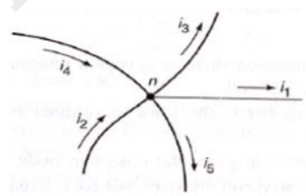
UNIT I – ELECTRICAL CIRCUITS AND MEASUREMENTS
PART A

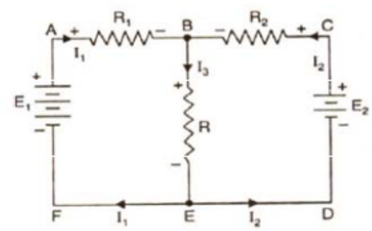
1. **Define Active & Passive elements.**
   The element which is capable of generating or supplying energy is called Active element. Example: Generators, Batteries, Operational Amplifiers etc., The element which is capable of receiving energy is called Passive element. Example: Resistor, Inductor, Capacitor
2. **Define the terms Loop and Mesh.**
   The closed path of a network is called a Loop. An elementary form of a loop which cannot be further divided is called a Mesh. In Mesh is closed path that does not contain any other loop within it.
3. **Define the terms Node and Junction.**
   A Node is a point in the network where two or more circuit elements are connected. A Junction is a point where three or more circuit elements are connected.
4. **Define Ohm's law.**
   The ratio between the potential difference across two terminals of a conductor and current through it remains constant, when the physical condition of the conductor remains unchanged. Here the physical condition is temperature.

$$I = \frac{V}{R},$$

5. **Define Kirchoff's current law.**
   The algebraic sum of currents entering and leaving a junction is equal to zero. A node 'n' is shown in the diagram. For this node according to Kirchoff's current law, $i_1-i_2+i_3-i_4+i_5=0$. In other words, the sum of currents entering a junction is equal to the sum of the currents leaving the junction. A node 'n' is shown in the diagram. For this node according to Kirchoff's current law, $i_1+i_3+i_5=i_2+i_4$.



6. **Define Kirchhoff's voltage law.**
   The algebraic sum of potential rises and potential drops around a closed circuit is equal to zero. For the circuit shown the diagram, consider the loop ABEFA, According to Kirchhoff's Voltage Law, $E_1-i_1R_1-i_3R=0$. In other words, the potential rises around any closed circuit equals the sum of the potential drops in that circuit. For the circuit shown the diagram, consider the loop ABEFA, according to Kirchhoff's Voltage Law, $E_1=i_1R_1+i_3R$.



7. **Define power and energy. Give the expression for electrical power and energy.**
   Power is the rate of doing work and its unit is Watt. The unit of electric power is defined in terms of the joule per second. One joule per second is the work done when one coulomb of electricity is moved through a potential difference of one volt in one second. Power $P = EI = I^2R = E^2/R$ Watts. Energy is the product of power and time. If the power remains constant at P during the period of time t seconds, the energy equals Pt Watt-sec or Joules. Energy $W = Pt = EIt = I^2Rt = E^2t/R$ Joules.
8. **Define RMS value of an ac voltage signal.(June 2011) (Dec 2012) (Dec 2013)**
   The effective value of an AC is defined as that value of DC which on passing through a resistance R ohms for a given time T seconds, produces the same heat as the AC passing through R for the same time T. Mathematically,

Or

9. **Define Average value of an ac voltage signal.**

The average of the instantaneous values taken over one complete cycle of the wave. Mathematically,

$$I_{av} = \frac{i_1 + i_2 + i_3 + \ldots.. + i_n}{n} \quad \text{OR} \quad I_{av} = \frac{\text{Area under the curve}}{\text{Base}}$$

10. **Define form factor.**
    The ratio between RMS value and average value is known as form factor. For sine wave signal the value of form factor is 1.11.
11. **Define peak factor.**
    The ratio between Maximum value and RMS value is known as peak factor. For sine wave signal the value of peak factor is 1.414
12. **Explain resonance in a RLC series circuit.**

The impedance of a RLC series circuit is given by $Z = R + j(X_L - X_C)$ ohm. In the above equation if $X_L = X_C$, then $Z = R$. i.e. the circuit acts as a pure resistive circuit. The total current drawn by the circuit is in phase with the applied voltage, the power factor will then be unity. This occurrence is called as series resonance.

13.Define Phasor and Phase angle.

A sinusoidal wave form can be represented or in terms of a phasor. A phasor is a vector with definite magnitude and direction. From the phasor the sinusoidal wave form can be reconstructed. Phase angle is the angular measurement that specifies the position of the alternating quantity relative to a reference.

14.Define Real or True or Average Power, Reactive Power and Apparent or Total power.

Real Power is the power which does some useful work in a given circuit. $P=VI \cos \phi$, Unit: W (Watts).Reactive power is imaginary power which flows from load to source $Q=VI \sin \phi$, unit is VAR. Apparent power $S=VI$, Unit: VA (volt-ampere) or $S= P+jQ$.

15.What are the advantages of 3 phase circuits over single phase circuits?

1. Generation, transmission and distribution of 3 phase power is cheaper, 2. More efficient, 3. Uniform torque production occurs.

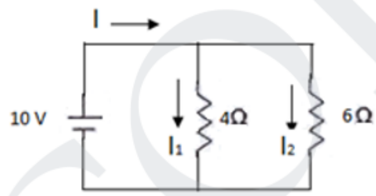
16.Mention the three torques required for the proper operation of indicating instrument.(June 2011)

1. Deflecting torque, 2. Controlling torque, 3. Damping torque.

17.What are the advantages of electromechanical measuring instruments? (DEC 2012)

1. Torque to weight ratio is high and hence error due to friction is very small.
2. Cheap in cost.
3. Simple in operation.
4. Unaffected by temperature variation.

18.Two resistances of 4Ω and 6Ω are connected in parallel across 10V battery. Determine the current through 6Ω resistance.(DEC 2013)



$I_1=I(R_2/(R_1+R_2))$

$I_2=I(R_1/(R_1+R_2))$

$R_1=4\Omega$, $R_2=6\ \Omega$, $I_1=6A$, $I_2=4A$

19.State the advantages of sinusoidal alternating quantity.(May 2014)

1) Mathematically, it is very easy to write the equations for purely sinusoidal waveform. 2) Any other type of waveform can be resolved into a series of sine or cosine waves of fundamental and higher frequencies, sum of all these waves gives the original waveform. Hence, it is always better to have sinusoidal waveform as the standard waveform.

20.What do you meant by balanced load in 3-phase circuit? (May 2014)

All 3 sources are represented by a set of balanced 3-phase variables and Line impedances are equal in all 3 phases.

Part-B

1. **Fig.1 shows a two D.C source network, the branch current I_1 and I_2 are marked in it. By using kirchoff's law to find the current I_1.**

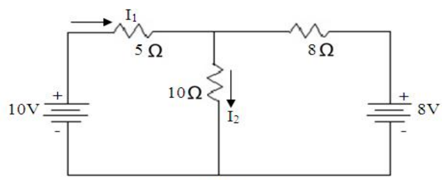
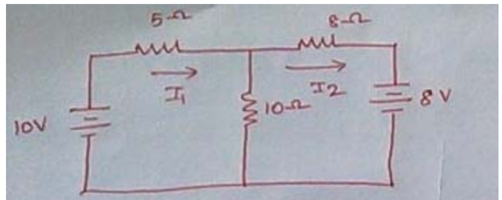


Fig.1



By KVL

$10 = 5I_1 + 10(I_1 + I_2)$

$10 = 15I_1 + 10I_2$ —— (1)

$8 = 8I_2 + 10(I_2 + I_1)$

$8 = 8I_2 + 10I_2 + 10I_1$

$8 = 10I_1 + 18I_2$ —— (2)

Solving (1) & (2)

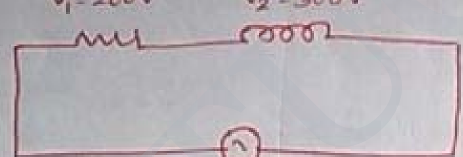
$\boxed{I_1 = 0.5882\ A}$

$\boxed{I_2 = 0.11764\ A}$

2.An A.C circuit consists of a pure resistance and an inductive coil connected in series. The power dissipated in the resistance and in the coil are 1000W and 200W respectively. The voltage drops across the resistance and the coil are 200V and 300V respectively. Calculate the following:- (i) Value of the pure resistance, (ii) Current through the circuit, (iii) Resistance of the coil, (iv) Impedance of the coil, (v) Reactance of the coil and supply voltage.

$P_1 = 1000\ W$ $P_2 = 200W$

$V_1 = 200V$ $V_2 = 300V$



$R = \frac{V_1^2}{P_1} = \frac{(200)^2}{1000}$

$\boxed{R = 40\Omega}$

$I = \frac{P_1}{V_1} = \frac{1000}{200} = 5A$

$\boxed{I = 5A}$

$P_T = P_1 + P_2 = 1200\ W$

$V_T = V_1 + V_2 = 500V$

$P_T = V_T I \cos\phi$

$1200 = 500 \times 5 \cos\phi$

$\cos\phi = 0.48 = R/Z$

$0.48 = \frac{40}{Z}$

$Z = 83.3\Omega$

$Z = \sqrt{R^2 + X_L^2}$

$83.3 = \sqrt{40^2 + X_L^2}$

$X_L = 73.10 = 2\pi f L$

$\boxed{L = 0.2326 H}$

3.A moving coil instrument gives a full scale deflection for a current of 20mA with a potential difference of 200 mV across it. Calculate (i) Shunt required using it as an ammeter to get a range of 0 – 200 A. (ii) Multiplier required to use it as a voltmeter of range 0 – 500 V.

5) Meter current $I_m = 20mA$

$V_m = 200mV$

$V_m = I_m R_m$

$(200\times10^{-3}) = (20\times10^{-3}) R_m$

$R_m = 10\Omega$

For using it as ammeter,

$I = 200A$

$$R_{sh} = \frac{I_m R_m}{I - I_m} = \frac{20\times10^{-3}\times10}{200-(20\times10^{-3})}$$

$R_{sh} = 0.001\Omega$//

For using it as voltmeter,

$V = 500V$

$$R_s = \frac{V}{I_m} - R_m = \frac{500}{20\times10^{-3}} - 10$$

$R_s = 24.99k\Omega$

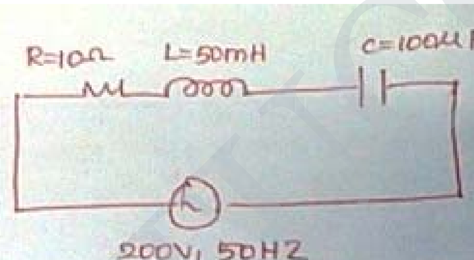
$= 24.99k\Omega$// => This the multiplier required.

