negative half cycle the diode D2 is applied with the positive cycle. D2 starts conducting as it is in forward bias. The diode D1 is in reverse bias and this does not conduct. Thus current flows from diode D2 and hence negative cycle is also rectified, it appears at the load resistor RL.
- By comparing the current flow through load resistance in the positive and negative half cycles, it can be concluded that the direction of the current flow is same. Thus the frequency of rectified output voltage is two times the input frequency. The output that is rectified is not pure, it consists of a dc component and a lot of ac components of very low amplitudes.

Output waveforms of full wave rectifier

The output waveforms of the full wave rectifier is shown in the below figure.

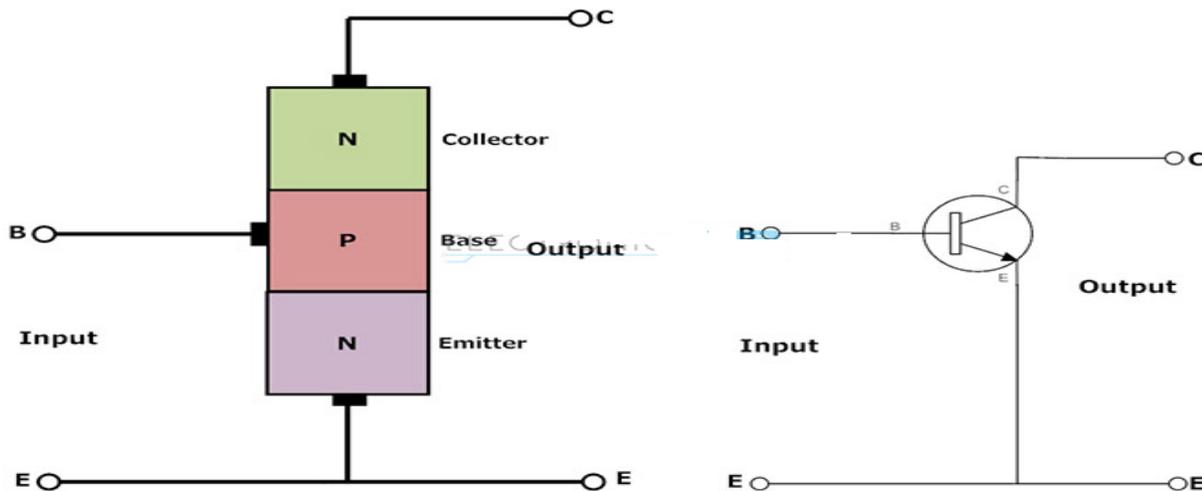
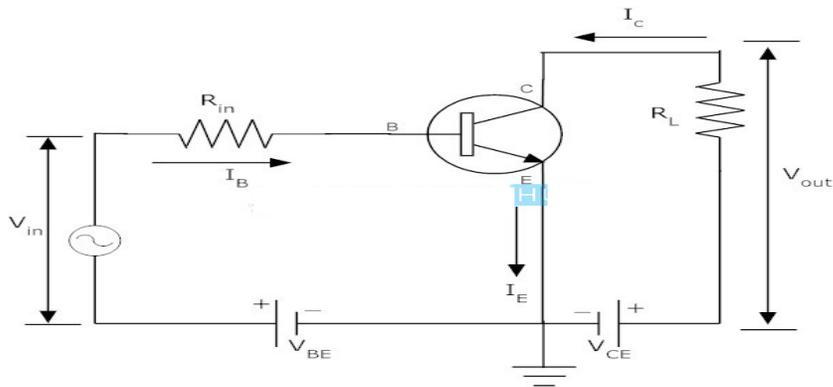
- The first waveform represents an input AC signal. The second waveform and third waveform represents the DC signals or DC current produced by diode D₁ and diode D₂.
- The last waveform represents the total output DC current produced by diodes D₁ and D₂. From the above waveforms, we can conclude that the output current produced at the load resistor is not a pure DC but a pulsating DC.



6. Explain how you will obtain the static characteristics of common emitter configuration.
(M/J-2016,A/M-2017,N/D-2015)

Common Emitter Configuration

- In this configuration we use emitter as common terminal for both input and output. This common emitter configuration is an inverting amplifier circuit. Here the input is applied between base-emitter region and the output is taken between collector and emitter terminals.
- In this configuration the input parameters are V_{BE} and I_B and the output parameters are V_{CE} and I_C . This type of configuration is mostly used in the applications of transistor based amplifiers. In this configuration the emitter current is equal to the sum of small base current and the large collector current. i.e. $I_E = I_C + I_B$.
- We know that the ratio between collector current and emitter current gives current gain alpha in Common Base configuration similarly the ratio between collector current and base current gives the current gain beta in common emitter configuration.
- This configuration is mostly used one among all the three configurations. It has medium input and output impedance values. It also has the medium current and voltage gains. But the output signal has a phase shift of 180° i.e. both the input and output are inverse to each other.



Now let us see the relationship between these two current gains.

$$\text{Current gain } (\alpha) = I_C / I_E$$

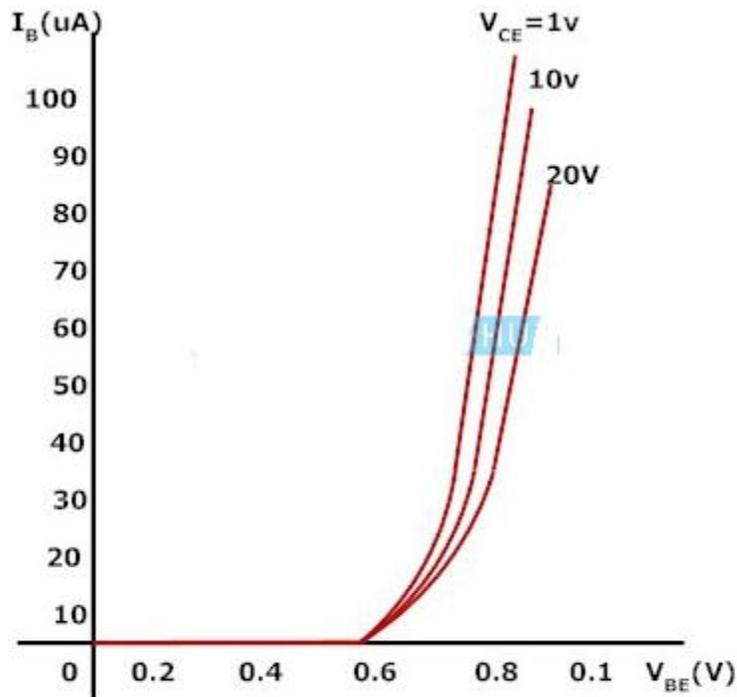
$$\text{Current gain } (\beta) = I_C / I_B$$

$$\text{Collector current } I_C = \alpha I_E = \beta I_B$$

Input Characteristics

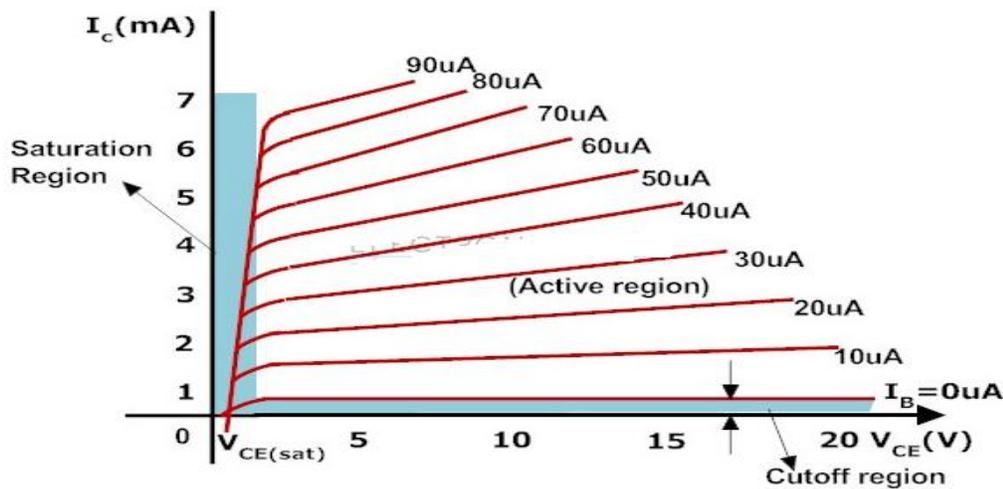
The input characteristics of common emitter configuration are obtained between input current I_B and input voltage V_{BE} with constant output voltage V_{CE} . Keep the output voltage V_{CE} constant and vary the input voltage V_{BE} for different points, now record the values of input current at each point. Now using these values we need to draw a graph between the values of I_B and V_{BE} at constant V_{CE} . The equation to calculate the input resistance R_{in} is given below.

$$R_{in} = V_{BE} / I_B \text{ (when } V_{CE} \text{ is at constant)}$$



Output Characteristics

The output characteristics of common emitter configuration are obtained between the output current I_C and output voltage V_{CE} with constant input current I_B . Keep the base current I_B constant and vary the value of output voltage V_{CE} for different points, now note down the value of collector I_C for each point. Plot the graph between the parameters I_C and V_{CE} in order to get the output characteristics of common emitter configuration. The equation to calculate the output resistance from this graph is given below.



7. Describe the working of a PN junction diode with neat diagrams. Also explain its V-I characteristics.(N/D-2015,A/M-2015,A/M-2017,A/M-2017)

Working of a PN junction diode:

- if an external potential is applied to the terminals of PN junction, it will alter the potential between the P and N-regions. This potential difference can alter the flow of majority carriers, so that the PN junction can be used as an opportunity for the diffusion of electrons and holes.
- If the voltage applied decreases the width of the depletion layer, then the diode is assumed to be in forward bias and if the applied voltage increases the depletion layer width then the diode is assumed to be in reverse bias. If the width of depletion layer do not alters then it is in the zero bias state.
- **Forward Bias:** External voltage decreases the built-in potential barrier.
- **Reverse Bias:** External voltage increases the built-in potential barrier.
- **Zero Bias:** No external voltage is applied.

Forward Biased Diode

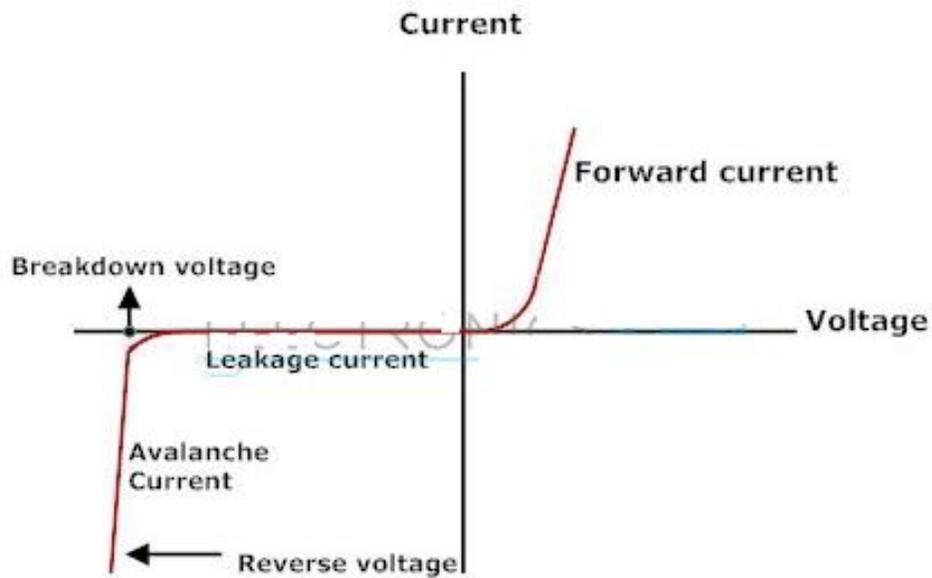
- With the externally applied voltage, a potential difference is altered between the P and N regions.
- When positive terminal of the source is connected to the P side and the negative terminal is connected to N side then the junction diode is said to be connected in forward bias condition. Forward bias lowers the potential across the PN junction.

Reverse Biased Diode

- When positive terminal of the source is connected to the N side and the negative terminal is connected to P side, then the junction diode is said to be connected in reverse bias condition.
- In this type of connection majority charge carriers are attracted away from the depletion layer by their respective battery terminals connected to PN junction

V-I Characteristics of PN Junction Diode

- In the current–voltage characteristics of junction diode, from the first quadrant in the figure current in the forward bias is incredibly low if the input voltage applied to the diode is lower than the threshold voltage (V_r). The threshold voltage is additionally referred to as cut-in voltage.
- Once the forward bias input voltage surpasses the cut-in voltage (0.3 V for germanium diode, 0.6-0.7 V for silicon diode), the current spectacularly increases, as a result the diode functions as short-circuit.

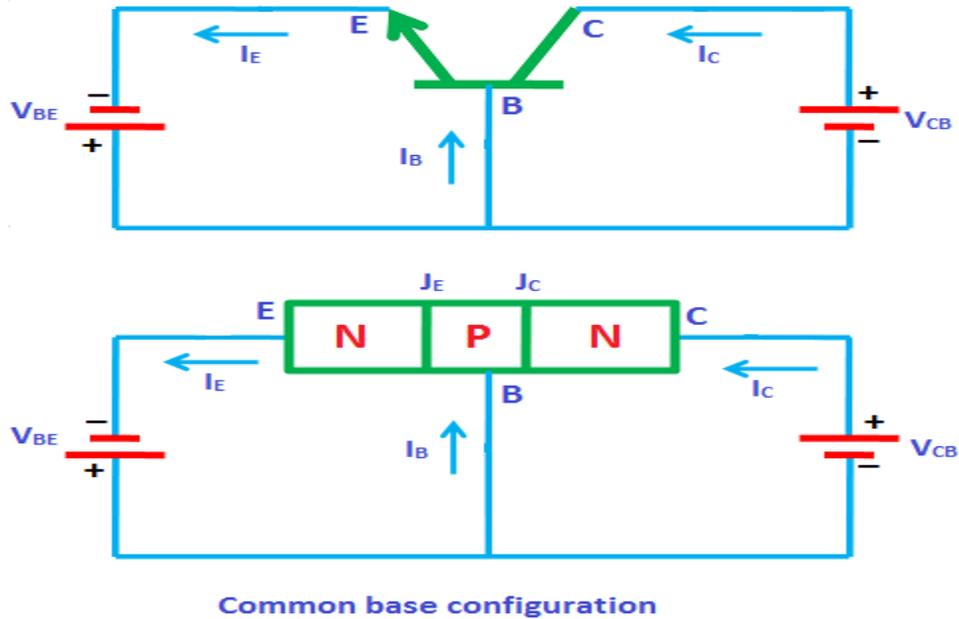


- The reverse bias characteristic curve of diode is shown in the fourth quadrant of the figure above. The current in the reverse bias is low till breakdown is reached and therefore the diode looks like as open circuit. When the reverse bias input voltage has reached the breakdown voltage, reverse current increases spectacularly.

8. Explain the working of CB configuration of a BJT and draw its input, output characteristics. (A/M-2015,A/M-2017)

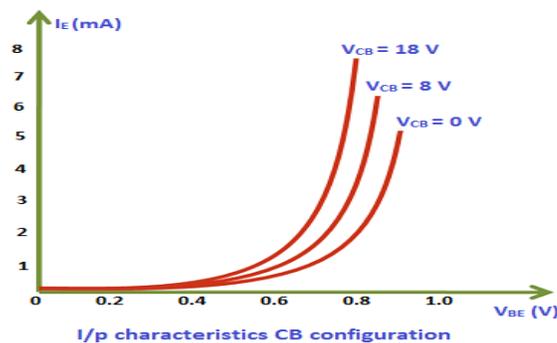
Common Base Configuration

- In common base configuration, emitter is the input terminal, collector is the output terminal and base terminal is connected as a common terminal for both input and output. That means the emitter terminal and common base terminal are known as input terminals whereas the collector terminal and common base terminal are known as output terminals.
- In common base configuration, the base terminal is grounded so the common base configuration is also known as grounded base configuration. Sometimes common base configuration is referred to as common base amplifier, CB amplifier, or CB configuration.
- The input signal is applied between the emitter and base terminals while the corresponding output signal is taken across the collector and base terminals. Thus the base terminal of a transistor is common for both input and output terminals and hence it is named as common base configuration.



Input characteristics

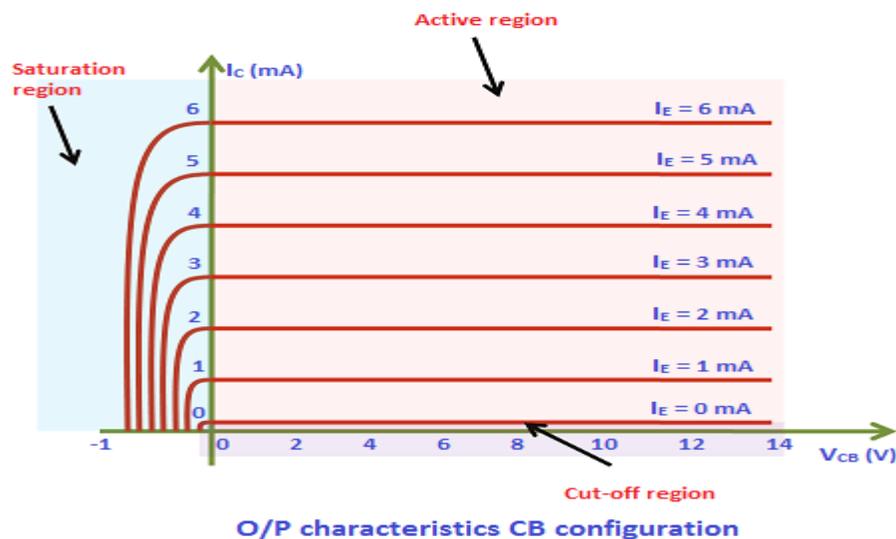
- The input characteristics describe the relationship between input current (I_E) and the input voltage (V_{BE}).
- First, draw a vertical line and horizontal line. The vertical line represents y-axis and horizontal line represents x-axis. The input current or emitter current (I_E) is taken along the y-axis (vertical line) and the input voltage (V_{BE}) is taken along the x-axis (horizontal line).
- To determine the input characteristics, the output voltage V_{CB} (collector-base voltage) is kept constant at zero volts and the input voltage V_{BE} is increased from zero volts to different voltage levels. For each voltage level of the input voltage (V_{BE}), the input current (I_E) is recorded on a paper or in any other form.
- A curve is then drawn between input current I_E and input voltage V_{BE} at constant output voltage V_{CB} (0 volts).
- Next, the output voltage (V_{CB}) is increased from zero volts to a certain voltage level (8 volts) and kept constant at 8 volts. While increasing the output voltage (V_{CB}), the input voltage (V_{BE}) is kept constant at zero volts. After we kept the output voltage (V_{CB}) constant at 8 volts, the input voltage V_{BE} is increased from zero volts to



different voltage levels. For each voltage level of the input voltage (V_{BE}), the input current (I_E) is recorded on a paper or in any other form.

Output characteristics

- The output characteristics describe the relationship between output current (I_C) and the output voltage (V_{CB}).
- First, draw a vertical line and a horizontal line. The vertical line represents y-axis and horizontal line represents x-axis. The output current or collector current (I_C) is taken along the y-axis (vertical line) and the output voltage (V_{CB}) is taken along the x-axis (horizontal line).
- To determine the output characteristics, the input current or emitter current I_E is kept constant at zero mA and the output voltage V_{CB} is increased from zero volts to different voltage levels. For each voltage level of the output voltage V_{CB} , the output current (I_C) is recorded.
- When the emitter current or input current I_E is equal to 0 mA, the transistor operates in the cut-off region.



- Next, the input current (I_E) is increased from 0 mA to 1 mA by adjusting the input voltage V_{BE} and the input current I_E is kept constant at 1 mA. While increasing the input current I_E , the output voltage V_{CB} is kept constant.
- After we kept the input current (I_E) constant at 1 mA, the output voltage (V_{CB}) is increased from zero volts to different voltage levels. For each voltage level of the output voltage (V_{CB}), the output current (I_C) is recorded

9. Explain the working of CE configuration of a BJT and draw its input, output characteristics. (N/D-2016)

Output characteristics:-

Cut off, Active and saturation regions of a transistor:

1. Transistor Biasing:-

The application of suitable dc voltages across the transistor terminals is called biasing. Each junction of a transistor may be forward biased or reverse biased independently. These are following three different ways of biasing a transistor, which is also known as modes of transistor operation.

2. Forward active:-

Emitter-Base junction is forward biased
Collector- base junction is reverse biased.

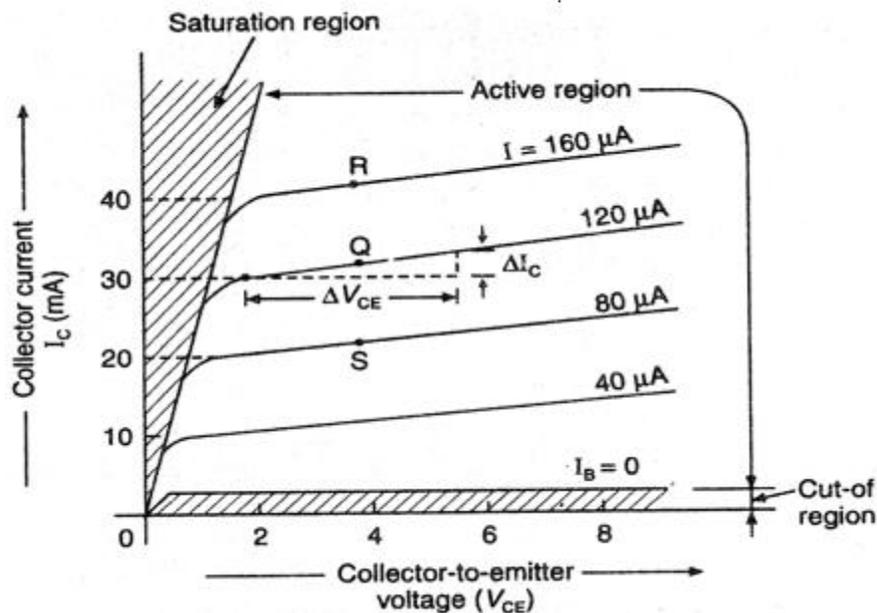
3. Saturation Region:-

Emitter-Base junction is forward biased Collector- base junction is forward biased
In this mode transistor has a very large value of current. The transistor is operated in this mode, when it is used as a closed switch. Here, there is a large change in the collector current I_C with a small change in V_{CE} .

4. Cut- off Region:-

Emitter-Base junction is reverse biased Collector- base junction is reverse biased

In this region both the junctions are Reverse Biased. In this mode transistor has zero current. The transistor is operated in this mode, when it is used as an open switch. Since the collector base junction is reversed biased, the current due to majority carriers flows from collector to emitter which is represented by I_{CEO}



Output characteristics of Common Emitter Transistor

Output resistance: $r_o = \Delta V_{ce} / \Delta I_c$

$I_B = \text{constant}$

Current gain = $\beta_{dc} = I_c / I_b$

$V_{CE} = \text{constant}$

$\beta_{ac} = I_c / I_b$

$V_{CE} = \text{constant}$

Modes of transistor action:

S.no	Junction bias condition		
	Mode	Emitter-base	Collector-base
1.	Forward-Active	Forward	Reverse
2.	Saturation	Forward	Forward
3.	Cut-off	Reverse	Reverse

Input characteristics:-

It is the graph of input current I_b v/s input voltage V_{be} at a constant output voltage V_{ce} . It resembles the characteristics of a forward-biased diode. The input current I_b increases as the input voltage V_{be} increases for a fixed value of V_{ce} .

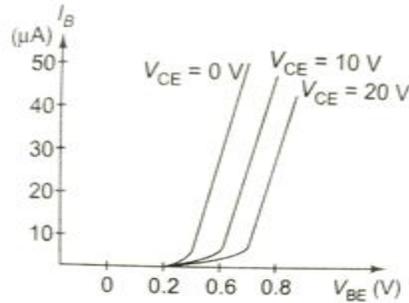
As the Reverse-Bias voltage V_{ce} increases, Depletion region in the collector –base junction increases.

Hence the width of the base available for conduction decreases. Hence, I_b decreases due to early effect and the graph shifts towards X-axis.

Dynamic input resistance =

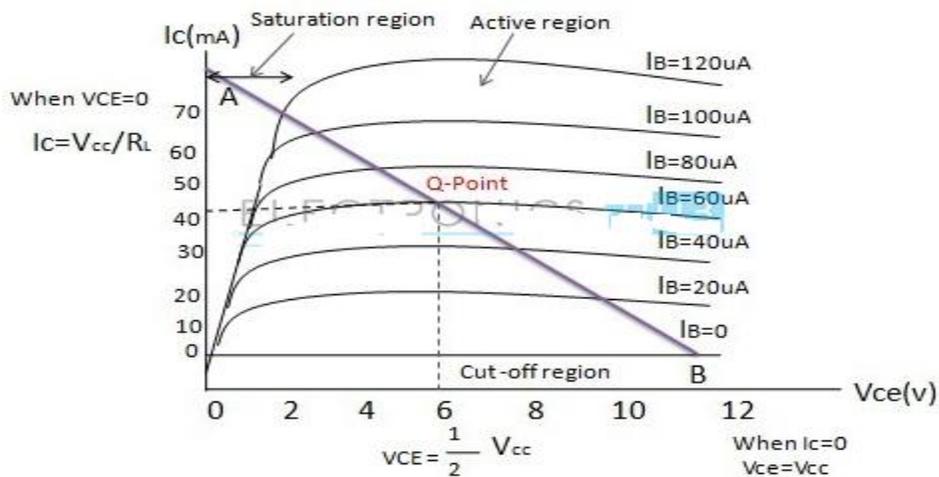
$$R_i = \Delta V_{be} / \Delta I_b$$

where $V_{CE} = \text{constant}$



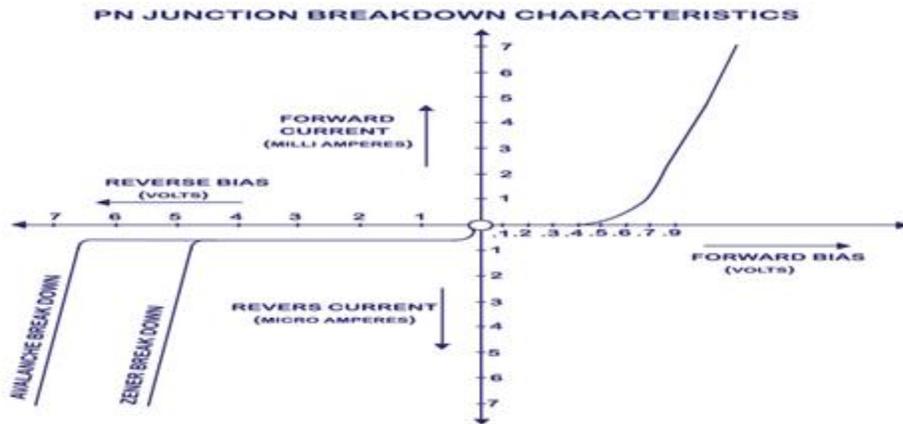
Output Characteristics

- The family of output characteristics curves of a bipolar transistor is given below. The curves show the relationship between the collector current (I_C) and the collector-emitter voltage (V_{CE}) with the varying of base current (I_B).
- We know that the transistor is 'ON' only when at least a small amount of current and small amount of voltage is applied at its base terminal relative to emitter otherwise the transistor is in 'OFF' state.



10. i) Explain the avalanche effect that accounts for the reverse breakdown voltage (PIV) of a Diode.

PN Junction Breakdown : Electrical break down of any material (say metal, conductor, semiconductor or even insulator) can occur due to two different phenomena. Those two phenomena are 1) Zener breakdown and 2) Avalanche breakdown



- These two phenomena are quite like a natural occurrence. It even applies to our daily life while lightning. We all know air is an insulator under normal conditions.
- But when lightning occurs (an extremely high voltage), it charges the air molecules nearby and charges get transferred via air medium. Now that's a kind of electrical breakdown of an insulator. A similar kind of situation arises in zener and avalanche breakdown as well.

Avalanche effects:

- Avalanche breakdown occurs in a pn junction diode which is moderately doped and has a thick junction (means its depletion layer width is high).
- Avalanche breakdown usually occurs when we apply a high reverse voltage across the diode (obviously higher than the zener breakdown voltage, say V_z). So as we increase the applied reverse voltage, the electric field across junction will keep increasing.

If applied reverse voltage is V_a and the depletion layer width is d ; then the generated electric field can be calculated as $E_a = V_a/d$

- This generated electric field exerts a force on the electrons at junction and it frees them from covalent bonds. These free electrons will gain acceleration and it will start moving across the junction with high velocity.
- This results in collision with other neighboring atoms. These collisions in high velocity will generate further free electrons. These electrons will start drifting and electron-hole pair recombination occurs across the junction. This results in net current that rapidly increases.
- We learned that avalanche breakdown occurs at a voltage (V_a) which is higher than zener breakdown voltage (V_z). The reason behind this is simple. We know, avalanche phenomena occurs in a diode which is moderately doped and junction width (say d) is high.
- A zener break down occurs in a diode with heavy doping and thin junction (here d is small). The electric field that occur due to applied reverse voltage (say V) can be calculated as $E = V/d$.

So in a Zener breakdown, the electric field necessary to break electrons from covalent bond is achieved with lesser voltage than in avalanche breakdown. The reason is thin depletion layer width. In avalanche breakdown, the depletion layer width is higher and hence much more reverse voltage has to be applied to develop the same electric field strength (necessary enough to break electrons free)

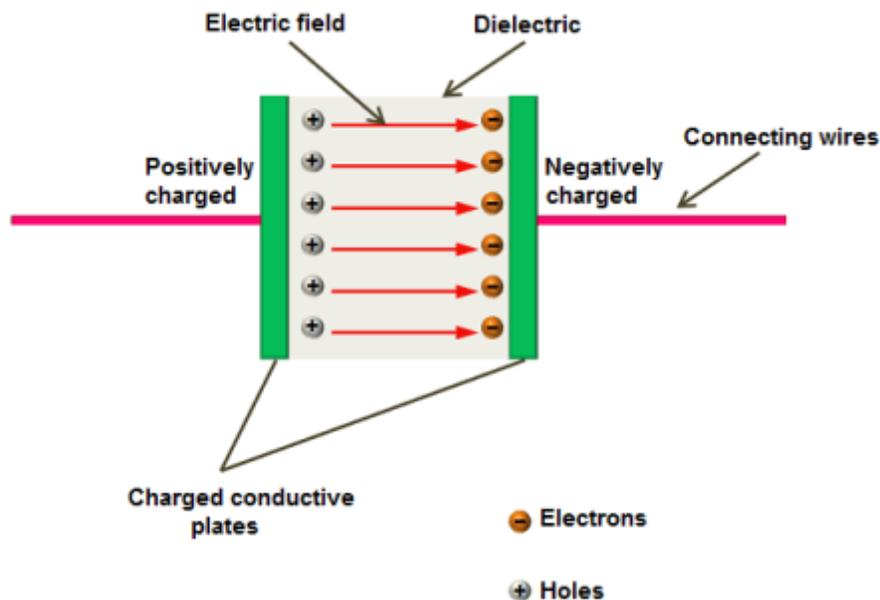
10. What is the effect of capacitance of a PN junction diode as forward and reverse bias are applied?(M/J-2016)

In a p-n junction diode, two types of capacitance take place. They are,

- Transition capacitance (C_T)
- Diffusion capacitance (C_D)

1. Transition capacitance (C_T)

- We know that capacitors store electric charge in the form of electric field. This charge storage is done by using two electrically conducting plates (placed close to each other) separated by an insulating material called dielectric.
- The conducting plates or electrodes of the capacitor are good conductors of electricity. Therefore, they easily allow electric current through them. On the other hand, dielectric material or medium is poor conductor of electricity. Therefore, it does not allow electric current through it. However, it efficiently allows electric field.