4.A series circuit has R= 10Ω, L= 50mH, and C=100μF and is supplied with 200V, 50Hz. Find:- Impedance

(1) Current(2)Power(3)Power factor(4)Phase angle

(5)Voltage drop across the each element (8) **(May 2014)**

18)



$X_L = 2\pi f L$

$= 15.7\Omega$

$X_C = 1/2\pi f C$

$= 31.847\Omega$

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

$= \sqrt{10^2 + (15.7 - 31.84)^2}$

$\boxed{Z = 18.992\Omega}$

$\cos\phi = \frac{R}{Z} = 0.5265$ $\boxed{pf = 0.5265}$

$\boxed{\phi = 58.22°}$

$P = VI\cos\phi$

$P = \frac{V^2}{Z} = \frac{200^2}{18.992} = \boxed{2106.15\,W = P}$

$2106.15 = 200 \times I \times 0.5265$

$\boxed{I = 20A}$

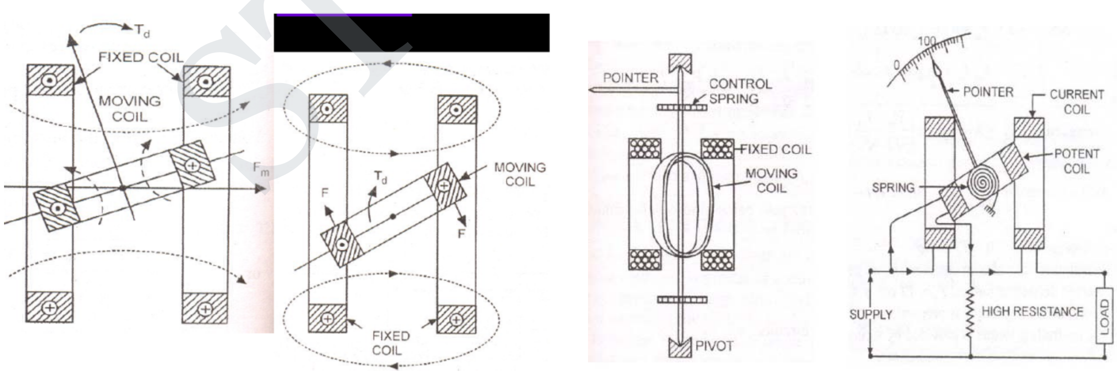
5.Draw and explain the followings:- Dynamometer type watt meter. Mention its advantages anddisadvantages. (June 2011)

Dynamometer type wattmeter

Principle:

When a current carrying moving coil is placed in a magnetic field produced by the current carrying fixedcoil, a mechanical force is exerted on the coil sides of themoving coil and deflection takes place.In other words, when the field produced by the currentcarrying moving coil (F r) tries to come in line with thefield produced by the current carrying fixed coil (F m), adeflecting torque is exerted on the moving system.

In general, a watt meter is used to measure the electric power of a circuit, or sometime it also measures the rate of energy transferred from one circuit to another circuit. When a moving coil (that is free to rotate) is kept under the influence of a current carrying conductor, then automatically a mechanical force will be applied to the moving coil, and this force will make a little deflection of the moving coil. If a pointer is connected with the moving coil, which will move of a scale, then the deflection can be easily measured by connecting the moving coil with that pointer. This is the principle of operation of all dynamo meter type instruments, and this principle is equally applicable for dynamo meter type watt meter also.
This type of watt meter consists of two types of coil, more specifically current coil and voltage coil. There are two current coils which are kept at constant position and the measurable current will flow through those current coils. A voltage coil is placed inside those two current coils, and this voltage coil is totally free to rotate. The current coils are arranged such a way, that they are connected with the circuit in series. And the voltage coil is connected in parallel with the circuit. As simple as other voltmeter and ammeter connection. In fact, a watt meter is a package of an ammeter and a voltmeter, because the product of voltage and current is the power, which is the measurable quantity of a watt meter.
When current flows through the current coils, then automatically a magnetic field is developed around those coils. Under the influence of the electromagnetic field, voltage coil also carries some amount of current as it is connected with the circuit in parallel. In this way, the deflection of the pointer will proportional to both current and voltage of the circuit. In this way, Watt = Current × Voltage equation is satisfied and the deflection shows the value of power inside the circuit. A dynamo meter type watt meter is used in various applications where the power or energy transfer has to be measured.



Advantages of Dynamometer type Instruments:
•Can be used on both DC & AC circuits.
•Uniform scale.
•High degree of accuracy can be obtained.
Disadvantages of Dynamometer type Instruments:
•At low power factors, the inductances of the potential coilcauses serious errors.

•The reading of the instrument may be affected by stray fieldsacting on the moving coil.

Energy Meter:

Introduction

The energy meter is an electrical measuring device, which is used to record Electrical Energy Consumed over a specified period of time in terms of units.Electric meters are typically calibrated in billing units, the most common one being the kilowatt hour. A periodic reading of electric meters establishes billing cycles and energy used during a cycle.

Features:

* Display of current time (24 hours type), week, load power and cost tariff.
* Display of total on time, total used energy and accrued energy cost.
* Display of total record time, total on time and percentage.
* Dual programmable power tariffs.
* Connection, operation settings.

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6. Draw and explain the operation of permanent magnet moving iron and moving coil type instruments with neat diagrams. Obtain an expression for its deflecting torque. (June 2011) (DEC2012).

Permanent Magnet Moving Coil Instrument

The **permanent magnet moving coil instrument** or **PMMC type instrument** uses two permanent magnets in order to create stationary magnetic field. These types of instruments are only used for measuring the dc quantities as if we apply ac current to these type of instruments the direction of current will be reversed during negative half cycle and hence the direction of torque will also be reversed which gives average value of torque zero. The pointer will not deflect due to high frequency from its mean position showing zero reading. However it can measure the direct current very accurately.

Let us move towards the constructions of **permanent magnet moving coil instrument**s. We will see the construction of these types of instruments in five parts and they are described below:

(a) **Stationary part or magnet system:** In the present time we use magnets of high field intensities, high coercive force instead of using U shaped permanent magnet having soft iron pole pieces. The magnets which we are using nowadays are made up of materials like alcomax and alnico which provide high field strength.

(b) **Moving coil:** The moving coil can freely moves between the two permanent magnets as shown in the figure given below. The coil is wound with many turns of copper wire and is placed on rectangular aluminium which is pivoted on jeweled bearings.

(c) **Control system:** The spring generally acts as control system for PMMC instruments. The spring also serves another important function by providing the path to lead current in and out of the coil.

(d) **Damping system:** The damping force hence torque is provided by movement of aluminium former in the magnetic field created by the permanent magnets.

(e) **Meter:** Meter of these instruments consists of light weight pointer to have free movement and scale which is linear or uniform and varies with angle.

Let us derive a general expression for torque in permanent magnet moving coil instruments or**PMMC instrument**s. We know that in moving coil instruments the deflecting torque is given by the expression:

$$T_d = NBldI$$

where N is number of turns,

B is magnetic flux density in air gap,

l is the length of moving coil,

d is the width of the moving coil,

And I is the electric current.

Now for a moving coil instruments deflecting torque should be proportional to current, mathematically we can write T_d = GI. Thus on comparing we say G = NBIdl. At steady state we have both the controlling and deflecting torques are equal. T_c is controlling torque, on equating controlling torque with deflection torque we have

GI = K.x where x is deflection thus current is given by

$$I = \frac{K}{G}x$$

Since the deflection is directly proportional to the current therefore we need a uniform scale on the meter for measurement of current.

Now we are going to discuss about the basic circuit diagram of the ammeter. Let us consider a circuit as shown below:

The current I is shown which breaks into two components at the point A. The two components are I_s and I_m. Before I comment on the magnitude values of these currents, let us know more about the construction of shunt resistance. The basic properties of shunt resistance are written below,

The electrical resistance of these shunts should not differ at higher temperature, it they should posses very low value of temperature coefficient. Also the resistance should be time independent. Last and the most important property they should posses is that they should be able to carry high value of current without much rise in temperature. Usually manganin is used for making dc resistance. Thus we can say that the value of I_s much greater than the value of I_m as resistance of shunt is low. From the we have,

$$I_s \cdot R_s = I_m \cdot R_m$$

Where R_s is resistance of shunt and R_m is the electrical resistance of the coil.

$$Also\ I_s = I - I_m$$

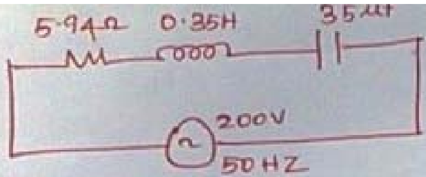
From the above two equations we can write,

$$m = \frac{I}{I_m} = 1 + \frac{R_m}{R_s}$$

Where m is the magnifying power of the shunt.

7. i) A coil of resistance 5.94Ohms and inductance of 0.35 H is connected in series with a capacitance of 35 Micro Farad across a 200V, 50Hz supply. Find the impedance (Z), Current and the phase difference betweenvoltage and current (Φ). DEC(2012).