- When voltage is applied to the capacitor, charge carriers start flowing through the conducting wire. When these charge carriers reach the electrodes of the capacitor, they

experience a strong opposition from the dielectric or insulating material. As a result, a large number of charge carriers are trapped at the electrodes of the capacitor.

The transition capacitance can be mathematically written as,

$$C_T = \epsilon A / W$$

Where,

ϵ = Permittivity of the semiconductor

A = Area of plates or p-type and n-type regions

W = Width of depletion region

2. Diffusion capacitance (C_D)

- Diffusion capacitance occurs in a forward biased p-n junction diode. Diffusion capacitance is also sometimes referred as storage capacitance. It is denoted as C_D .
- In a forward biased diode, diffusion capacitance is much larger than the transition capacitance. Hence, diffusion capacitance is considered in forward biased diode.
- The diffusion capacitance occurs due to stored charge of minority electrons and minority holes near the depletion region.
- When forward bias voltage is applied to the p-n junction diode, electrons (majority carriers) in the n-region will move into the p-region and recombines with the holes. In the similar way, holes in the p-region will move into the n-region and recombines with electrons. As a result, the width of depletion region decreases.

The formula for diffusion capacitance is

$$C_D = dQ / dV$$

Where,

C_D = Diffusion capacitance

dQ = Change in number of minority carriers stored outside the depletion region

dV = Change in voltage applied across diode

UNIT-4 DIGITAL ELECTRONICS

PART-A:

1. Explain Universal gates. (N/D-2016)

A universal gate is a gate which can implement any Boolean function without need to use any other gate type. The NAND and NOR gates are universal gates. In practice, this is advantageous since NAND and NOR gates are economical and easier to fabricate and are the basic gates used in all IC digital logic families

2. Convert $(63)_8$ to hexadecimal. (N/D-2016)

ANS:3 F

3. State the de-morgan's theorem. (A/M-2017)

The Demorgan's theorem mostly used in digital programming and for making digital circuit diagrams. There are two DeMorgan's Theorems. They are described below in detail.

According to DeMorgan's first theorem, a NOR gate is equivalent to a bubbled AND gate. The Boolean expressions for the bubbled AND gate can be expressed by the equation shown below. For NOR gate, the equation is

$$Z = A + B$$

DeMorgan's Second Theorem

DeMorgan's Second Theorem states that the NAND gate is equivalent to a bubbled OR gate.

$$Z = A . B$$

4. What is the register in digital systems?(M/J-2016)

Flip-flop is a 1 bit memory cell which can be used for storing the digital data. To increase the storage capacity in terms of number of bits, we have to use a group of flip-flop. Such a group of flip-flop is known as a Register. The n-bit register will consist of n number of flip-flop and it is capable of storing an n-bit word.

5 .Define the logic operation of AND gate with Boolean equation.(N/D-2015)

Boolean Expression $Q = A.B.C$. Read as A AND B AND C gives Q. Because the Boolean expression for the logic AND function is defined as ($.$), which is a binary operation, AND gates can be cascaded together to form any number of individual inputs.

6. Convert $(778)_8$ to decimal.(A/M-2017)

Ans: 28

7. Define flip flop. What are the different types of flip flop?(M/J-2016,A/M-2017)

The designing of the flip flop circuit can be done by using logic gates such as two NAND and NOR gates. Each flip flop consists of two inputs and two outputs, namely set and reset, Q and Q'. This kind of flip flop is stated to as an SR flip flop or SR latch.

TYPES:

- RS flip-flop
- JK flip-flop
- D flip-flop
- T flip-flop

8. What are registers? (A/M-2017)

Registers are data storage devices that are more sophisticated than latches. A register is a group of binary cells suitable for holding binary information. A group of cascaded flip-flops used to store related bits of information is known as a register.

9. What are the logic gates? (N/D-2016)

These gates are the AND, OR, NOT, NAND, NOR, EXOR and EX-NOR gates.

10. What is the use of counters? (N/D-2016)

Counter is a digital device and the output of the counter includes a predefined state based on the clock pulse applications. The output of the counter can be used to count the number of pulses. Generally, counters consist of a flip-flop arrangement which can be synchronous counter or asynchronous counter.

PART-B:

1. Draw a full adder circuit using logic gates. Explain with truth table. Give also the expression for sum and carry(N/D-2016,M/J-2016)

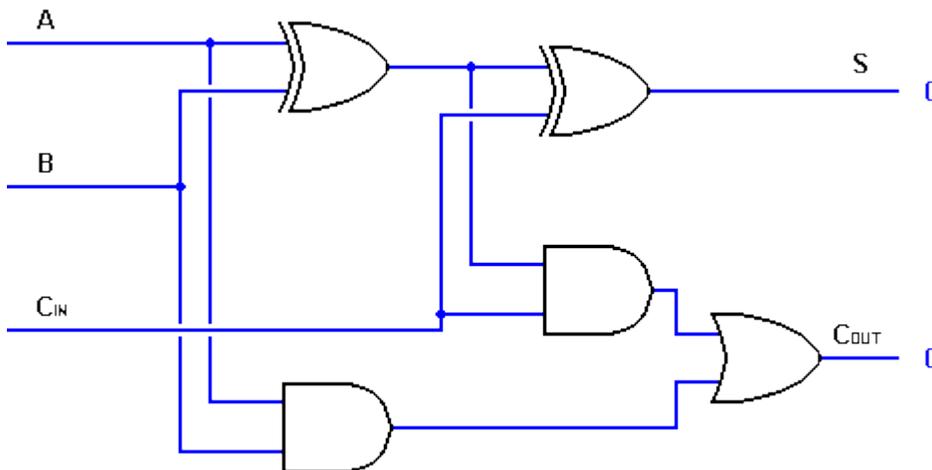
Full Adder

- This type of adder is a little more difficult to implement than a half-adder. The main difference between a half-adder and a full-adder is that the full-adder has three inputs and two outputs. The first two inputs are A and B and the third input is an input carry designated as CIN.
- When a full adder logic is designed we will be able to string eight of them together to create a byte-wide adder and cascade the carry bit from one adder to the next. The output carry is designated as COUT and the normal output is designated as S. Take a look at the truth-table

Truth-Table

INPUTS		OUTPUTS		
A	B	CIN	C OUT	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

- From the above truth-table, the full adder logic can be implemented. We can see that the output S is an EXOR between the input A and the half-adder SUM output with B and CIN inputs. We must also note that the COUT will only be true if any of the two inputs out of the three are HIGH.
- Thus, we can implement a full adder circuit with the help of two half adder circuits. The first will half adder will be used to add A and B to produce a partial Sum.
- The second half adder logic can be used to add CIN to the Sum produced by the first half adder to get the final S output. If any of the half adder logic produces a carry, there will be an output carry. Thus, COUT will be an OR function of the half-adder Carry outputs. Take a look at the implementation of the full adder circuit shown below.



For the SUM (S) bit:

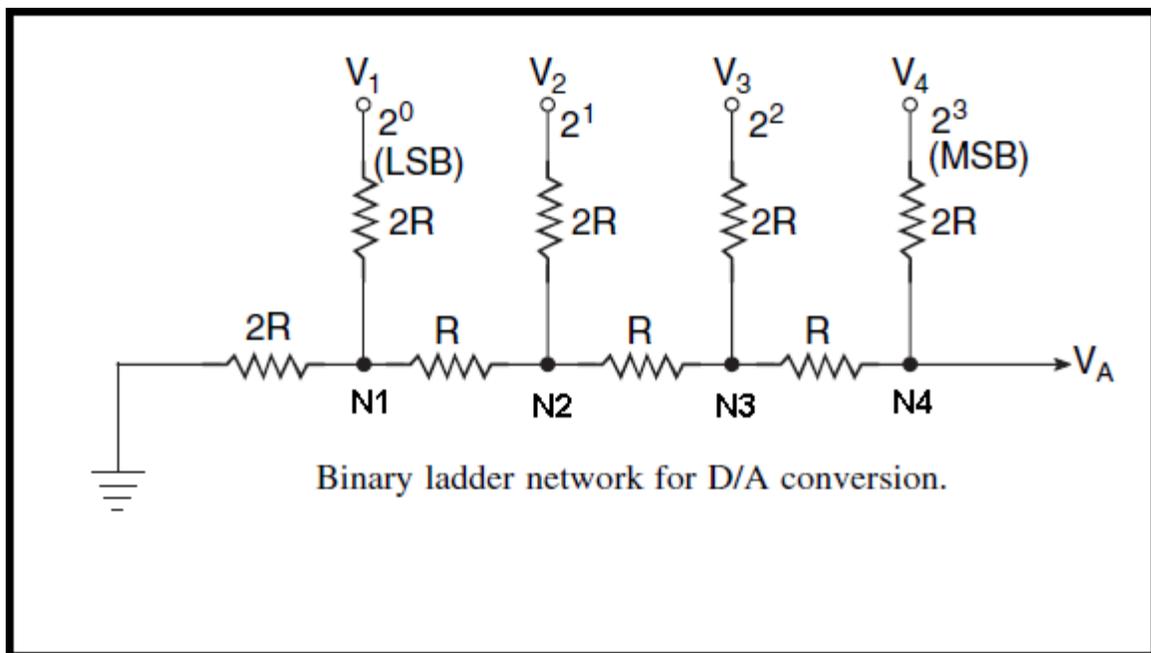
$$\text{SUM} = (A \text{ XOR } B) \text{ XOR } \text{Cin} = (A \oplus B) \oplus \text{Cin}$$

For the CARRY-OUT (Cout) bit:

$$\text{CARRY-OUT} = A \text{ AND } B \text{ OR } \text{Cin} (A \text{ XOR } B) = A.B + \text{Cin} (A \oplus B)$$

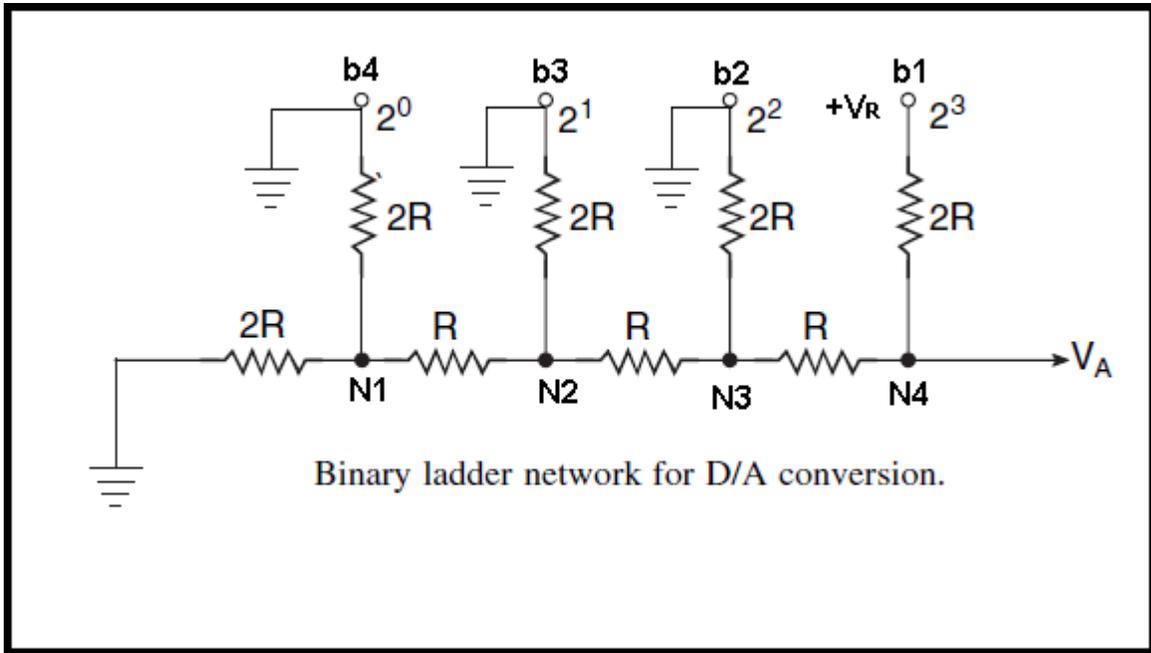
2. With a neat circuit diagram explain the working of binary ladder network for digital to analog conversion. (N/D-2016)

- To overcome huge range of resistor used in weighted resistor D/A converter, R-2R ladder D/A converter is introduced. In my previous post I discussed about weighted resistor D/A converter.
- But the vital problem in weighted register D/A converter is use of huge range of different resistance. Suppose we have to design 8-bit weighted register D/A converter then we need the resistance value $2^0R + 2^1R + \dots + 2^7R$. So the largest resistor corresponding to bit b_8 is 128 times the value of the smallest resistor correspond to b_1 . But in case of R-2R ladder D/A converter, Resistors of only two value (R and 2R) are used. Now in bellow see the simple ladder network.

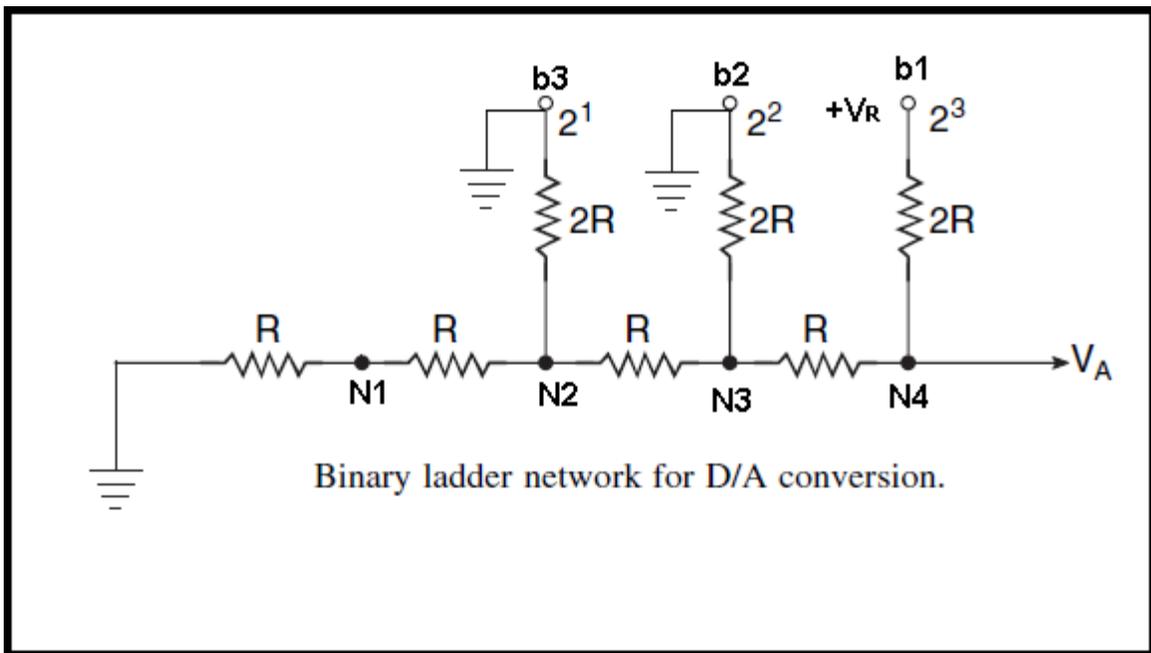


In ladder circuit the output voltage is also weighted sum of the corresponding digital input. Let take an example to understand how it works? As we can see the above network is a 4-bit

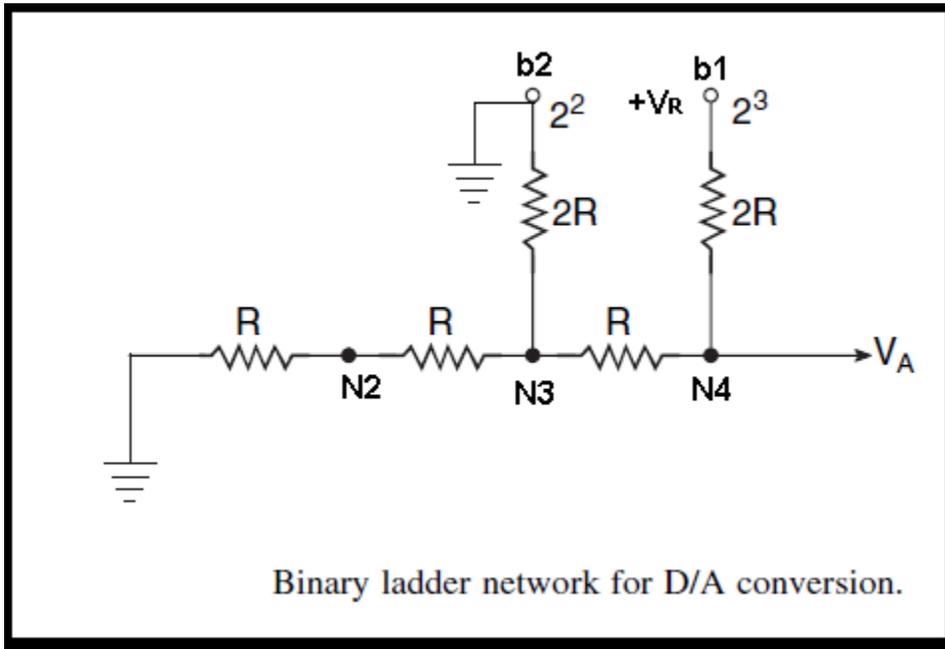
ladder network so we take an example to convert analog signal correspond of **1000** digital bit. For **1000** bit we can see only MSB got 1 and rest all bits got 0. See the bellow picture to understand how it work if it got **1000**.