13) (i)



$X_L = 2\pi f L = 109.9\,\Omega$

$X_C = \frac{1}{2\pi f C} = 90.99\,\Omega$

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

$= \sqrt{5.94^2 + (109.9 - 90.99)^2}$

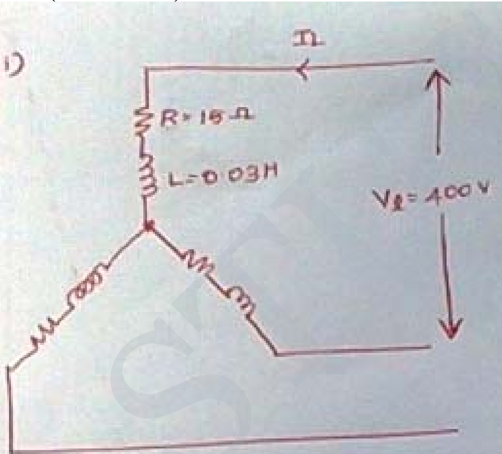
$\boxed{Z = 19.821\,\Omega}$

$\cos\phi = R/Z = \frac{5.94}{19.821} = 0.299$

$\boxed{\phi = 72.56^\circ}$

ii) Three inductive coils each with a resistance of 15 Ohms and an inductance of 0.03H are connected in star to a three phase 400V, 50Hz supply. Calculate the phase current, line current and power absorbed.(DEC2012).

13) ii)



$X_L = 2\pi f L$
$= 2 \times 3.14 \times 50 \times 0.03$
$= 9.42\,\Omega$

$Z_{ph} = \sqrt{R^2 + X_L^2}$
$= \sqrt{15^2 + 9.42^2}$

$\boxed{Z_{ph} = 17.7\,\Omega}$

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{231}{17.7}$

$\boxed{I_{ph} = 13.04\,A = I_L}$

$\cos\phi = \frac{R}{Z} = \frac{15}{17.7} = 0.847$

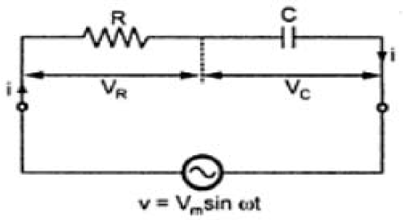
$V_{ph} = \frac{V_\ell}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 231$

$P = \sqrt{3} V_L I_L \cos\phi$
$= \sqrt{3} \times 400 \times 13.04 \times 0.847$

$\boxed{P = 7.656\,KW}$

8.Derive the expression for phase angle in the R-L series circuit, R-C series circuit and R-L-C series circuit. (16) **(DEC 2013)**

A.C. through Series R-C Circuit



Series R-C circuit

Consider a circuit consisting of pure resistance R-ohms and connected in series with a pure capacitor of C-farads as shown in the Fig.

The series combination is connected across a.c. supply given by

$$v = V_m \sin \omega t$$

Circuit draws a current I, then there are two voltage drops,

a) Drop across pure resistance $V_R = I \times R$

b) Drop across pure capacitance $V_C = I \times X_C$

Impedance

Similar to R-L series circuit, in this case also, the impedance is nothing but opposition to the flow of alternating current. It is measured in ohms given by $Z = \sqrt{(R)^2 + (X_C)^2}$ where $X_C = \frac{1}{2\pi f C}$ Ω called capacitive reactance.

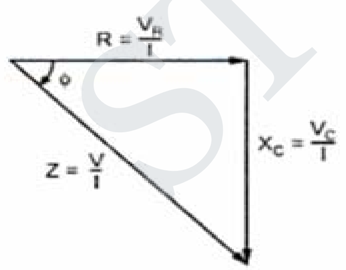
In R-C series circuit, current leads voltage by angle ϕ or supply voltage V lags current I by angle ϕ as shown in the phasor diagram in Fig. 7.20.

From voltage triangle, we can write,

$$\tan \phi = \frac{V_C}{V_R} = \frac{X_C}{R}, \quad \cos \phi = \frac{V_R}{V} = \frac{R}{Z}, \quad \sin \phi = \frac{V_C}{V} = \frac{X_C}{Z}$$

If all the sides of the voltage triangle are divided by the current, we get a triangle called **impedance triangle.**

Two sides of the triangle are 'R' and 'X_C' and the third side is impedance 'Z'.



Impedance triangle

The X component of impedance is R and is given by

$$R = Z \cos \phi$$

and Y component of impedance is X_C and is given by

$$X_C = Z \sin \phi$$

But, as direction of the X_C is the negative Y direction, the rectangular form of the impedance is denoted as,

$$\boxed{Z = R - j X_C \ \Omega}$$

While in polar form, it is denoted as,

$$\boxed{Z = |Z| \angle -\phi \ \Omega}$$

$$Z = R - j X_C = |Z| \angle -\phi$$

where $|Z| = \sqrt{R^2 + X_C^2}, \ \phi = \tan^{-1}\left[\frac{-X_C}{R}\right]$

A.C. through Series R-L Circuit

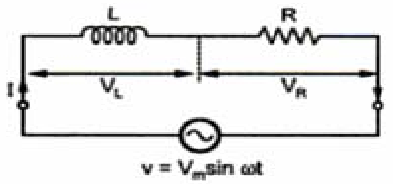


Fig. Series R-L circuit

Consider a circuit consisting of pure resistance R ohms connected in series with a pure inductance of L henries as shown in the Fig.

The series combination is connected across a.c. supply given by $v = V_m \sin \omega t$.

Circuit draws a current I then there are two voltage drops,

a) Drop across pure resistance, $V_R = I \times R$

b) Drop across pure inductance, $V_L = I \times X_L$ where $X_L = 2\pi f L$

I = r.m.s. value of current drawn

V_R, V_L = r.m.s. values of the voltage drops.

The Kirchhoff's voltage law can be applied to the a.c. circuit but only the point to remember is the addition of voltages should be a phasor (vector) addition and no longer algebraic as in case of d.c.

$\therefore \quad \overline{V} = \overline{V_R} + \overline{V_L}$ (Phasor addition)

$\therefore \quad \overline{V} = \overline{IR} + \overline{I X_L}$

Let us draw the phasor diagram for the above case.

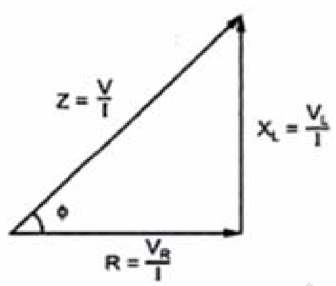


Fig. 7.15 Impedance triangle

If all the sides of the voltage triangle are divided by current, we get a triangle called impedance triangle as shown in the Fig. 7.15.

Sides of this triangle are resistance R, inductive reactance X_L and an impedance Z.

From this impedance triangle, we can see that the X component of impedance is R and is given by,

$$R = Z \cos \phi$$

and Y component of impedance is X_L and is given by,

$$X_L = Z \sin \phi$$

In rectangular form the impedance is denoted as,

$$\boxed{Z = R + j X_L \quad \Omega}$$

While in polar form, it is denoted as,

where

$$\boxed{\begin{aligned} Z &= |Z| \angle \phi \quad \Omega \\ |Z| &= \sqrt{R^2 + X_L^2}, \quad \phi = \tan^{-1}\left[\frac{X_L}{R}\right] \end{aligned}}$$

A.C. through Series R-L-C Circuit

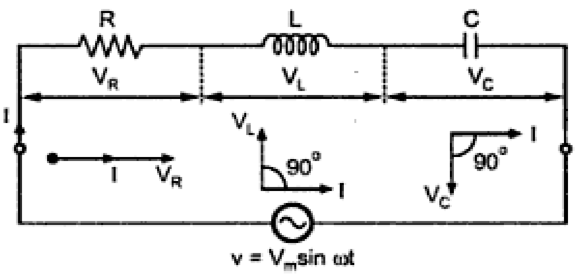


Fig. R-L-C series circuit

Consider a circuit consisting of resistance R ohms pure inductance L henries and capacitance C farads connected in series with each other across a.c. supply. The circuit is shown in the Fig.

The a.c. supply is given by,

v = V_m sin ωt. The circuit draws a current I. Due to current I, there are different voltage drops across R, L and C which are given by,

a) Drop across resistance R is $V_R = I R$

b) Drop across inductance L is $V_L = I X_L$

c) Drop across capacitance C is $V_C = I X_C$

The values of I, V_R, V_L and V_C are r.m.s. values

The characteristics of three drops are,

a) V_R is in phase with current I.

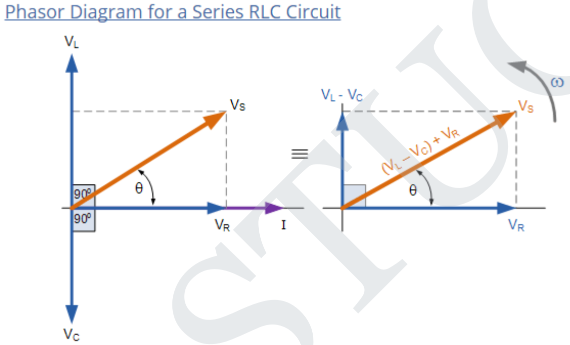
b) V_L leads current I by 90°.

c) V_C lags current I by 90°.

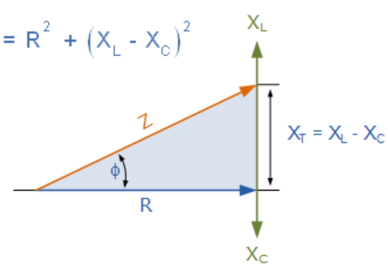
According to Kirchhoff's laws, we can write,

$$\bar{V} = \bar{V}_R + \bar{V}_L + \bar{V}_C \quad \text{... Phasor addition}$$

Phasor Diagram for a Series RLC Circuit



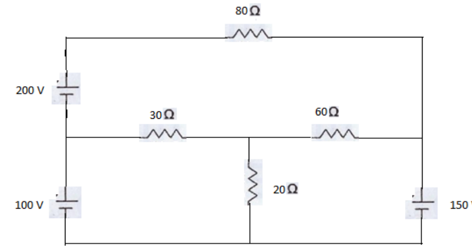
The Impedance Triangle for a Series RLC Circuit



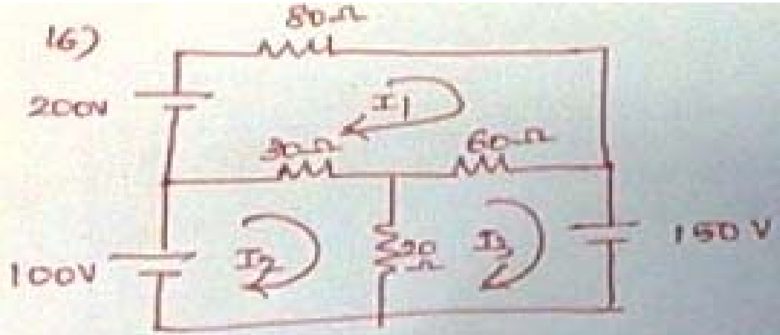
$$\text{Impedance, } Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$\cos\phi = \frac{R}{Z} \qquad \sin\phi = \frac{X_L - X_C}{Z} \qquad \tan\phi = \frac{X_L - X_C}{R}$$

9.Using Mesh analysis, find the current through the various branches in the circuit of the following figure. (16) **(Dec2013)**



16)



$200 = 8I_1 + 60(I_1 + I_2) + 30(I_1 - I_2)$

$200 = 170I_1 - 30I_2 + 60I_3$ — (1)

$100 = 30(I_2 - I_1) + 20(I_2 + I_3)$

$100 = -30I_1 + 50I_2 + 20I_3$ — (2)

$150 = 60(I_3 + I_1) + 20(I_3 + I_2)$

$150 = 60I_1 + 20I_2 + 80I_3$ — (3)

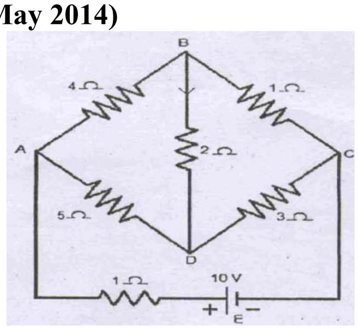
Solving (1), (2) & (3)

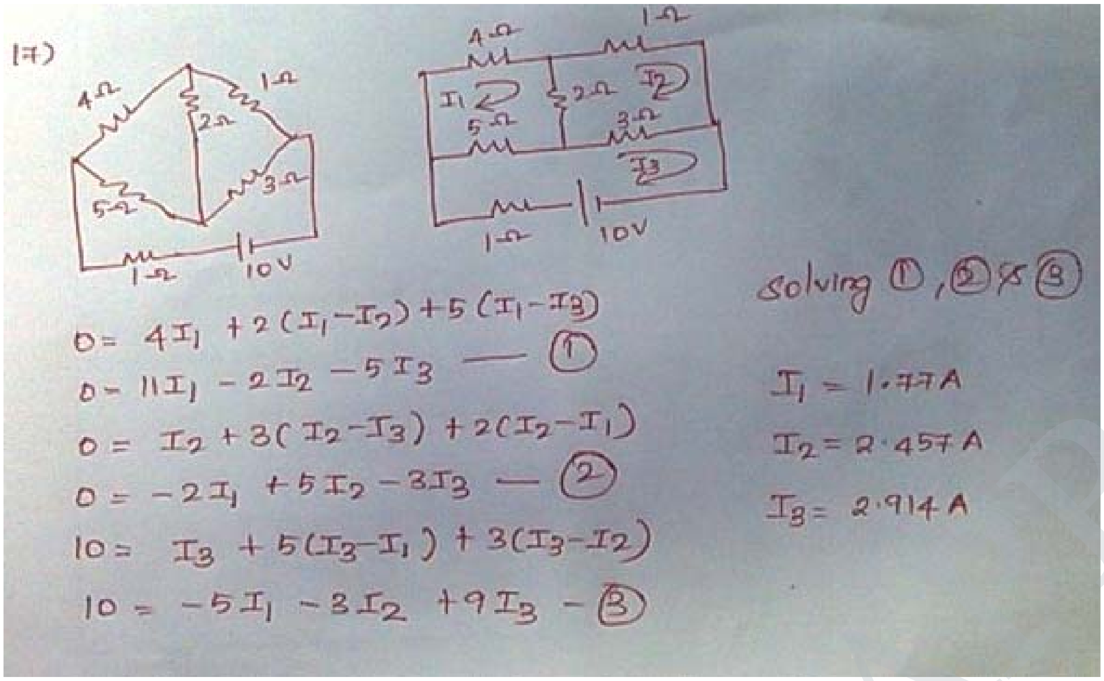
$I_1 = 1.875\,A$

$I_2 = 3.263\,A$

$I_3 = -0.347\,A$

10. In the circuit shown, determine the current through 2ohm resistor and the total current delivered by the battery. Use Kirchhoff's laws. (16) **(May 2014)**





UNIT II – ELECTRICAL MACHINES
PART-A

1. **What is the principle of operation of DC generator?**

When a coil rotates in a magnetic field, the flux linked with the coil changes. Hence an emf is induced in the coil which is proportional to the rate of change of flux linkage. $E = \frac{d\emptyset}{dt}$

2. **What is the principle of operation of DC Motor? (DEC 2013)**

When current carrying conductor is placed in a magnetic field, it experiences a force. The magnitude of force is given by Lorentz force equation whose direction is given by Fleming's left hand rule.

3..What is back emf or counter emf?(DEC 2012)

In a D.C motor, when armature rotates the armature conductors cut the field magnetic field and therefore an emf is induced in the armature. This induced emf acts in opposition to the applied voltage and also it opposes the incoming line current. It is customary to call this opposing emf as back emf or counter emf.

4. **State the applications of DC generators.**

A)DC Series Generator:- i)Used in DC locomotives, ii)Series arc lighting, iii)Series Boosters
B)DC Shunt Generator:- i)Battery Charging, ii)Lighting, iii)Power Supply Purposes
C)DC Compound Generator:- i)Arc Welding, ii)Lighting , iii)Power Services

5. **Name the different types of DC motors.**

1)Shunt motor, 2)Series motor, 3)Compound motor, 3.1)Long shunt compound generator,3.1.a)Cumulative long shunt, 3.1.b)Differential long shunt, 3.2)Short shunt compoundgenerator, 3.2.a)Cumulative short shunt, 3.2.b)Differential short shunt

6. Write the emf equation for a dc generator and torque equation for a dc motor

The emf equation of a dc generator is given by, $E = \frac{P\emptyset NZ}{60A}$. The torque equation of a dc motor is given by, $T = 0.159\ \Phi Z I a \frac{P}{A}$ Nm, where P - No of poles; Φ – Flux per pole; N- Speed; Z - No. of armature conductors; A- No. of parallel paths; Ia – Armature current

7. Define critical speed and critical resistance of a dc generator.

It is the maximum value of field resistance above which the generator fails to build up voltage is known as critical resistance. Critical speed of a dc generator is that speed for which the field resistance is equal to the value of critical resistance

8. What is armature reaction in a dc machine?

When current flows in the armature conductors a flux surrounds these conductors. The direction of this armature flux is such that it reduces the flux from the field poles, resulting in reduction in net flux and there by reduction in induced emf. This is called armature reaction.

9. Why should not dc series motor be started without load?

The speed of a dc series motor is given by the formula, $N = \frac{E*60}{\emptyset z}\left(\frac{A}{P}\right)$ r.p.m. i.e. $N \propto 1/\emptyset$

and α $I_f = I_a$ (for series motor). If the motor is started without load, the armature current I_a will be very small and the speed becomes dangerously high, which damages the motor. Hence, the DC series motor should never be started without some initial load.

10. Explain the function of Commutator in DC Generator and DC motor.

Commutator acts as a mechanical rectifier. In Generator, it converts AC (induced in armature conductors) into DC (in the external load).In Motor, its function is to produce unidirectional torque in the armature.

11. Explain the function of brushes in DC generator and DC motor.

The rotating armature and external circuit are connected through brushes. In DC generators, Brushes are employed to collect current from the Commutator and deliver it to the load. In a DC motor, brushes are employed to supply the current to the armature. The brushes are made up of Graphite, because in addition to the above function the graphite brushes act as lubricant.

12. State the necessity of starter in a dc motor. (MAY 2014)

The current drawn by the motor armature is given by the relation, $I_a = (V- E_b)/R_a$. When the motor is at rest, there is no back emf developed in the armature. If now full supply voltage is applied across the stationary armature, it will draw a very large current because armature resistance is relatively small. This excessive current will blow out the fuses and prior to that it will damage the commutator and brushes.

13. Explain the principle of operation of transformer.

A transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. This is accomplished by electromagnetic induction between two electric circuits which are electrically isolated and magnetically coupled through a path of low reluctance.

14. What is statically induced emf?

The emf induced by changing the flux linking with the coil (or conductor), without moving the coil or field system is called statically induced emf. The flux is changed by varying the current in the field system. Eg. EMF induced in the transformer winding.

15. Write the EMF equation of a transformer.

$E_1 = 4.44fN_1 \phi_m$ & $E_2 = 4.44fN_2 \phi_m$ Where, E_1 – emf induced in the primary winding (volts), E_2 – emf induced in the secondary winding (volts), N_1 – no. of turns in the primary winding, N_2 – no. of turns in the secondary, f - supply frequency (Hz), ϕ_m – maximum flux (Weber)

16.. Define Voltage transformation ratio (K). (DEC 2012)(DEC2013)

It is the ratio of secondary voltage to primary voltage.

17.. Define Voltage Regulation of a transformer. (MAY 2014)

The voltage regulation of a transformer is the arithmetic difference between the no-load secondary voltage and the secondary voltage on-load, expressed as percentage of no-load voltage. % of Voltage Regulation = (No load secondary voltage – Full load secondary voltage)/ No load secondary voltage *100

18. What is the function of breather in a transformer?

Good transformer oil should be absolutely free from alkalis, sulphur and particularly from moisture. The presence of even an extremely small percentage of moisture in the oil decreases the dielectric strength of the oil considerably. Hence, champers containing silica gel is provided on the top of the transformer tank. This is called as breather. The atmospheric moisture is entrapped in this breather and is not allowed to pass on to the oil as the atmospheric air flows in or out the transformer tank while the transformer oil expand or contract as its temperature increases or decreases.