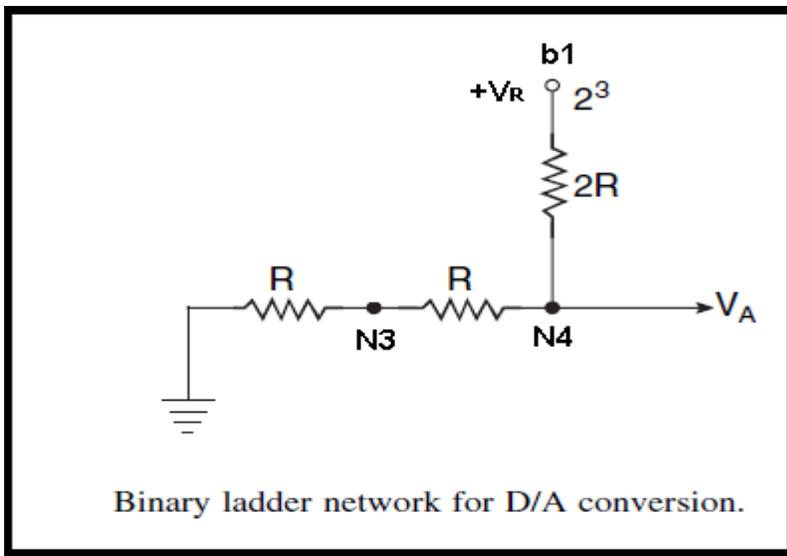
Now see at node1 (N1) resistor 2R connecting in b4 parallel with resistor 2R. And those 2R parallel 2R resistors make equivalent register of R shown in bellow diagram.



Now for N2 same thing happen B3 series with 2R and parallel with R + R resistors. It will also make equivalent resistor R at N3. See the bellow diagram



Repeating the same process we got equivalent of R resistor at N4.



Now at N4, if we calculate the output analog equivalent voltage then we will get

$$V_A = \frac{V_R \cdot 2R}{(R+R+2R)}$$

$$= \frac{V_R}{2}$$

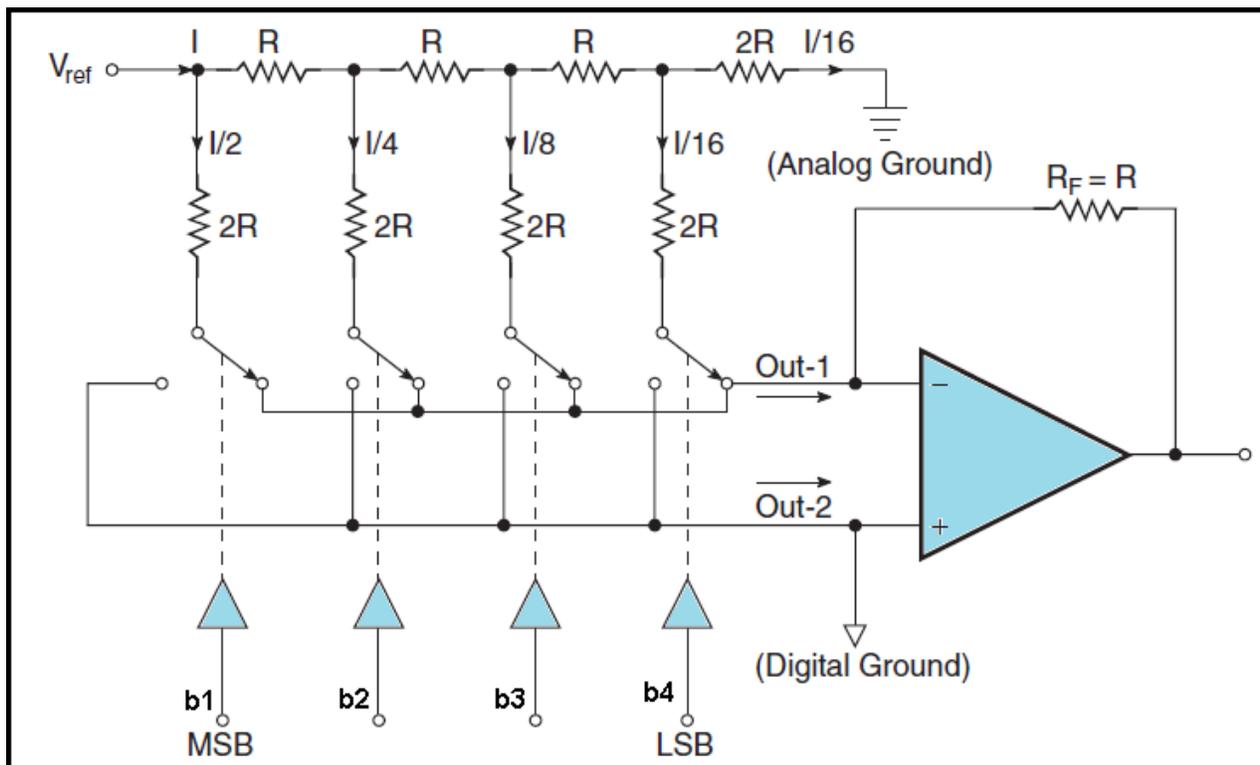
Thus when bit 1000 the output is $V_R/2$. Similarly it can be found that using above process for bit 0100 the output will be $V_R/4$, for bit 0010 output will be $V_R/8$ and for bit 0001 output will be $V_R/16$.

By using superposition theorem we can find in any n-bit ladder network the output voltage will be

$$V_A = V_R/2^1 + V_R/2^2 + V_R/2^3 + \dots + V_R/2^n$$

Where n is the total number of bits at the input.

Now see the practical circuit arrangement of 4-bit R-2R ladder D/A converter using op amp.



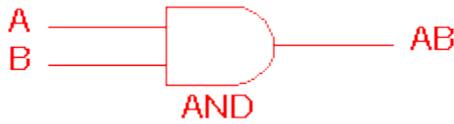
The inverting input terminal of the op amp work as a summing amplifier for the ladder inputs. So we can get out put voltage by bellow equation.

$$V_0 = V_R \cdot (R_F/R) [b_1/2^1 + b_2/2^2 + b_3/2^3 + b_4/2^4]$$

3. List various types of logic gates with its logic symbols and truth table. List also universal gates. (M/J-2016,N/D-2015)

Digital systems are said to be constructed by using logic gates. These gates are the AND, OR, NOT, NAND, NOR, EXOR and EXNOR gates. The basic operations are described below with the aid of truth tables.

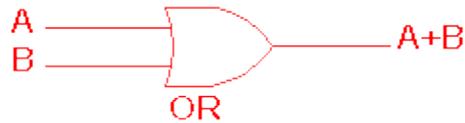
AND gate



2 Input AND gate		
A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

The AND gate is an electronic circuit that gives a **high** output (1) only if **all** its inputs are high. A dot (.) is used to show the AND operation i.e. A.B. Bear in mind that this dot is sometimes omitted i.e. AB

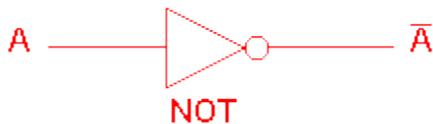
OR gate



2 Input OR gate		
A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

The OR gate is an electronic circuit that gives a high output (1) if **one or more** of its inputs are high. A plus (+) is used to show the OR operation.

NOT gate

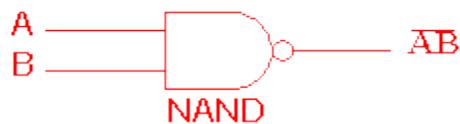


NOT gate	
A	Ā
0	1
1	0

The NOT gate is an electronic circuit that produces an inverted version of the input at its output. It is also known as an *inverter*. If the input variable is A, the inverted output is known as NOT A.

This is also shown as A', or A with a bar over the top, as shown at the outputs. The diagrams below show two ways that the NAND logic gate can be configured to produce a NOT gate. It can also be done using NOR logic gates in the same way.

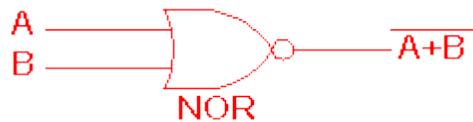
NAND gate



2 Input NAND gate		
A	B	A.B̄
0	0	1
0	1	1
1	0	1
1	1	0

This is a NOT-AND gate which is equal to an AND gate followed by a NOT gate. The outputs of all NAND gates are high if any of the inputs are low. The symbol is an AND gate with a small circle on the output. The small circle represents inversion.

NOR gate



A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

This is a NOT-OR gate which is equal to an OR gate followed by a NOT gate. The outputs of all NOR gates are low if any of the inputs are high. The symbol is an OR gate with a small circle on the output. The small circle represents inversion.

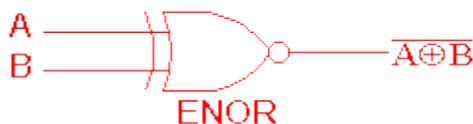
EXOR gate



A	B	$A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

The 'Exclusive-OR' gate is a circuit which will give a high output if **either, but not both**, of its two inputs are high. An encircled plus sign (\oplus) is used to show the EOR operation

EX-NOR gate



A	B	$\overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

The 'Exclusive-NOR' gate circuit does the opposite to the EOR gate. It will give a low output if **either, but not both**, of its two inputs are high. The symbol is an EXOR gate with a small circle on the output. The small circle represents inversion.

The NAND and NOR gates are called *universal functions* since with either one the AND and OR functions and NOT can be generated.

Note:

A function in *sum of products* form can be implemented using NAND gates by replacing all AND and OR gates by NAND gates.

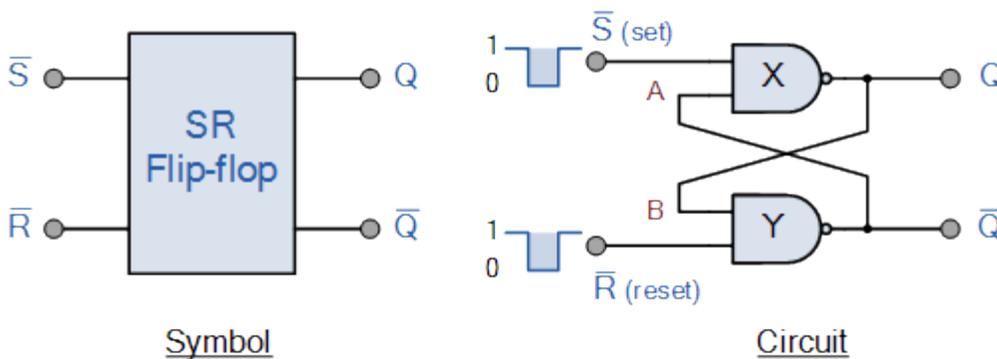
A function in product of sums form can be implemented using NOR gates by replacing all AND and OR gates by NOR gates.

4. Draw and explain the operation of following flip-flops,(i) SR flip-flops (ii) D-flip lops.(N/D-2015,A/M-2015)

SR Flip-Flop

- The **SR flip-flop**, also known as a *SR Latch*, can be considered as one of the most basic sequential logic circuit possible. This simple flip-flop is basically a one-bit memory bistable device that has two inputs, one which will “SET” the device (meaning the output = “1”), and is labelled S and another which will “RESET” the device (meaning the output = “0”), labelled R.
- Then the SR description stands for “Set-Reset”. The reset input resets the flip-flop back to its original state with an output Q that will be either at a logic level “1” or logic “0” depending upon this set/reset condition.
- A basic NAND gate SR flip-flop circuit provides feedback from both of its outputs back to its opposing inputs and is commonly used in memory circuits to store a single data bit. Then the SR flip-flop actually has three inputs, Set, Reset and its current output Q relating to it’s current state or history. The term “Flip-flop” relates to the actual operation of the device, as it can be “flipped” into one logic Set state or “flopped” back into the opposing logic Reset state.

The Basic SR Flip-flop



The Set State

- Consider the circuit shown above. If the input R is at logic level “0” ($R = 0$) and input S is at logic level “1” ($S = 1$), the NAND gate Y has at least one of its inputs at logic “0” therefore, its output Q must be at a logic level “1” (NAND Gate principles). Output Q is

also fed back to input “A” and so both inputs to NAND gate *X* are at logic level “1”, and therefore its output *Q* must be at logic level “0”.

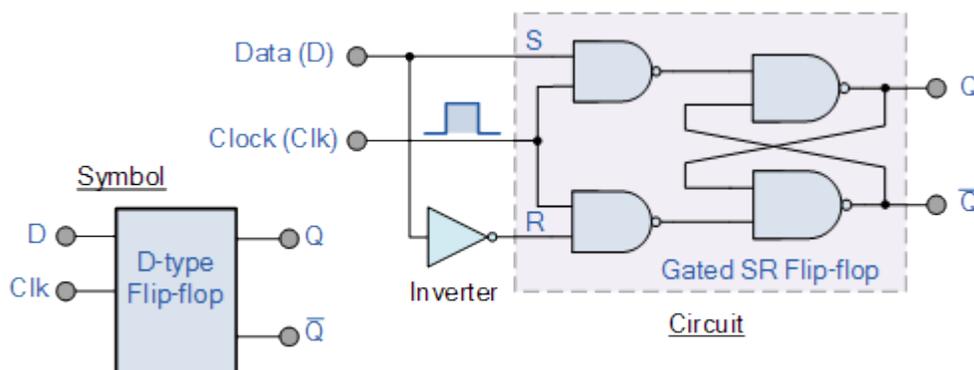
Reset State

In this second stable state, *Q* is at logic level “0”, (not $\bar{Q} = “0”$) its inverse output at \bar{Q} is at logic level “1”, ($\bar{Q} = “1”$), and is given by $R = “1”$ and $S = “0”$. As gate *X* has one of its inputs at logic “0” its output *Q* must equal logic level “1” (again NAND gate principles). Output *Q* is fed back to input “B”, so both inputs to NAND gate *Y* are at logic “1”, therefore, $\bar{Q} = “0”$.