19. Define 'All day efficiency' of a single phase transformer.

As the load on a transformer is not constant, the efficiency of the transformer is measured in terms of energy consumed in a day. All day efficiency = Output in KWh / Input in KWh (for 24 hours)

20. An 8 pole, lap wound armature rotated at 350rpm is required to generate 260V. The useful flux/pole is 0.05wb. If the armature has 120 slots, calculate the number of conductors per slot.
(June 2011)

$$E_g = \frac{P\emptyset NZ}{60A} Z = \frac{E_g * 60A}{P\emptyset N} = \frac{260*60*8}{8*0.05*350} = 890\Omega$$

No.of conductors/slot = 890/120 = 7.14
Thus conductors / slot =8

PART-B

1.Discuss the construction and working principle of a D.C Generator with neat diagram. (DEC2013).

DC generator:

An electrical generator is a device that converts mechanical energy to electrical energy, generally using electromagnetic induction. The energy conversion in generator is based on the principle of the production of dynamically induced e.m.f. whenever a conductor cuts magnetic flux, dynamically induced e.m.f is produced in it according to Faraday's Laws of Electromagnetic induction. This e.m.f causes a current to flow if the conductor circuit is closed. Hence, two basic essential parts of an electrical generator are (i) a magnetic field and (ii) a conductor or conductors which can so move as to cut the flux.

Generator Construction:

Simple loop generator is having a single-turn rectangular copper coil rotating about its own axis in a magnetic field provided by either permanent magnet or electro magnets. In case of without commutator the two ends of the coil are joined to slip rings which are insulated from each other and from the central shaft. Two collecting brushes (of carbon or copper) press against the slip rings. Their function is to collect the current induced in the coil. In this case the current waveform we obtain is alternating current (you can see in fig). In case of with commutator the slip rings are replaced by split rings. In this case the current is unidirectional.

Construction of DC Motor

Components of a generator:

Yoke: Yoke is a outer frame. It serves two purposes.
(i) It provides mechanical support for the poles and acts as a protecting cover for the whole machine and (ii) It carries the magnetic flux produced by the poles. In small generators where cheapness rather than weight is the main consideration, yokes are made of cast iron. But for large machines usually cast steel or rolled steel is employed. The modern process of forming the yoke consists of rolling a steel slab round a cylindrical mandrel and then welding it at the bottom. The feet and the terminal box etc., are welded to the frame afterwards. Such yokes possess sufficient mechanical strength and have high permeability.

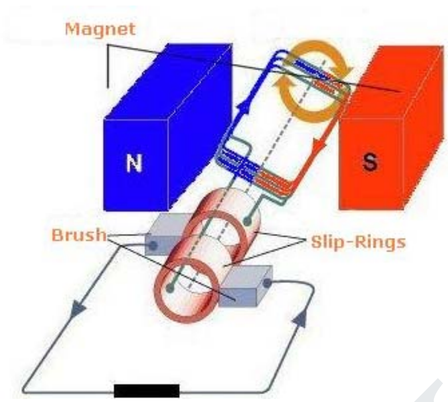
Rotor: In its simplest form, the rotor consists of a single loop of wire made to rotate within magnetic field. In practice, the rotor usually consists of several coils of wire wound on an armature.

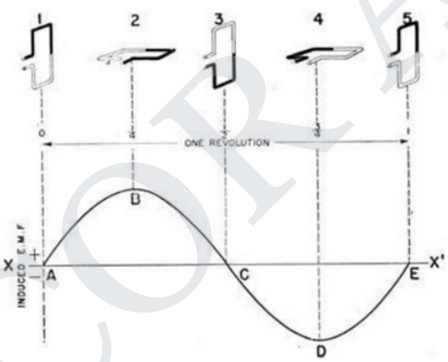
Armature: The armature is a cylinder of laminated iron mounted on an axle. The axle is carried in bearings mounted in the external structure of the generator. Torque is applied to the axle to make the rotor spin.

Coil: Each coil usually consists of many turns of copper wire wound on the armature. The two ends of each coil are connected either to two slip rings (AC) or two opposite bars of a split-ring commutator (DC).

Stator: The stator is the fixed part of the generator that supplies the magnetic field in which the coils rotate. It may consist of two permanent magnets with opposite poles facing and shaped to fit around the rotor. Alternatively, the magnetic field may be provided by two electromagnets.
Field electromagnets: Each electromagnet consists of a coil of many turns of copper wire wound on a soft iron core. The electromagnets are wound, mounted and shaped in such a way that opposite poles face each other and wrap around the rotor.
Brushes: The brushes are carbon blocks that maintain contact with the ends of the coils via the slip rings (AC) or the split-ring commutator (DC), and conduct electric current from the coils to the external circuit.
Principle of operation:
DC generator converts mechanical energy into electrical energy. when a conductor move in a magnetic field in such a way conductors cuts across a magnetic flux of lines and emf produces in a generator and it is defined by **faradays law** of electromagnetic induction :emf causes current to flow if the conductor circuit is closed.

$$e= -N\, d Ø/dt$$





2. Derive the EMF equation of a D.C Generator. (June 2011)(DEC2012).

EMF equation
Let Ø= flux per pole in weber
Z = Total number of conductor
P = Number of poles
A = Number of parallel paths
N =armature speed in rpm
Eg = emf generated in any on of the parallel path

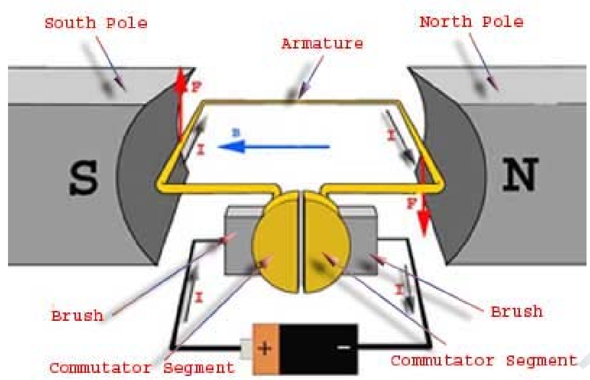
Flux cut by 1 conductor in 1 revolution $= P * \varphi$
Flux cut by 1 conductor in 60 sec $= P \varphi N /60$
Avg emf generated in 1 conductor $= P\varphi N/60$
Number of conductors in each parallel path $= Z /A$

$$E_g = P\varphi NZ/60A$$

The armature conductors are generally connected in two different ways, lap winding and wave winding.For lap wound armatures, the number of parallel path is equal to the number of poles(A=P).In wave wound machines, A=2, always.

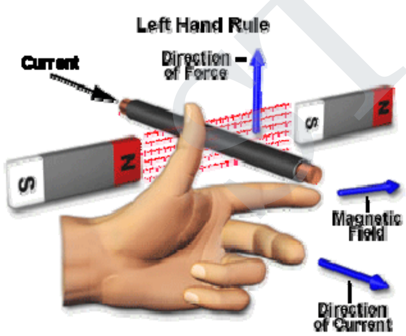
3.Explain the operating principle of a D.C Motor. What is meant by back emf? What is its significance? (June 2011)

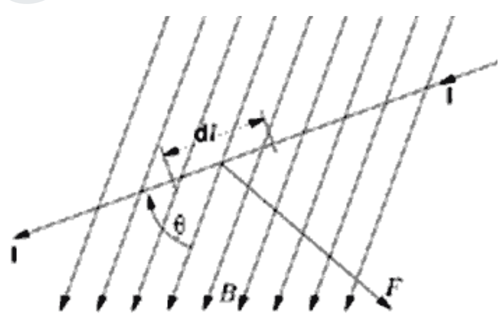
A DC motor in simple words is a device that converts direct current(electrical energy) into mechanical energy. In order to understand the operating principle of dc motor we need to first look into its constructional feature.



The very basic construction of a dc motor contains a current carrying armature which is connected to the supply end through commutator segments and brushes and placed within the north south poles of a permanent or an electro-magnet as shown in the diagram below.
Now to go into the details of the operating principle of DC motor its important that we have a clear understanding of Fleming's left hand rule to determine the direction of force acting on the armature conductors of dc motor.

Fleming's left hand rule says that if we extend the index finger, middle finger and thumb of our left hand in such a way that the current carrying conductor is placed in a magnetic field (represented by the index finger) is perpendicular to the direction of current (represented by the middle finger), then the conductor experiences a force in the direction (represented by the thumb) mutually perpendicular to both the direction of field and the current in the conductor.
For clear understanding the principle of DC motor we have to determine the magnitude of the force, by considering the diagram below.





The magnitude of force (F)experienced by the conductor in a motor is given by

F=B I l Newtons

Where B= Magnetic field density wb/m^2
I= Current in amperes
L= Length of the conductors in meters

Back emf:

In a D.C motor, when armature rotates the armature conductors cut the field magnetic field and therefore an emf is induced in the armature. This induced emf acts in opposition to the applied voltage and also it opposes the incoming line current. It is customary to call this opposing emf as back emf or counter emf. Its value depends upon the speed of rotation of the armature conductors.

In starting, the value of back emf is zero.

<u>Significances of back emf include</u>

1.It leads to increase in resistance of the motor leading to lower power consumption during rotation.

2. It limits the speed of the motor

4..With a neat sketch, explain the constructional details of a Transformer. (May 2013)

Atransformer is a statis device and its construction is simple as there are no moving parts.

The main components of a transformer are

i. Magnetic core
ii. Primary and secondary winding
iii. Insulation of windings
iv. Expansion tank or conservator
v. Lead and tappings for coils with their supports,terminals and terminal insulators
vi. Tank oil,cooling arrangement,temperature gauge,oil gauge
vii. Buchholz relay
viii. Silica gel breather

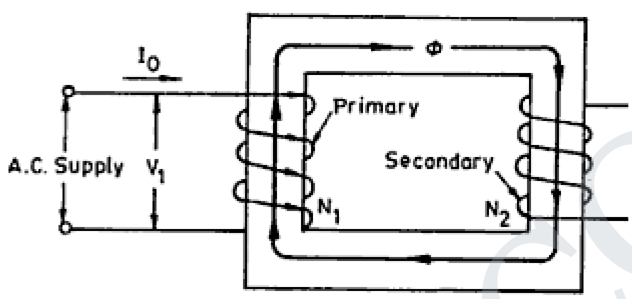


Fig. 2.2. Magnetic circuit of a core-type transformer.

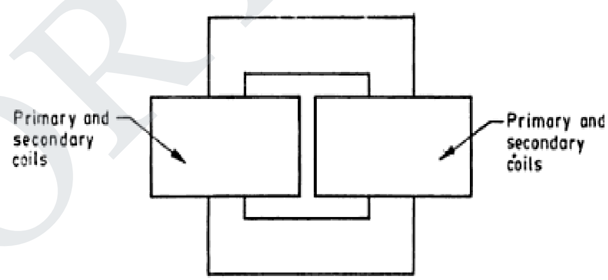


Fig. 2.3. Core-type transformer.

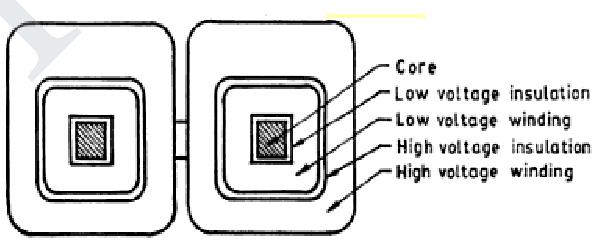


Fig. 2.4. Cross-section of a core-type transformer.

Fig. 2.5 shows the coils and laminations of a core-type transformer with a cruciform core and circular coils.

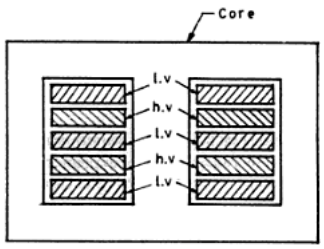


Fig. 2.11. Sandwich coils.

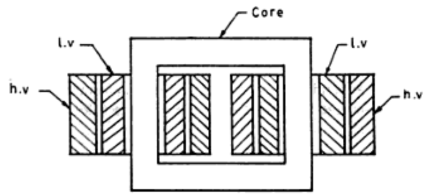
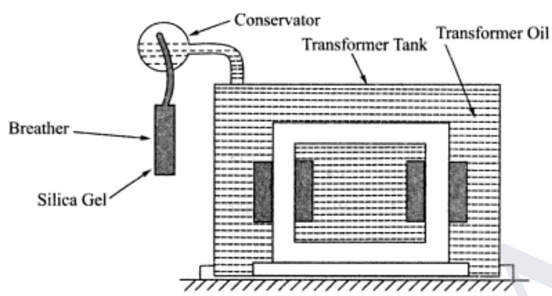


Fig. 2.10. Concentric coils.



1)BUCHHOLZ RELAY: it is a very sensitive gas and oil operated instrument which safely detect the formation of gas or sudden pressure inside the oil transformer.
2)CONSERVATOR: it is used to provide adequate space for the expansion of oil when transformer is loaded or when ambient temprature changes.
3)SILICA GEL BREATHER: it sucks the moisture from the air which is taken by transformer so that dry air is taken by transformer.
4)DOUBLE DIAPHRAGM EXPLOSION VENT: it is used to discharge excess presure in the atmospher when excess pressure is developed inside the transformer during loading.
5)OIL LEVEL INDICATOR: it is used to show the oil level in the transformer.
6)winding temprature indicator: used to show the temprature of transformer winding.
7)RADIATORS: these are used for cooling of the transformer oil.

5. Explain the operating principle of a various types of single phase Induction Motor with neat diagram. Mention its applications also. (June 2011) (DEC2012) (DEC2013).

Types of Single Phase Induction Motors

In practice some arrangement is provided in the single phase induction motors so that the stator flux produced becomes **rotating type** rather than the alternating type, which rotates in one particular direction only. So torque produced due to such rotating magnetic field is unidirectional as there is no oppositely directed torque present. Hence under the influence of rotating magnetic field in one direction, the induction motor becomes self starting. It rotates in same direction as that of rotating magnetic field. Thus depending upon the methods of producing **rotating** stator magnetic flux, the single phase induction motors are classified as,

1. Split phase induction motor
2. Capacitor start induction motor
3. Capacitor start capacitor run induction motor
4. Shaded pole induction motor.

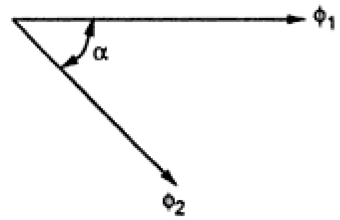


Fig.

To produce rotating magnetic field, it is necessary to have minimum two alternating fluxes having a phase difference between the two. The interaction of such two fluxes produce a resultant flux which is rotating magnetic flux, rotating in space in one particular direction. So an attempt is made in all the single phase induction motors to produce an additional flux other than stator flux, which has a certain phase difference with respect to stator flux. Such two fluxes are shown in the Fig. having phase difference of α between them.

More the phase difference angle α, more is the starting torque produced. Thus **production of rotating magnetic field** at start is important to make the single phase induction motors self starting. Once the motor starts, then another flux ϕ_2 may be removed and motor can continue to rotate under the influence of stator flux or main flux alone.

Split Phase Induction Motor

This type of motor has single phase stator winding called **main winding**. In addition to this, stator carries one more winding called **auxiliary winding** or **starting winding**. The auxiliary winding carries a series resistance such that its impedance is highly resistive in nature. The main winding is inductive in nature.

As main winding is inductive, current I_m lags voltage V by a large angle ϕ_m while I_{st} is almost in phase in V as auxiliary winding is highly resistive. Thus there exists a phase difference of α between the two currents and hence between the two fluxes produced by the two currents. This is shown in the Fig. (c). The resultant of these two fluxes is a rotating magnetic field. Due to this, the starting torque, which acts only in one direction is produced.

The auxiliary winding has a centrifugal switch in series with it. When motor gathers a speed upto 75 to 80% of the synchronous speed, centrifugal switch gets opened mechanically and in running condition auxiliary winding remains out of the circuit. So motor runs only on stator winding. So auxiliary winding is designed for short time use while the main winding is designed for continuous use. As the current I_m and I_{st} are splitted from each other by angle 'α' at start, the motor is commonly called **split phase motor**.

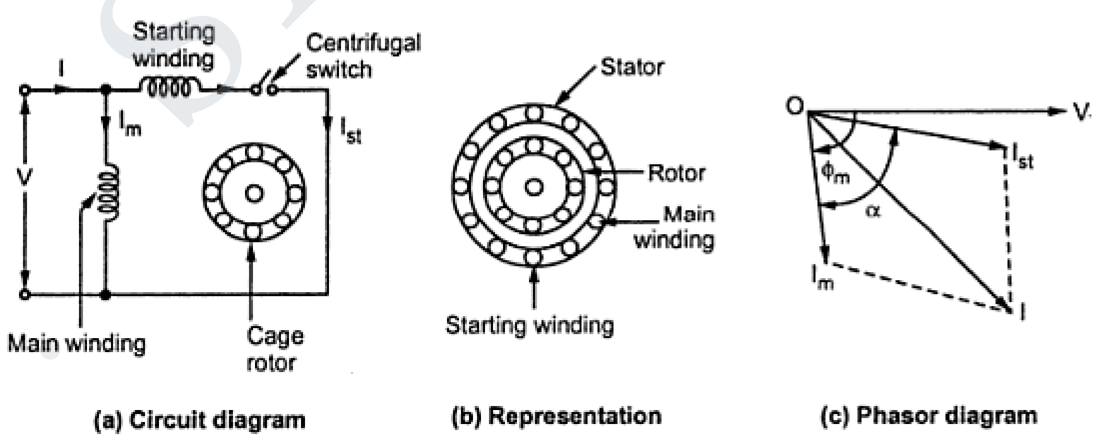


Fig. Split phase induction motor

Applications

These motors have low starting current and moderate starting torque. These are used for easily started loads like fans, blowers, grinders, centrifugal pumps, washing machines, oil burners, office equipments etc. These are available in the range of 1/20 to ½ kW.

Capacitor Start Induction Motors

The construction of this type of motor is similar to the resistance split phase type. The difference is that in series with the auxiliary winding the capacitor is connected. The capacitive circuit draws a leading current, this feature is used in this type to increase the split phase angle α between the two currents I_m and I_{st}.

Depending upon whether capacitor remains in the circuit permanently or is disconnected from the circuit using centrifugal switch, these motors are classified as,

1. Capacitor start motors and 2. Capacitor start capacitor run motors

The construction of capacitor start motor is shown in the Fig. (a). The current I_m lags the voltage by angle ϕ_m while due to capacitor the current I_{st} leads the voltage by angle ϕ_{st}. Hence there exists a large phase difference between the two currents which is almost 90°, which is an ideal case. The phasor diagram is shown in the Fig. (b).

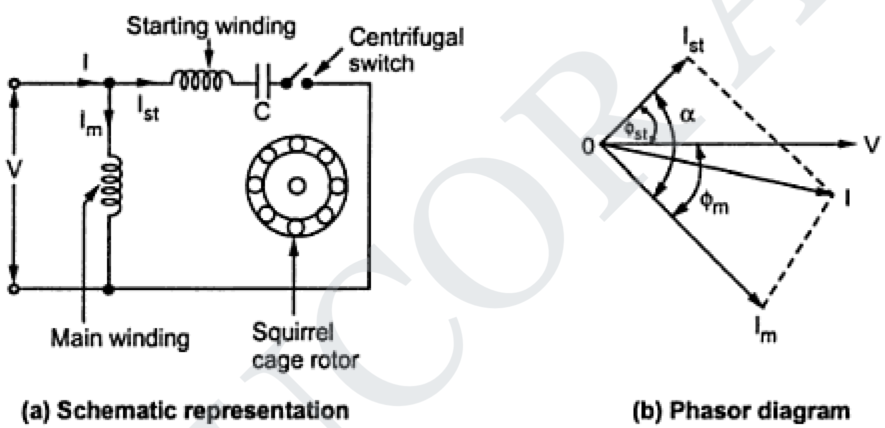


Fig. Capacitor start motor

The starting torque is proportional to 'α' and hence such motors produce very high starting torque.

When speed approaches to 75 to 80% of the synchronous speed, the starting winding gets disconnected due to operation of the centrifugal switch. The capacitor remains in the circuit only at start hence it is called capacitor start motors.