Truth Table for this Set-Reset Function

State	S	R	Q	\bar{Q}	Description
Set	1	0	0	1	Set $Q \gg 1$
	1	1	0	1	no change
Reset	0	1	1	0	Reset $Q \gg 0$
	1	1	1	0	no change
Invalid	0	0	1	1	Invalid Condition

D-type Flip-Flop Circuit



- A simple SR flip-flop requires two inputs, one to “SET” the output and one to “RESET” the output. By connecting an inverter (NOT gate) to the SR flip-flop we can “SET” and “RESET” the flip-flop using just one input as now the two input signals are complements of each other.
- This complement avoids the ambiguity inherent in the SR latch when both inputs are LOW, since that state is no longer possible.

- Thus this single input is called the “DATA” input. If this data input is held HIGH the flip flop would be “SET” and when it is LOW the flip flop would change and become “RESET”. However, this would be rather pointless since the output of the flip flop would always change on every pulse applied to this data input.
- To avoid this an additional input called the “CLOCK” or “ENABLE” input is used to isolate the data input from the flip flop’s latching circuitry after the desired data has been stored. The effect is that D input condition is only copied to the output Q when the clock input is active. This then forms the basis of another sequential device called a **D Flip Flop**.

Truth Table for the D-type Flip Flop

Clk	D	Q	Q	Description
↓ » 0	X	Q	Q	Memory no change
↑ » 1	0	0	1	Reset Q » 0
↑ » 1	1	1	0	Set Q » 1

5. With necessary diagrams describe the operation of a 4-bit binary, ripple counter.(N/D-2015,A/M-2015,A/M-2017)

Ripple Counter

- A ripple counter is an asynchronous counter where only the first flip-flop is clocked by an external clock. All subsequent flip-flops are clocked by the output of the preceding flip-flop. Asynchronous counters are also called ripple-counters because of the way the clock pulse ripples it way through the flip-flops.
- The MOD of the ripple counter or asynchronous counter is 2^n if n flip-flops are used. For a 4-bit counter, the range of the count is 0000 to 1111 (2^4-1).
- A counter may count up or count down or count up and down depending on the input control. The count sequence usually repeats itself. When counting up, the count sequence goes from 0000, 0001, 0010, ... 1110 , 1111 , 0000, 0001, ... etc. When counting down the count sequence goes in the opposite manner: 1111, 1110, ... 0010, 0001, 0000, 1111, 1110, ... etc.
- The complement of the count sequence counts in reverse direction. If the complemented output counts up, the complemented output counts down. If the complemented output counts down, the complemented output counts up.

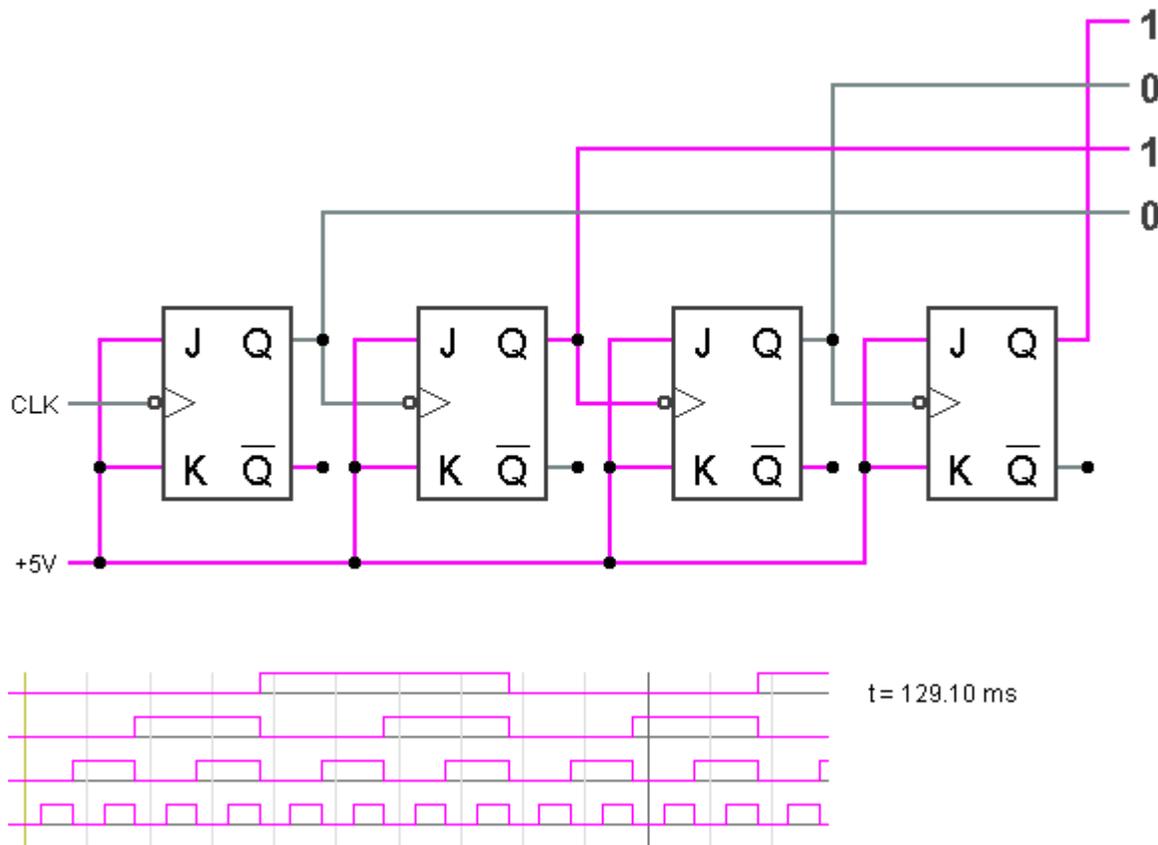
There are many ways to implement the ripple counter depending on the characteristics of the flip flops used and the requirements of the count sequence.

- Clock Trigger: Positive edged or Negative edged
- JK or D flip-flops
- Count Direction: Up, Down, or Up/Down

Asynchronous counters are slower than synchronous counters because of the delay in the transmission of the pulses from flip-flop to flip-flop. With a synchronous circuit, all the bits in the count change synchronously with the assertion of the clock. Examples of synchronous counters are the Ring and Johnson counter.

It can be implemented using D-type flip-flops or JK-type flip-flops.

The circuit below uses 2 D flip-flops to implement a divide-by-4 ripple counter ($2^n = 2^2 = 4$). It counts down.



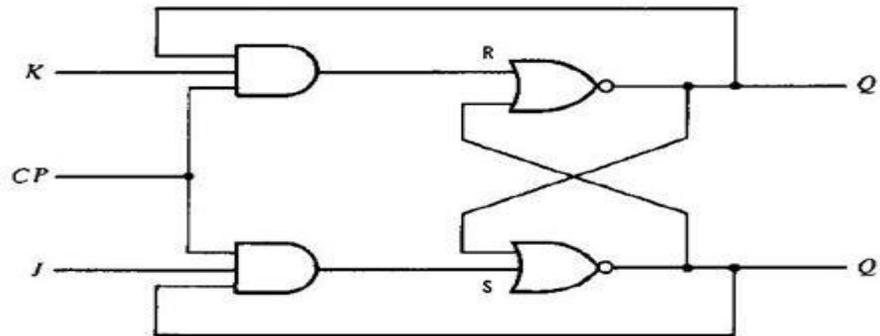
- This circuit is a 4-bit binary ripple counter. All the JK flip-flops are configured to toggle their state on a downward transition of their clock input, and the output of each flip-flop is

fed into the next flip-flop's clock. So, when each bit changes from 1 to 0, it "carries the one" to the next higher bit.

6. Explain the working of JK and D-flip flops. (N/D-2015,N/D-2016,A/M-2017,A/M-2017)

JK FLIP FLOP:

- A JK flip-flop has two inputs similar to that of RS flip-flop. We can say JK flip-flop is a refinement of RS flip-flop. JK means Jack Kilby, a Texas instrument engineer who invented IC. The two inputs of JK Flip-flop is J (set) and K (reset). A JK flip-flop is nothing but a RS flip-flop along with two AND gates which are augmented to it.
- The flip-flop is constructed in such a way that the output Q is AND gated with K and CP. This arrangement is made so that the flip-flop is cleared during a clock pulse only if Q was previously 1. Similarly Q' is AND gated with J and CP, so that the flip-flop is cleared during a clock pulse only if Q' was previously 1.



(a) Logic diagram

Q	J	K	Q(t + 1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

(b) Characteristic table

Q	JK		J	
	00	01	11	10
0			1	1
1	1			1

$$Q(t + 1) = JQ' + K'Q$$

(c) Characteristic equation

i) When $J=K=0$

- When both J and K are 0, the clock pulse has no effect on the output and the output of the flip-flop is the same as its previous value. This is because when both the J and K are 0, the output of their respective AND gate becomes 0.

ii) When $J=0, K=1$

- When $J=0$, the output of the AND gate corresponding to J becomes 0 (i.e.) $S=0$ and $R=1$. Therefore Q' becomes 0. This condition will reset the flip-flop. This represents the RESET state of Flip-flop.

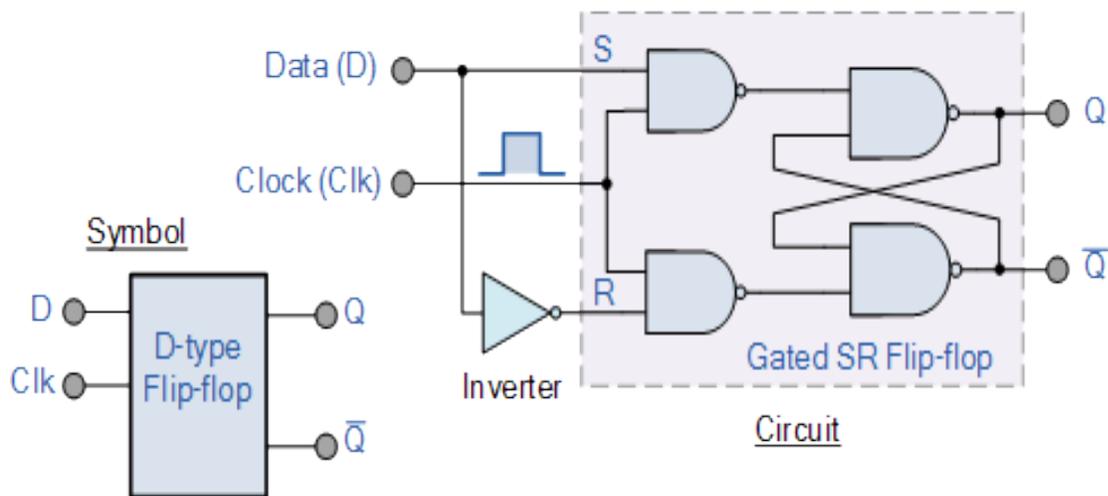
iii) When $J=1, K=0$

- In this case, the AND gate corresponding to K becomes 0 (i.e.) $S=1$ and $R=0$. Therefore Q becomes 0. This condition will set the Flip-flop. This represents the SET state of Flip-flop.

iv) When $J=K=1$

- Consider the condition of $CP=1$ and $J=K=1$. This will cause the output to complement again and again. This complement operation continues until the Clock pulse goes back to 0. Since this condition is undesirable, we have to find a way to eliminate this condition. This undesirable behavior can be eliminated by Edge triggering of JK flip-flop or by using master slave JK Flip-flops.

D FLIP FLOP:



- A simple SR flip-flop requires two inputs, one to “SET” the output and one to “RESET” the output. By connecting an inverter (NOT gate) to the SR flip-flop we can “SET” and “RESET” the flip-flop using just one input as now the two input signals are complements of each other. This complement avoids the ambiguity inherent in the SR latch when both inputs are LOW, since that state is no longer possible.
- Thus this single input is called the “DATA” input. If this data input is held HIGH the flip flop would be “SET” and when it is LOW the flip flop would change and become “RESET”. However, this would be rather pointless since the output of the flip flop would always change on every pulse applied to this data input.

7. Explain the working of half adder and full adder using truth table. (A/M-2017)

Half Adder

With the help of half adder, we can design circuits that are capable of performing simple addition with the help of logic gates.

Let us first take a look at the addition of single bits.

$$0+0 = 0$$

$$0+1 = 1$$

$$1+0 = 1$$

$$1+1 = 10$$

These are the least possible single-bit combinations. But the result for 1+1 is 10. Though this problem can be solved with the help of an EXOR Gate, if you do care about the output, the sum result must be re-written as a 2-bit output.

INPUTS		OUTPUTS	
A	B	SUM	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

From the equation it is clear that this 1-bit adder can be easily implemented with the help of EXOR Gate for the output 'SUM' and an AND Gate for the carry. Take a look at the implementation below.

Full Adder

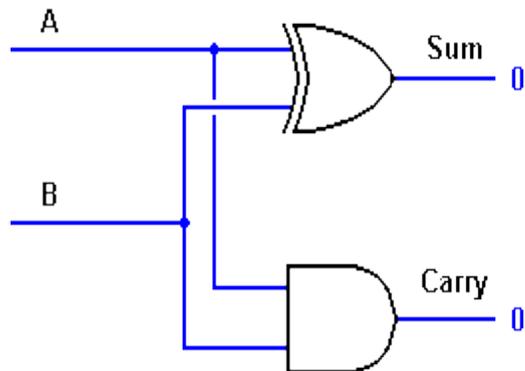
- This type of adder is a little more difficult to implement than a half-adder. The main difference between a half-adder and a full-adder is that the full-adder has three inputs and two outputs. The first two inputs are A and B and the third input is an input carry designated as CIN.

- When a full adder logic is designed we will be able to string eight of them together to create a byte-wide adder and cascade the carry bit from one adder to the next.

The output carry is designated as COUT and the normal output is designated as S. Take a look at the truth-table.

INPUTS		OUTPUTS		
A	B	CIN	COUT	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

From the above truth-table, the full adder logic can be implemented. We can see that the output S is an EXOR between the input A and the half-adder SUM output with B and CIN inputs. We must also note that the COUT will only be true if any of the two inputs out of the three are HIGH.

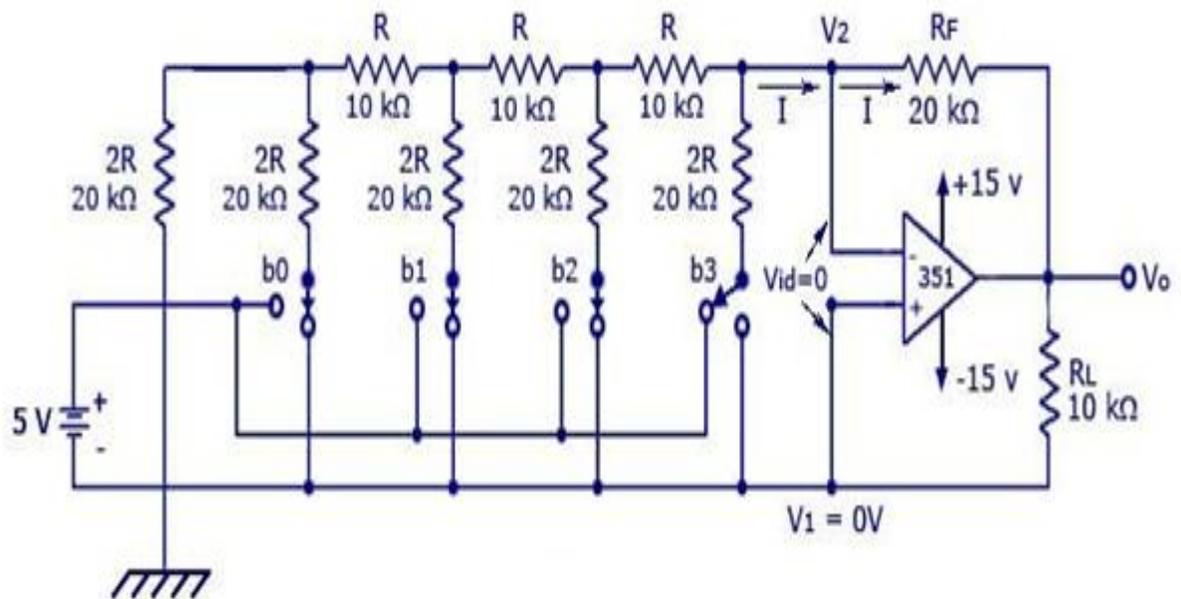


8. Explain the operation of any one type of digital to analog converter with its schematic diagram. (N/D-2016)

Digital to Analog Converter with R and 2R Resistors

- A D/A converter with R and 2R resistors is shown in the figure below. As in the binary-weighted resistors method, the binary inputs are simulated by the switches (b0-b3), and the output is proportional to the binary inputs. Binary inputs can be either in the HIGH (+5V) or LOW (0V) state. Let b3 be the most significant bit and thus is connected to the +5V and all the other switches are connected to the ground.