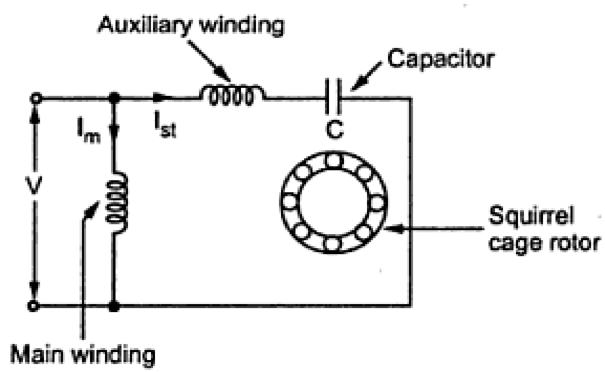


Fig. Capacitor start capacitor run motor

In case of capacitor start capacitor run motor, there is no centrifugal switch and capacitor remain permanently in the circuit. This improves the power factor. The schematic representation of such motor is shown in the Fig.

The phasor diagram remains same as shown in the Fig. (b) . The performance not only at start but in running condition also depends on the capacitor C hence its value is to be designed so as to compromise between best starting and best running condition. Hence the starting torque available in such type of motor is about 50 to 100% of full load torque.

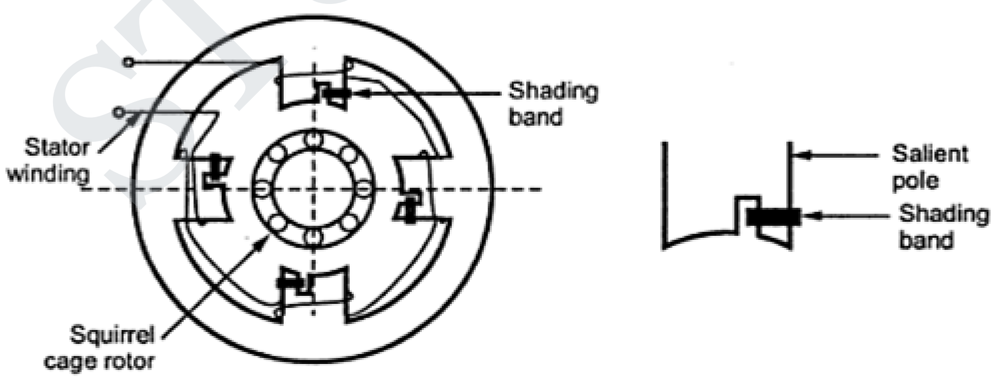
The direction of rotation, in both the types can be changed by interchanging the connections of main winding or auxiliary winding. The capacitor permanently in the circuit improves the power factor. These motors are more costly than split phase type motors.

Applications

These motors have high starting torque and hence are used for hard starting loads. These are used for compressors, conveyors, grinders, fans, blowers, refrigerators, air conditioners etc. These are most commonly used motors. The capacitor start capacitor run motors are used in ceiling fans, blowers and air-circulators. These motors are available upto 6 kW.

Shaded Pole Induction Motors

This type of motor consists of a squirrel cage rotor and stator consisting of salient poles i.e. projected poles. The poles are shaded i.e. each pole carries a copper band on one of its unequally divided part called **shading band**. Fig. (a) shows 4 pole shaded pole construction while Fig. (b) shows a single pole consisting of copper shading band.



(a) 4 - pole shaded pole construction (b) Salient pole with shading band

When single phase a.c. supply is given to the stator winding, due to shading provided to the poles, a rotating magnetic field is generated.

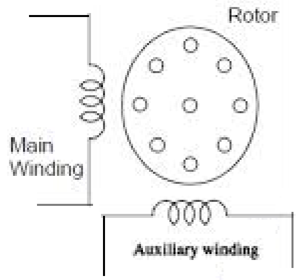
Applications

These motors are cheap but have very low starting torque, low power factor and low efficiency. These motors are commonly used for the small fans, toy motors, advertising displays, film projectors, record players, gramophones, hair dryers, photo copying machines etc.

6. Explain the starting methods of single phase induction motor.

The starting method of single-phase induction motor is very simple. An auxiliary winding in the stator is provided in addition to the main winding. Then the induction motor starts as a two phase motor. It is shown in the following figure.

The main winding axis and auxiliary winding axis are displaced by 90 electrical degrees. The impedance of the windings differs and currents in the main and auxiliary winding are phase shifted from each other. As a result of this, a rotating stator field is produced and the rotor rotates.



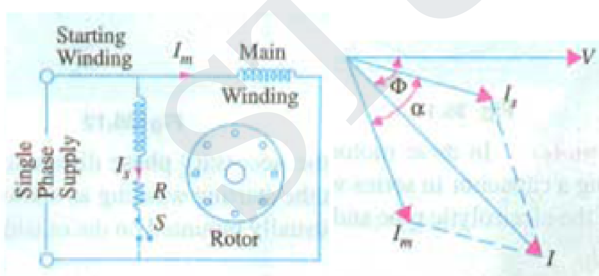
When the motor speed is about 75% of synchronous speed, the auxiliary winding is disconnected from the circuit. This is done by connecting a centrifugal switch in the auxiliary winding which is used for starting purpose only. That is why it is called starting winding.

Under running condition, a single phase induction motor can develop torque with only the main winding. That is why it is called running winding.

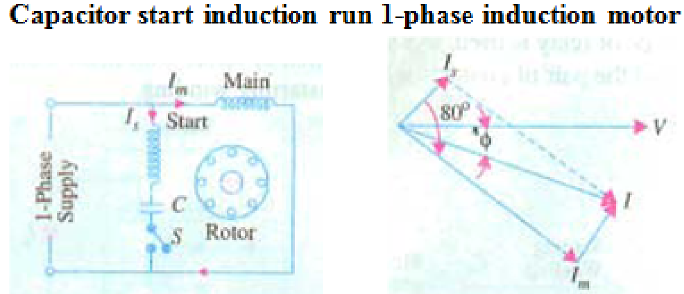
Methods of starting:

1. Split phase 1-phase induction motor
2. Capacitor start induction run 1-phase induction motor
3. Capacitor start and run 1-phase induction motor
4. Shaded pole 1-phase induction motor

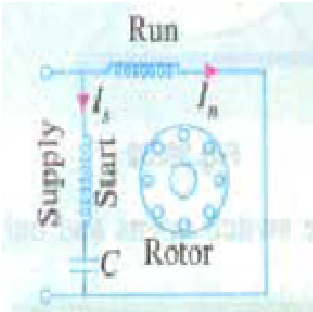
Split phase 1-phase induction motor



Capacitor start induction run 1-phase induction motor



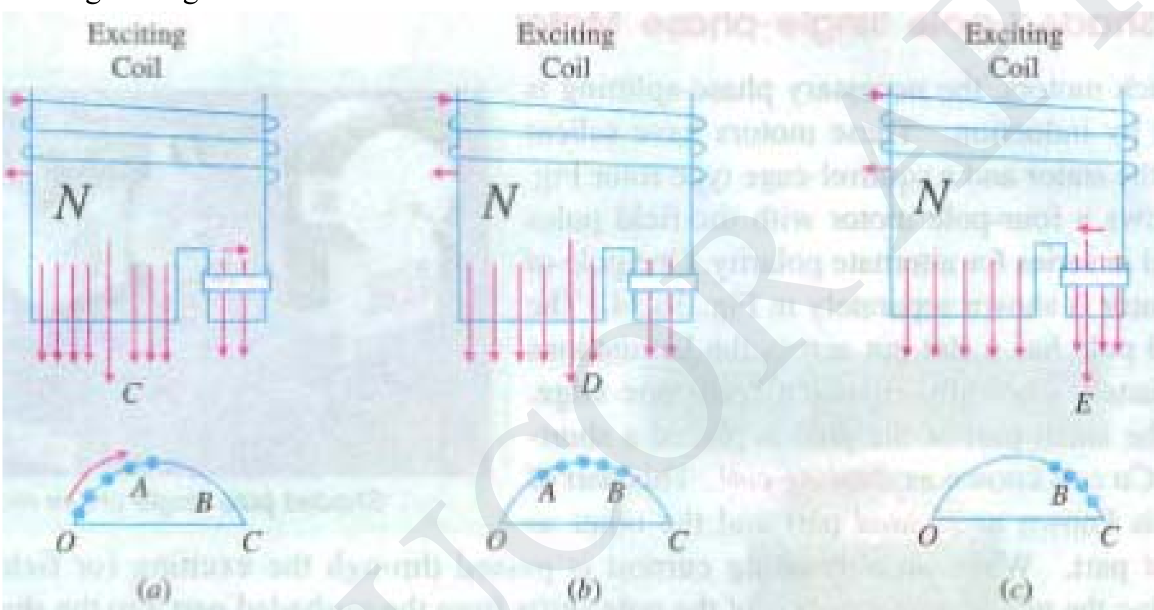
Capacitor start and run single phase induction motor



Shaded pole single phase induction motor:

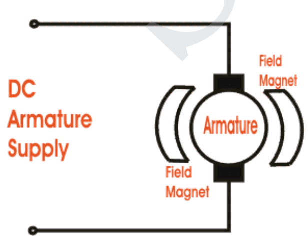
Shaded pole single phase motor

Shifting of magnetic axis:



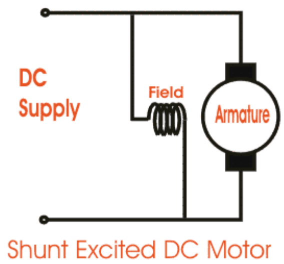
7. Write short notes on types of DC Machines. (May 2013)

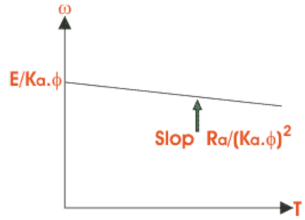
<u>Permanent Magnet DC Motor</u>



For permanent magnet dc motor $T_g = K_{a1} I_a$

Shunt Wound DC Motor

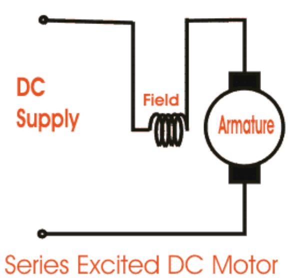


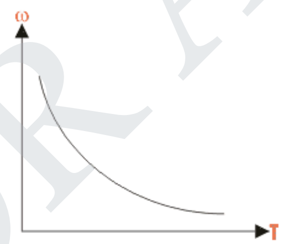


$$\omega = \frac{E}{k_a\varphi} - \frac{R_a T_g}{(K_a\ \varphi)^2}$$

The shunt wound dc motor is a constant speed motor, as the speed does not vary here with the variation of mechanical load on the output.