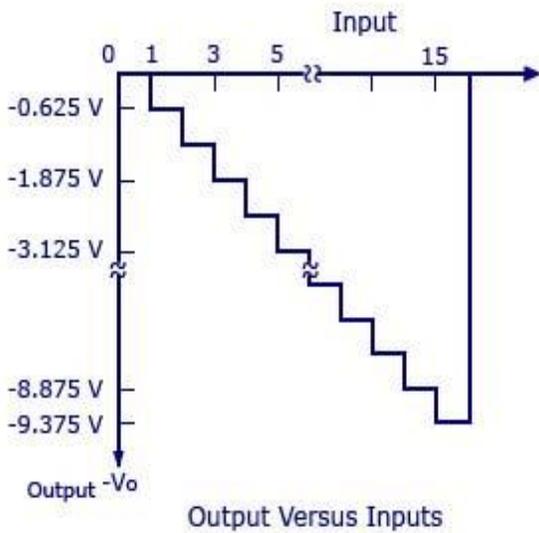
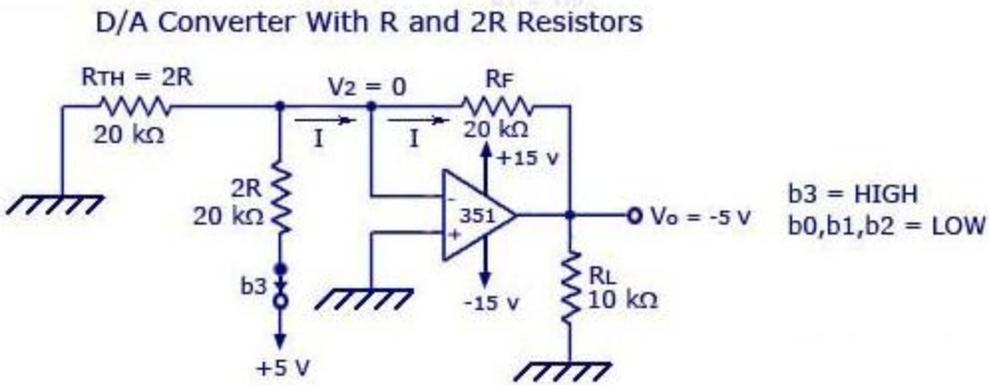
D/A Converter With R and 2R Resistors



Thus, according to Thevenin's equivalent resistance, R_{TH} ,

$$R_{TH} = \{ \{ [(2R \parallel 2R) + R] \parallel 2R \} + R \} \parallel 2R + R = 2R = 20k\Omega$$

The resultant circuit is shown below.



In the figure shown above, the negative input is at virtual ground, therefore the current through $R_{TH}=0$.

Current through $2R$ connected to $+5V = 5V/20k\Omega = 0.25 \text{ mA}$

The current will be the same as that in R_f .

$$V_o = -(20k\Omega) \cdot (0.25\text{mA}) = -5V$$

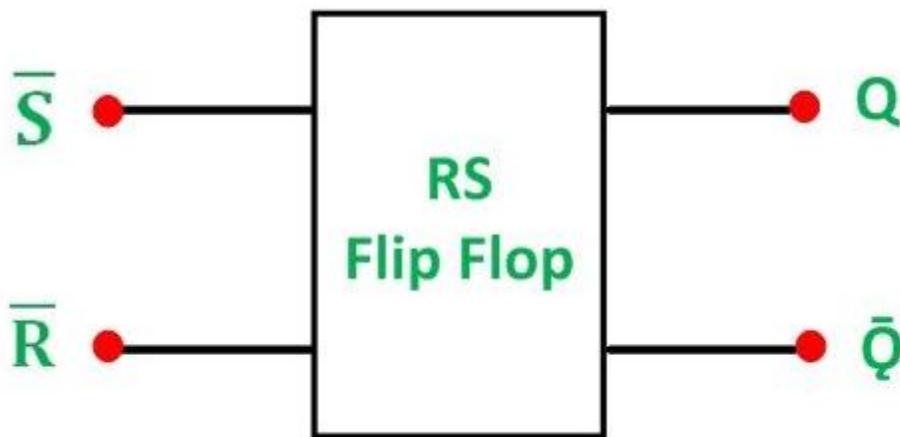
Output voltage equation is given below.

$$V_o = -R_f (b_3/2R + b_2/4R + b_1/8R + b_0/16R)$$

9. Write short notes on i)RS flip flop ii)D- flip flop, iii) JK flip flop, iv)T-flip flop.(M/J-2016)

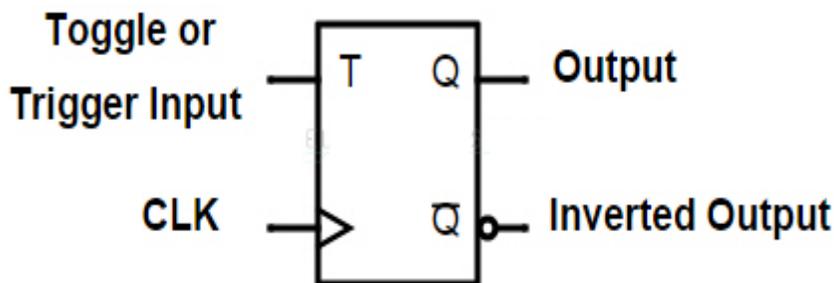
i) RS flip flop

A Flip Flop is a bi-stable device. There are three classes of flip flops they are known as Latches, pulse-triggered flip-flop, Edge- triggered flip flop. In this set word means that the output of the circuit is equal to 1 and the word reset means that the output is 0. There are two types of flip flop one is an RS Flip Flop and JK Flip Flop. In this article RS Flip Flop is explained in detail.



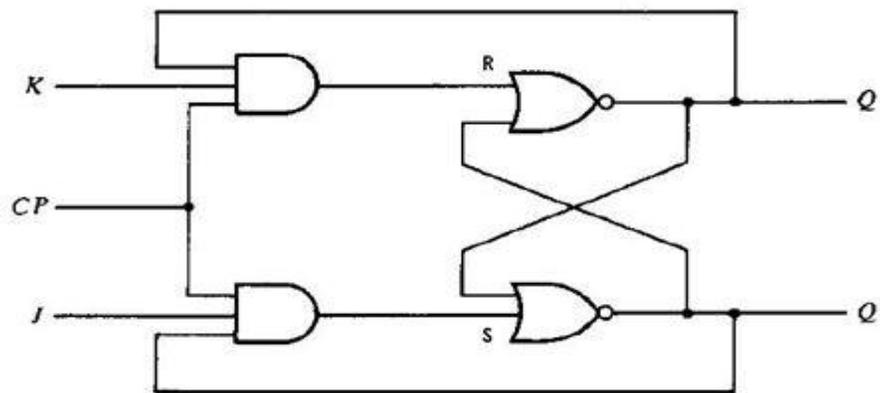
ii) T-FLIPFLOP

T flip – flop is also known as “Toggle Flip – flop”. To avoid the occurrence of intermediate state in SR flip – flop, we should provide only one input to the flip – flop called Trigger input or Toggle input (T). Then the flip – flop acts as a Toggle switch. Toggling means ‘Changing the next state output to complement of the present state output’.



iii) **JK FLIP FLOP:**

- A JK flip-flop has two inputs similar to that of RS flip-flop. We can say JK flip-flop is a refinement of RS flip-flop. JK means Jack Kelby, a Texas instrument engineer who invented IC. The two inputs of JK Flip-flop is J (set) and K (reset).
- A JK flip-flop is nothing but a RS flip-flop along with two AND gates which are augmented to it.
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(a) Logic diagram

Q	J	K	Q(t+1)
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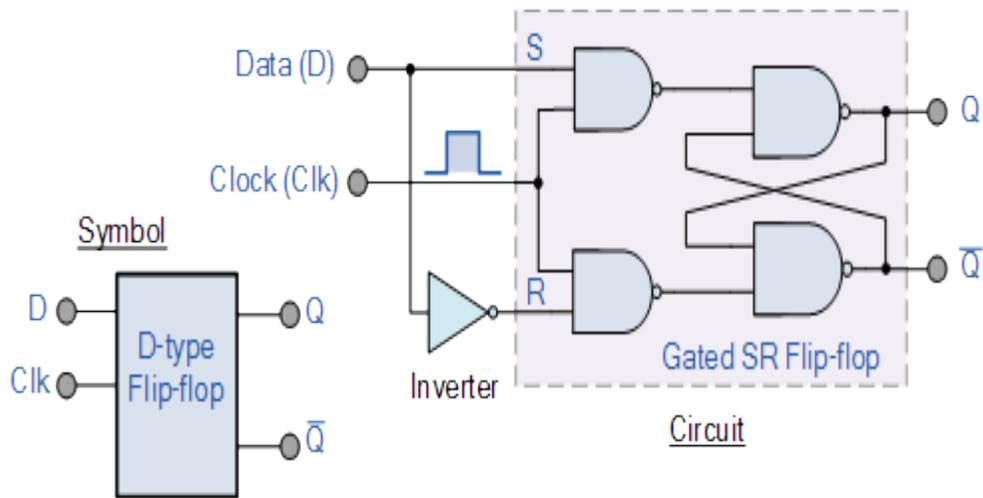
(b) Characteristic table

Q	JK		J	
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0			1	1
1	1			1

$$Q(t+1) = JQ' + K'Q$$

(c) Characteristic equation

D FLIP FLOP:



We remember that a simple SR flip-flop requires two inputs, one to “SET” the output and one to “RESET” the output. By connecting an inverter (NOT gate) to the SR flip-flop we can “SET” and “RESET” the flip-flop using just one input as now the two input signals are complements of each other. This complement avoids the ambiguity inherent in the SR latch when both inputs are LOW, since that state is no longer possible

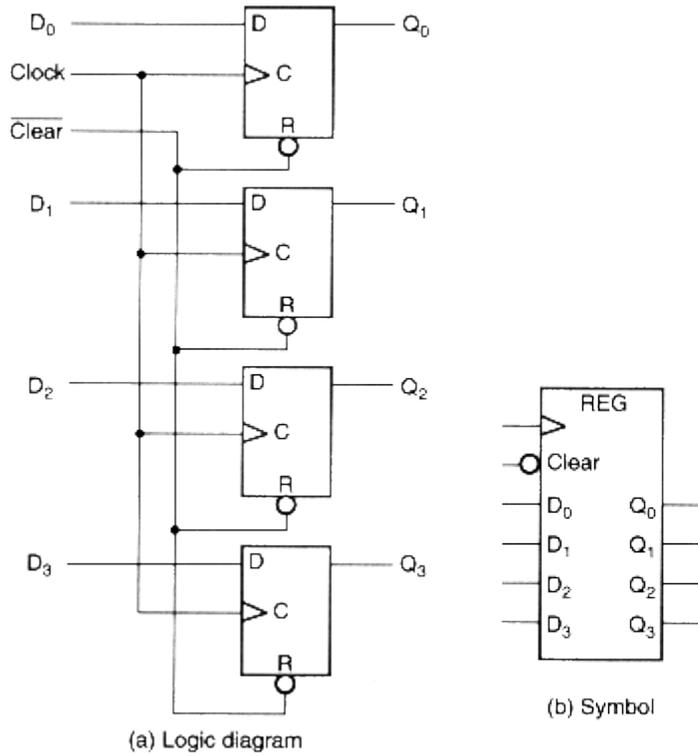
10. Write short notes on i) registers and counters , ii) A/D conversion.(A/M-2015)

i) registers and counters

- The ideas in combinational circuits (discussed in topics 2-4) and sequential methods (discussed in topics 5 and 6) when brought together as one system gives sequential building blocks, usually in the form of registers and counters.
- A register is a set of flip-flops with combinational logic to implement state transitions that allow information to be stored and retrieved from them. In the simplest form, a flip-flop is a one-bit register.
- A counter is simply a register with combinational logic to implement counting, that is it is possible to retrieve the contents, add or subtract one to the contents, and then store it back into the register in one operation.

four-bit register

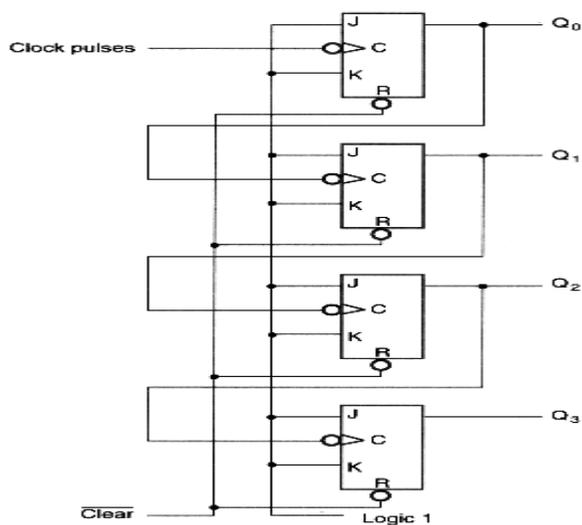
A simple four-bit register with combinational logic to allow storage and retrieval is illustrated below.



The clear input is asynchronous and immediately clears the contents to zeroes.

Counters

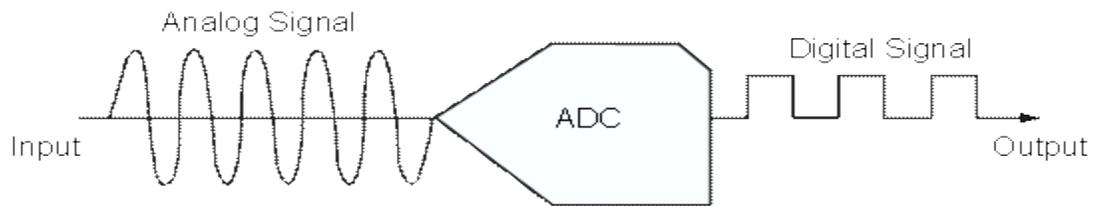
A four-bit up-counter using *J-K* flip-flops is shown below. This will always count on each clock pulse.



When we need to count based on a given *enable* signal, the ripple carry problem emerges.

ii) Analog-to-Digital converter:

Analog-to-Digital converters (ADC) translate analog signals, real world signals like temperature, pressure, voltage, current, distance, or light intensity, into a digital representation of that signal. This digital representation can then be processed, manipulated, computed, transmitted or stored.



UNIT-5 FUNDAMENTALS OF COMMUNICATION ENGINEERING

PART-A:

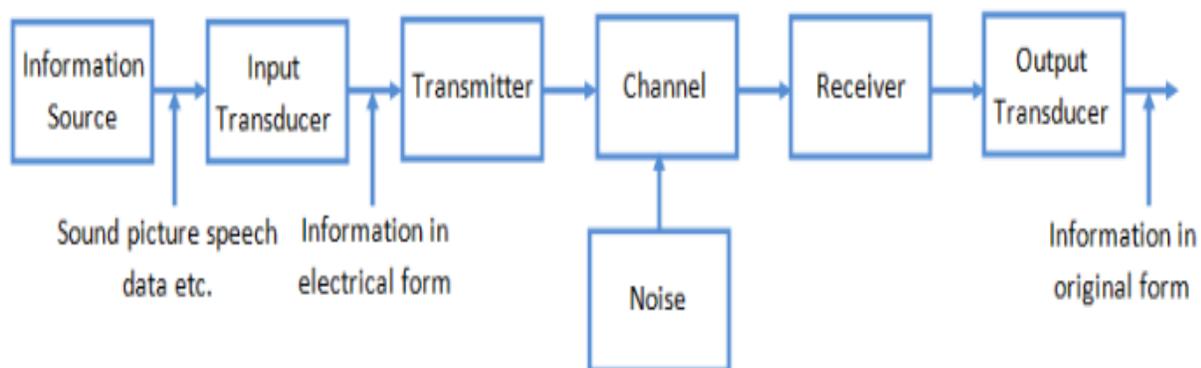
1. Compare analog and digital signals.(N/D-2016)

Analog signal	Digital signal
Analog signal is a continuous signal which represents physical measurements	Digital signals are discrete time signals generated by digital modulation
Denoted by sine waves	Denoted by square waves
EX: Human voice in air, analog electronic devices	Ex: Computers, CDs, DVDs, and other digital electronic devices.

2. Mention the applications of fibre optic communication systems. (N/D-2016)

- The use and demand for optical fiber has grown tremendously and optical-fiber applications are numerous.
- Telecommunication applications are widespread, ranging from global networks to desktop computers.
- These involve the transmission of voice, data, or video over distances of less than a meter to hundreds of kilometers, using one of a few standard fiber designs in one of several cable designs.

3. Draw the block diagram of communication system . (M/J-2016)



4. What is ISDN? (M/J-2016)

ISDN is the broadband counterpart to Integrated Services Digital Network, which provides digital transmission over ordinary telephone company copper wires on the narrowband local loop.

5. Define analog and digital signal. (N/D-2015)

Analog Signal

An analog signal is a continuous wave denoted by a sine wave (pictured below) and may vary in signal strength (amplitude) or frequency (time). The sine wave's amplitude value can be seen as the higher and lower points of the wave, while the frequency (time) value is measured in the sine wave's physical length from left to right.

Digital Signal

A digital signal - a must for computer processing - is described as using binary (0s and 1s), and therefore, cannot take on any fractional values.

6. What are the advantages of optical fiber communication? (N/D-2015)

- i) fiber-optic communication systems can be used to transmit more information than copper cables and are well-suited for use with digital communications.
- ii) optical fibers offer low power loss. Signals can be transmitted further.
- iii) compared to copper cables, fiber-optic cables are immune to electromagnetic interference and produce no interference when operating.
- iv) fiber has high quality in secrecy performance and communication.

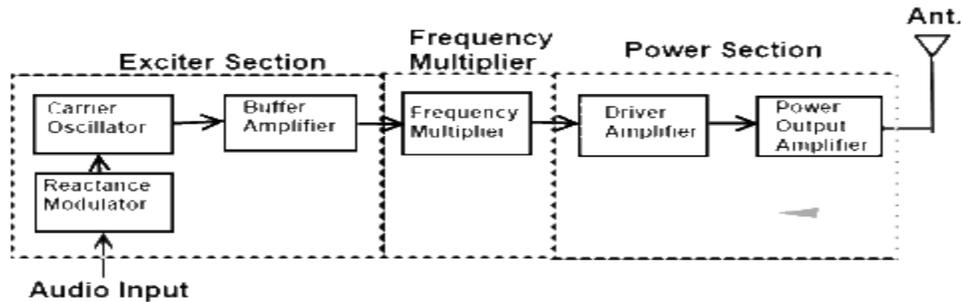
7. List few applications of amplitude modulation. (A/M-2015)

- Broadcast transmissions:
- Air band radio:
- Single sideband:
- Quadrature amplitude modulation

8. What is the function of satellite? (A/M-2017)

Communication satellites has uplink and down link frequency and used for various research works and weather forecasting

9. Sketch the block diagram of FM receiver. (A/M-2017)



10. Define the modulation index for amplitude modulation. (A/M-2017)

Modulation index of amplitude modulation is defined as the ratio of the amplitude of the modulating wave to the amplitude of the carrier wave.

PART-B

1. Explain the principle of amplitude modulation and Frequency modulation with relevant expressions. (N/D-2015, N/D-2016, N/D-2015, A/M-2015, N/D-2016)

Amplitude modulation theory & equations

It is possible to look at the theory of the generation of an amplitude modulated signal in four steps:

1. Carrier signal
2. Modulating signal
3. Overall modulated signal for a single tone
4. Expansion to cover a typical audio signal

These steps will be covered in greater details below:

1. Carrier signal equations

Looking at the theory, it is possible to describe the carrier in terms of a sine wave as follows:

$$C(t) = C \sin(\omega_c t + \phi)$$

2. Modulating signal equations

The modulating waveform can either be a single tone. This can be represented by a cosine waveform, or the modulating waveform could be a wide variety of frequencies - these can be represented by a series of cosine waveforms added together in a linear fashion.

For the initial look at how the signal is formed, it is easiest to look at the equation for a simple single tone waveform and then expand the concept to cover the more normal case. Take a single tone waveform:

$$m(t) = M \sin(\omega_m t + \phi)$$

Overall modulated signal for a single tone

The equation for the overall modulated signal is obtained by multiplying the carrier and the modulating signal together.

$$y(t) = [A + m(t)] \cdot c(t)$$

The constant A is required as it represents the amplitude of the waveform.

Substituting in the individual relationships for the carrier and modulating signal, the overall signal becomes:

$$y(t) = [A + M \cos(\omega_m t + \phi)] \cdot \sin(\omega_c t)$$

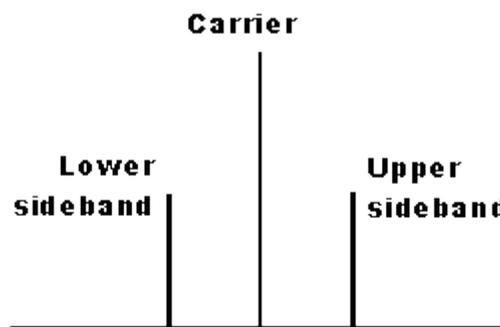
The trigonometry can then be expanded out to give an equation that includes the components of the signal:

$$y(t) = [A + M \cos(\omega_m t + \phi)] \cdot \sin(\omega_c t)$$

This can be expanded out using the standard trigonometric rules:

$$y(t) = A \cdot \sin(\omega_c t) + M/2 [\sin((\omega_c + \omega_m) t + \phi)] + M/2 [\sin((\omega_c - \omega_m) t - \phi)]$$

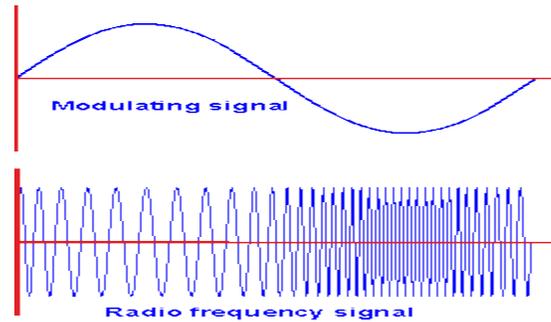
In this theory, three terms can be seen which represent the carrier, and upper and lower sidebands:



Frequency modulation basics

The most obvious method of applying modulation to a signal is to superimpose the audio signal onto the amplitude of the carrier. However this is by no means the only method which can be employed. It is also possible to vary the frequency of the signal to give frequency modulation or

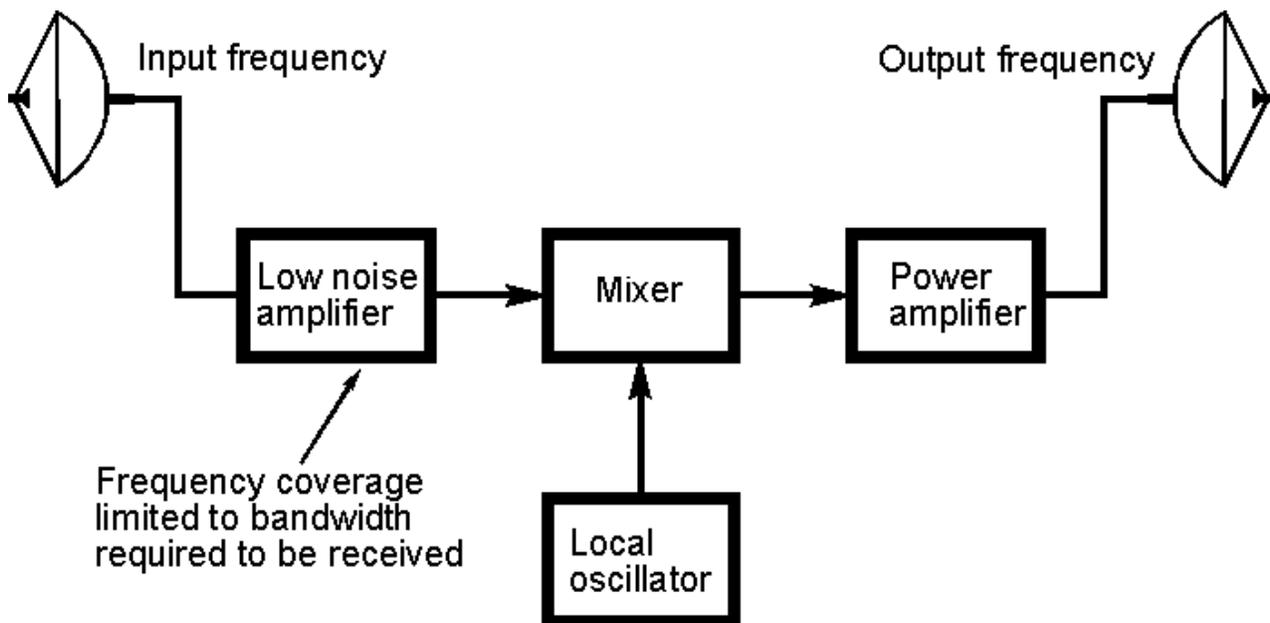
FM. It can be seen below that the frequency of the signal varies as the voltage of the modulating signal changes.



The amount by which the signal frequency varies is very important. This is known as the deviation and is normally quoted as the number of kiloHertz deviation. As an example the signal may have a deviation of ± 3 kHz. In this case the carrier is made to move up and down by 3 kHz

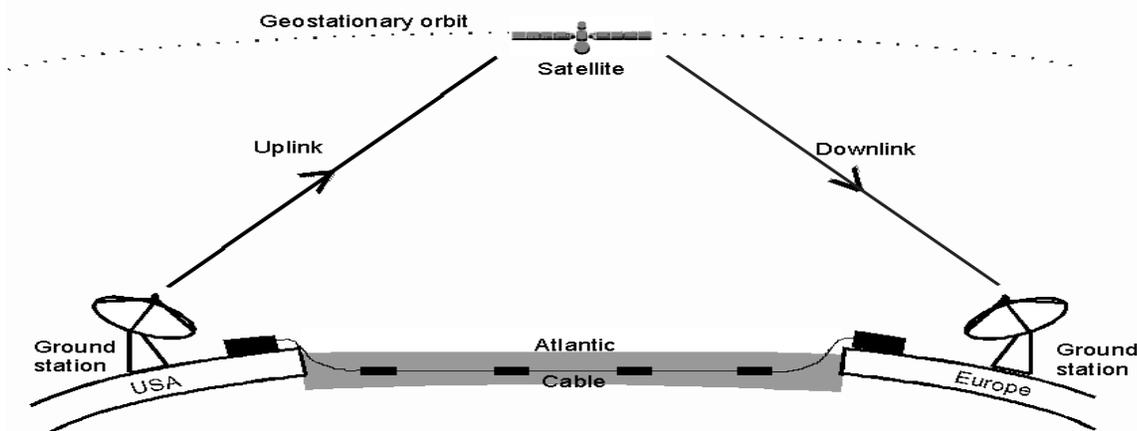
2. Draw the block diagram and explain the working of satellite communication systems. (A/M-2017)

Satellite communication: In telecommunications, the use of artificial satellites to provide communication links between various points on Earth. Satellite communications play a vital role in the global telecommunications system.



Approximately 2,000 artificial satellites orbiting Earth relay analog and digital signals carrying voice, video, and data to and from one or many locations worldwide.

- Satellite communication has two main components: the ground segment, which consists of fixed or mobile transmission, reception, and ancillary equipment, and the space segment, which primarily is the satellite itself.
- A typical satellite link involves the transmission or up linking of a signal from an Earth station to a satellite. The satellite then receives and amplifies the signal and retransmits it back to Earth, where it is received and re amplified by Earth stations and terminals.
- Satellite receivers on the ground include direct-to-home (DTH) satellite equipment, mobile reception equipment in aircraft, satellite telephones, and handheld devices.



3. What is meant by modulation? Explain different types of analog and digital modulation techniques with neat diagrams. (M/J-2016)

Modulation:

When we want to transmit a signal from one location to another, we have to strengthen the signal. After undergoing strengthening process the signal travels to a long distance. This is called as modulation.

- Analog Modulation
- Digital Modulation

Analog Modulation

In analog modulation, analog signal (sinusoidal signal) is used as a carrier signal that modulates the message signal or data signal. The general function Sinusoidal wave's is shown in the figure

below, in which, three parameters can be altered to get modulation – they are amplitude, frequency and phase; so, the types of analog modulation are

$$A_c \cos(2\pi fct + \phi)$$

Amplitude Frequency Phase

Angle

(Frequency= Rate of change of Angle)

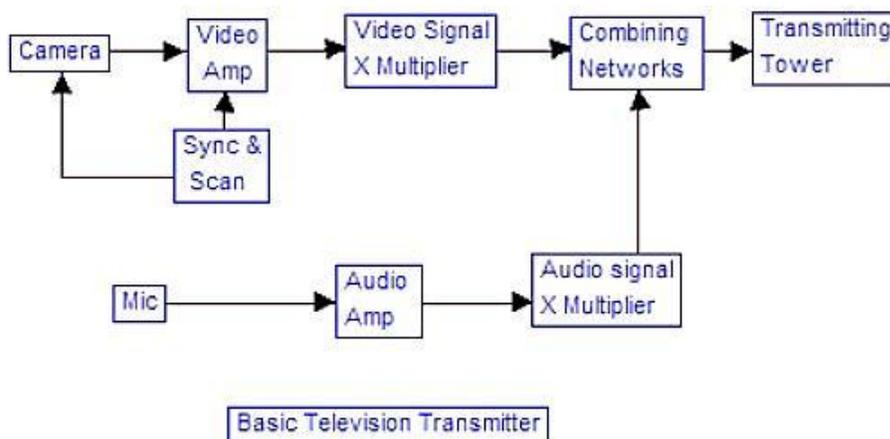
- Amplitude Modulation (AM)
- Frequency Modulation (FM)
- Phase Modulation (PM)

Digital Modulation

For a better quality and efficient communication, digital modulation technique is employed. The main advantages of the digital modulation over analog modulation include available bandwidth , high noise immunity and permissible power. In digital modulation, a message signal is converted from analog to digital message, and then modulated by using a carrier wave.

4.Draw the block diagram of TV receiver and explain its. (A/M-2017,N/D-2016)

Block diagram of television transmitter



Operation:

- The block diagram can be broadly divided into two separate sections, viz., one that - Generates an electronic signal (called video signal) corresponding to the actual picture and then uses this video signal to modulate an R-F carrier so as to be applied to the transmitting antenna for transmission, other that generates an electronic signal (called audio signal) containing sound information and then uses this signal to modulate another RF carrier and then applied to the transmitting antenna for transmission.
- However only one antenna is used for transmission of the video as well as audio signals. Thus these modulated signals have to be combined together in some appropriate network. In addition there are other accessories also. For instance, video as well as audio signals have to be amplified to the desired degree before they modulate their respective RF carriers.

5. Describe the functional block diagram of monochrome TV transmitter and receiver with a neat sketch. (N/D-2015.A/M-2015)

Monochrome TV Transmitter :

Monochrome TV Transmitter: Figure shows the simplified block diagram of a television transmitter. The video signals obtained from camera tube are applied to a number of video amplifier stages. First stage is located in camera housing to increase weak signal voltage to such a level as to be transmitted over a coaxial cable to the succeeding amplifier stages.

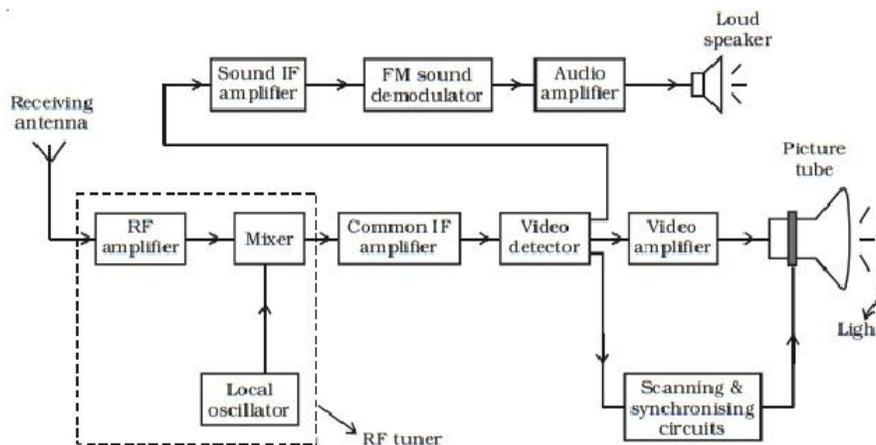


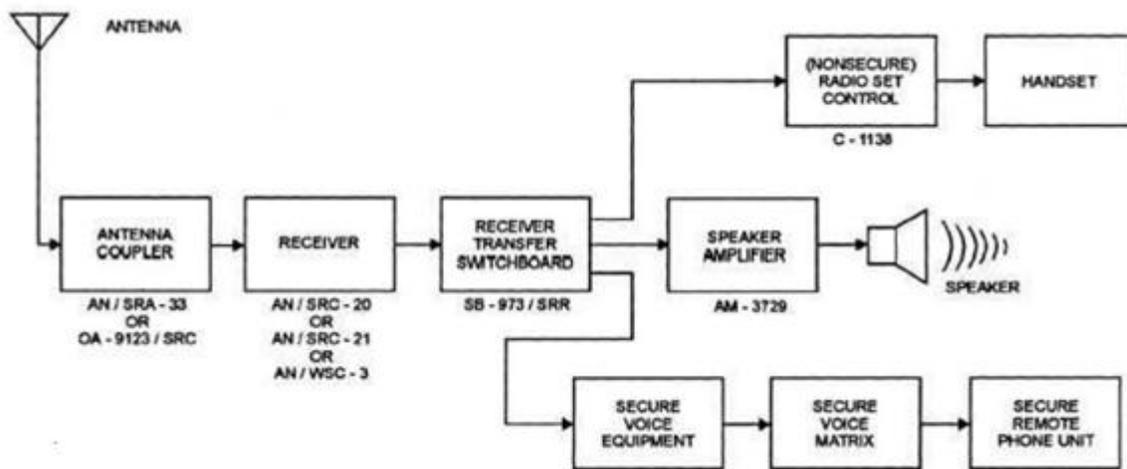
Fig Elementary block diagram of a monochrome TV receiver

- Synchronizing generator produces sets of pulses to operate the system at appropriate timings. This unit includes wave generating and shaping circuits. Eg: Multivibrator circuit, blocking oscillator circuit and clipping circuits etc. The repetition rates of the pulse trains are controlled by frequency stabilized master oscillator.
- The horizontal synchronizing pulses are applied to horizontal saw-tooth generator; vertical synchronizing pulses are applied to vertical deflection saw-tooth generator; two sets of blanking pulses are applied to control grid of camera tube to blank it during vertical and horizontal retrace; and a pulse train consisting all above pulse groups is applied to video-amplifier channel for transmission to receiver.
- An FM transmitter is used for the purpose of audio signal transmission. The carrier frequency used in audio modulation is 5.5 MHz above that which is used in audio modulation. Both, sound and picture signals are transmitted by the same antenna by using a diplexer called picture – sound diplexer.

6. Short notes on i) microwave communication, ii) FAX (A/M-2017)

i) Microwave communication:

- Microwave transmission refers to the technology of transmitting information or energy by the use of electromagnetic waves whose wavelengths are conveniently measured in small numbers of centimeter; these are called microwaves.



- Microwave transmission refers to the technology of transmitting information or energy by the use of electromagnetic waves whose wavelengths are conveniently measured in small numbers of centimeter; these are called microwaves. This part of the radio spectrum ranges across frequencies of roughly 1.0 gigahertz (GHz) to 30 GHz. These correspond to wavelengths from 30 centimeters down to 1.0 cm.

- Microwaves are widely used for point-to-point communications because their small wavelength allows conveniently-sized antennas to direct them in narrow beams, which can be pointed directly at the receiving antenna.
- This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do. Another advantage is that the high frequency of microwaves gives the microwave band a very large information-carrying capacity; the microwave band has a bandwidth 30 times that of all the rest of the radio spectrum below it.
- A disadvantage is that microwaves are limited to line of sight propagation; they cannot pass around hills or mountains as lower frequency radio waves can.

ii) FAX:

Definition:

Facsimile popularly known as Fax is a very important method of electronic communication. It is used to transmit any sort of written matter, picture, diagram etc. from one place to another. This device acts through telephone line

Working:

The **fax machine** has created it doable to send copies of necessary documents as well as certificates, testimonials, degrees, agreements, contracts, etc. from one place to a different at the speed of telephony. For this reason, it's universally used technique of communication.

Important or Advantages of Fax in Communication

Fax provides some important or advantages that are unique over other *electronic communication* media. The advantages of **using fax** are mentioned below-

- **Universal Method of Communication:** The fax machine has made it possible to send copies of important documents including certificates, testimonials, degrees, agreements, contracts etc. from one place to another at the speed of a telephone call. For this reason, it is universally used method of communication.
- **Sending Message Directly by Computer:** If a document is generated on computer, it can be sent directly using a fax modem, bypassing the need to print the document first.
- **Advantage over Telex:** Charts, graphs and other visuals cannot be sent through telex but they can be easily sent thorough fax.
- **Quickest Means of Communication:** Fax is one of the quickest means of transmitting information. In fax, the finally prepared document is inserted in the machine and almost instantly copy of the document comes out at the receiving end.

7. Explain the types of analog modulation with neat diagrams. (A/M-2017)

Analog Modulation:

Baseband signal is always analog for this modulation. There are three properties of a carrier signal amplitude, frequency and phase thus there are three basic types of analog modulations.

1. **Amplitude Modulation (AM)**
2. **Frequency Modulation (FM)**
3. **Phase modulation (PM)**

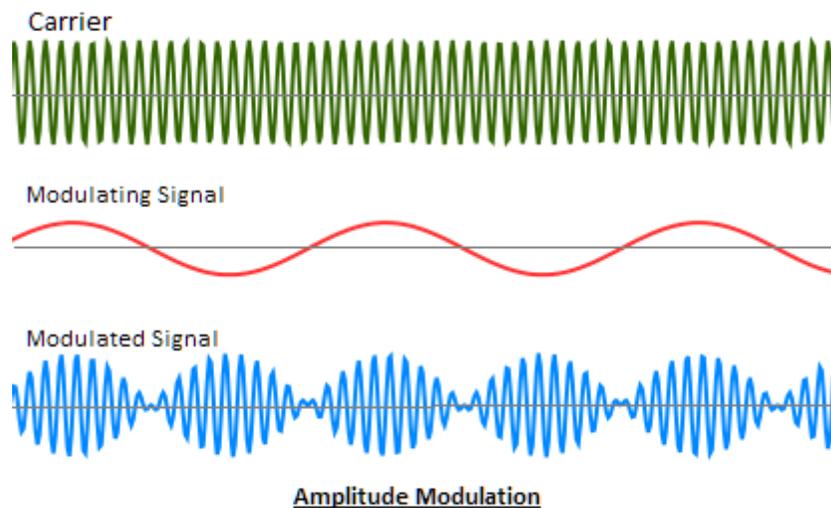
1. Amplitude Modulation

Amplitude modulation or AM is the process of varying the instantaneous amplitude of carrier signal accordingly with instantaneous amplitude of message signal. Thus, if $m(t)$ is the message signal and $c(t)=A\cos\omega_c t$ then AM signal $F(t)$ is written as

$$F(t)= A\cos\omega_c t+m(t) \cos\omega_c t$$

$$F(t)=[A+m(t)] \cos\omega_c t$$

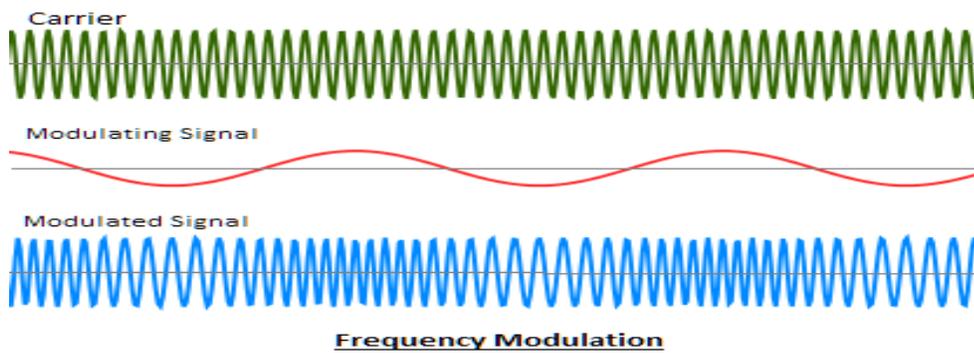
$$[A+m(t)] \cos\omega_c t$$



2. Frequency modulation

FM:-FM or Frequency modulation is the process of varying the instantaneous frequency of Carrier signal accordingly with instantaneous amplitude of message signal. Thus, if $m(t)$ is the message signal and $c(t)=A\cos\omega_c t$ then FM signal will be

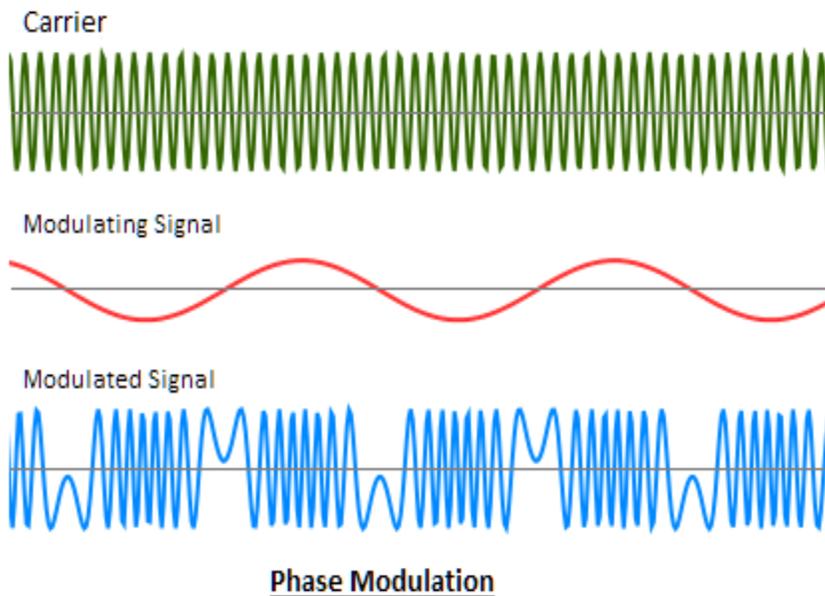
$$F(t)= A\cos(\omega_c t+k_f \int m(\alpha)d\alpha)$$



iii) Phase modulation (PM)

PM or Phase modulation is the process of varying the instantaneous phase of Carrier signal accordingly with instantaneous amplitude of message signal. Thus if $m(t)$ is the message signal and $c(t) = A \cos w_c t$ then PM signal will be

$$F(t) = A \cos(w_c t + k_p m(t))$$



PM Advantage

Modulation and demodulation does not catch any channel noise.

8. Why modulation is necessary? Write in detail about frequency modulation. (M/J-2016)

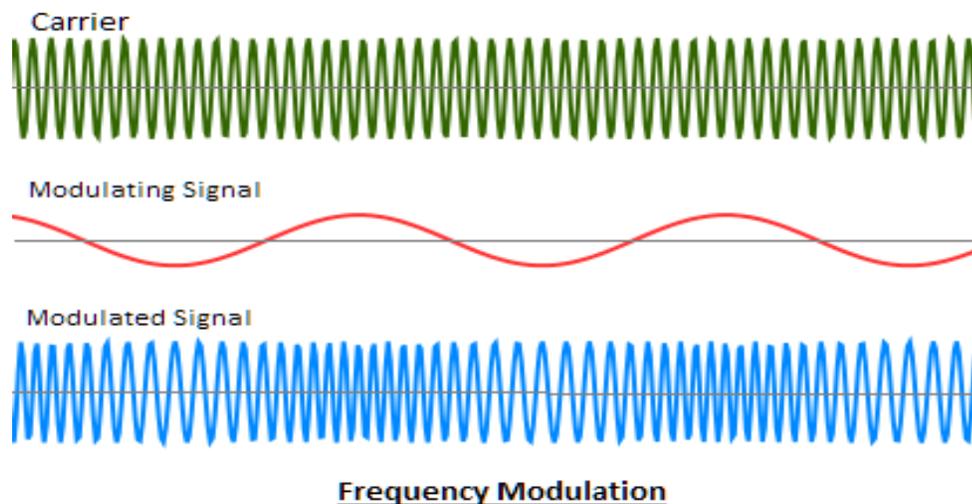
Necessary of modulation:

- Modulation allows us to send a signal over a bandpass frequency range. If every signal gets its own frequency range, then we can transmit multiple signals simultaneously over a single channel, all using different frequency ranges. Another reason to modulate a signal is to allow the use of a smaller antenna.

Frequency modulation

- FM or Frequency modulation is the process of varying the instantaneous frequency of Carrier signal accordingly with instantaneous amplitude of message signal. Thus, if $m(t)$ is the message signal and $c(t) = A \cos \omega_c t$ then FM signal will be

$$F(t) = A \cos(\omega_c t + k_f \int m(\alpha) d\alpha)$$



9. Discuss the usage of satellite for long distance communication with a neat block diagram of basic satellite transponder. (M/J-2016)

Basic Elements

The satellite itself is also known as the space segment, and is composed of three separate units, namely the fuel system, the satellite and telemetry controls, and the transponder. The transponder includes the receiving antenna to pick-up signals from the ground station, a broad

band receiver, an input multiplexer, and a frequency converter which is used to reroute the received signals through a high powered amplifier for downlink.

- The primary role of a satellite is to reflect electronic signals. In the case of a telecom satellite, the primary task is to receive signals from a ground station and send them down to another ground station located a considerable distance away from the first. This relay action can be two-way, as in the case of a long distance phone call.

The Ground Station.

- This is the earth segment. The ground station's job is two-fold. In the case of an uplink, or transmitting station, terrestrial data in the form of baseband signals, is passed through a baseband processor, an up converter, a high powered amplifier, and through a parabolic dish antenna up to an orbiting satellite.
- In the case of a downlink, or receiving station, works in the reverse fashion as the uplink, ultimately converting signals received through the parabolic antenna to base band signal.

Usage of long distance communication:

TV signals being of high frequency are not reflected by the ionosphere . Therefore , to reflect these signals , satellites are needed . That is why, satellites are used for long distance TV transmission .

10. With the help of block diagrams describe the working of

- i. a typical TV transmitter**
- ii. a typical TV receiver.(A/M-2015)**

i. TV transmitter:

TV Transmitter Circuit Principle:

The main principle of this circuit is to transmit the audio and video signals. Here audio signals are frequency modulated and video signals are PAL modulated. These modulated signals are applied for the antenna.

TV Transmitter Circuit Applications:

- This is used in broadcasting applications.
- This circuit can transmit audio and video signals from DVD, videogames, etc.
- The circuit can be used in surveillance cameras.