Series Wound DC Motor



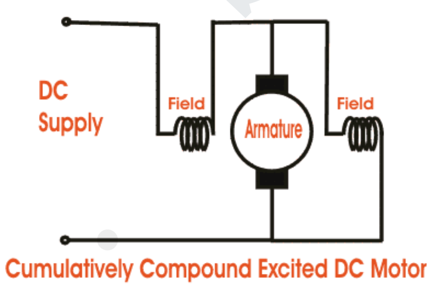


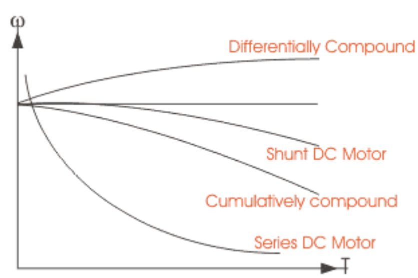
$$\omega = \frac{E}{K_s I_a} - \frac{R_a + R_s}{K_s}$$

In a series wound dc motor, the speed varies with load. And operation wise this is its main difference from a shunt wound dc motor.

Cumulative Compound DC Motor

When the shunt field flux assists the main field flux, produced by the main field connected in series to the armature winding then its called cumulative compound dc motor.





Differential Compound DC Motor

In case of a differentially compounded self excited dc motor i.e. differential compound dc motor, the arrangement of shunt and series winding is such that the field flux produced by the shunt field winding diminishes the effect of flux by the main series field winding.

$$\phi_{total} = \phi_{series} - \phi_{shunt}$$

The net flux produced in this case is lesser than the original flux and hence does not find much of a practical application. The compounding characteristic of the self excited dc motor is shown in the figure below.

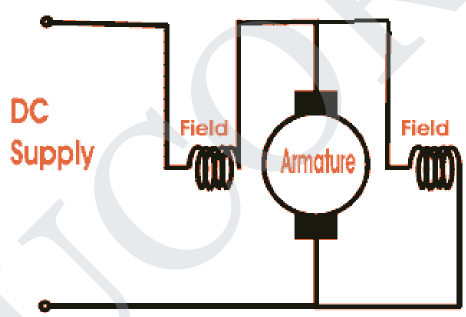
Both the cumulative compound and differential compound dc motor can either be of short shunt or long shunt type depending on the nature of arrangement.

Short Shunt DC Motor

If the shunt field winding is only parallel to the armature winding and not the series field winding then its known as short shunt dc motor or more specifically short shunt type compound wound dc motor.

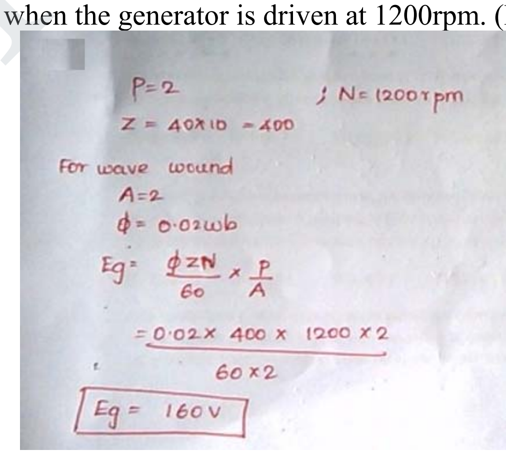
Long Shunt DC Motor

If the shunt field winding is parallel to the armature winding and the series field winding then it's known as long shunt type compounded wound dc motor or simply long shunt dc motor.Short shunt and long shunt type motors have been shown in the diagram below.



Short Shund DC Motor

8.. A 4 pole, wave wound generator having 40 slots and 10 conductors placed per slot. The flux per pole is 0.02wb. Calculate the generated emf when the generator is driven at 1200rpm. (May 2014)



9.. A 25kW, 250V, dc shunt generator has armature and field resistances of 0.06 ohm and 100 ohm respectively Determine the total armature power developed when working (i) as a generator delivering 25kW output and (ii)As a motor taking 25kW. (May 2014)

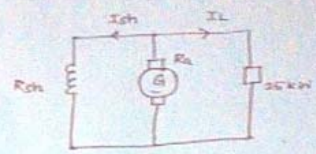
As generator

$P = 25\,kW$

$V = 250\,V$

$R_a = 0.06\,\Omega$

$R_{sh} = R_f = 100\,\Omega$



$I_L = \frac{P}{V} = \frac{25\times10^3}{250} = 100\,A$

$I_{sh} = \frac{V}{R_{sh}} = \frac{250}{100} = 2.5\,A$

$I_a = I_L + I_{sh} = 100 + 2.5$

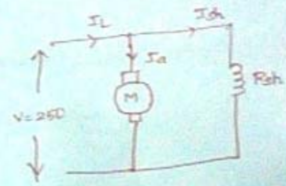
$\boxed{I_a = 102.5\,A}$

$E_g = V + I_a R_a = 250 + (102.5 \times 0.06)$

$E_g = 256.15\,V$

Power $= E_g I_a$ $\boxed{P = 28.25\,kW}$

As motor



$I_L = 100\,A$

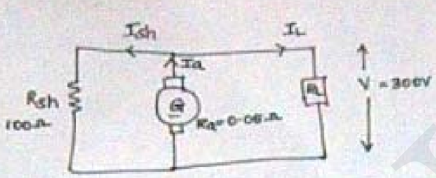
$I_{sh} = 2.5\,A$

$I_a = I_L - I_{sh} = 100 - 2.5 = 97.5\,A$

$E_b = V - I_a R_a = 250 - (97.5 \times 0.06) = 244.15\,V$

Power $= E_b I_a = 244.15 \times 97.5$

$\boxed{P = 23.804\,kW}$ ⇒ as motor



$I_L = \frac{P}{V} = \frac{230\times10^3}{300} = 766.67\,A$

$I_{sh} = \frac{V}{R_{sh}} = \frac{300}{100} = 3\,A$

$I_a = I_L + I_{sh}$

$I_a = 769.67\,A$

Generated emf

$E_g = V + I_a R_a = 300 + (769.6)(0.05)$

$\boxed{E_g = 338.48\,V}$

Power developed by the armature

$= E_g I_a$

$= 338.48 \times 769.67$

$= 260517.9$

$\boxed{P = 260.517\,KW}$

10. An ideal 25KVA transformer has 500 turns on the primary winding and 40 turns on the secondary winding. The primary is connected to 3000V, 50Hz supply. Calculate (1) primary and secondary currents on full load. (2)Secondary emf and (3) the maximum cores flux. (June 2011)

Given data:

Transformer rating = 25 kVA

No of Primary turns $N_1 = 500$

No of Secondary turns $N_2 = 40$

Primary voltage $V_1 = 3000V$

Frequency $f = 50$ Hz

Note:

$V_1 \rightarrow$ supply voltage across primary

$V_2 \rightarrow$ terminal voltage across sec

$E_1 \rightarrow$ Emf induced in primary wdg

$E_2 \rightarrow$ Emf induced in sec wdg

For ideal transformer

$V_1 = E_1$

$V_2 = E_2$

Sol: By transformation ratio 'k'

$$k = \frac{V_2}{V_1} = \frac{N_2}{N_1}$$

$$V_2 = \frac{40}{500} \times 3000 = 240V \Rightarrow \boxed{V_2 = 240V} \Rightarrow \text{Sec Induced emf}$$

Full load primary current

$$I_1 = \frac{\text{Transformer rating}}{\text{Primary voltage}} = \frac{25\times10^3}{3000} = 8.33A$$

$$\boxed{I_1 = 8.33A}$$

Full load secondary current

$$I_2 = \frac{25\times10^3}{V_2} = \frac{25\times10^3}{240} = 104.167A$$

Maximum core flux

$$E_1 = 4.44 f \phi_m N_1$$

$$\phi_m = \frac{E_1}{4.44 f N_1} = \frac{3000}{4.44\times50\times500} = 0.027\ wb$$

UNIT III Semiconductor Devices and Applications

PART A

1 **Define Semiconductors**.
Semiconductors are materials whose conducting properties lies between conductors and insulators. These materials are separated by a small energy gap (=1ev).Germanium and Silicon are commonly used semiconductors.

2 **Define: valence band, conduction band.**
The range of energies possessed by valence electrons is called valence band. The range of energies possessed by conduction electrons is called conduction band. The free electrons which are left in the valence band are occupying the conduction band.

3 **Define: forbidden energy gap**
The energy gap between the valence band and conduction band is defined as forbidden energy gap. For insulators. it is around 6ev, for semiconductors, its value is comparatively low. Germanium has energy

gap 0.7 eV and silicon has 1.1 eV. For conductors, since conduction and valence bands are overlapping the energy gap is zero.

4 **What is intrinsic semiconductor?**
Intrinsic semiconductors are pure form of semiconductors. The conductivity of a semiconductor lies between an insulator and a conductor. As temperature increases, the conductivity of the semiconductor also increases. Semiconductors have negative temperature co-efficient of resistance

5 **Define: extrinsic semiconductor**
The electrical conductivity of pure semiconductor can be increased by adding some impurity into it. The resulting semiconductor is called extrinsic semiconductor.

6 **What is meant by N-type and P-type semiconductor?**
When a small amount of impurity (eg. Antimony, Arsenic) is added to a pure semiconductor crystal the resulting extrinsic semiconductor is N-type semiconductor. If trivalent impurity (eg. Indium, Gallium) is added to a pure semiconductor then the resulting extrinsic semiconductor is known as P-type semiconductor.

7 **What is doping?**
The process of adding impurity to pure semiconductor is known as doping. As a result of it the characteristics of semiconductor is changed and hence the conductivity increases.

8 **What are donor and acceptor impurities?**
Pentavalent impurities (Antimony, Arsenic) have five valence electrons. They can donate one excess electron to adjacent atoms to complete lattice structure; therefore they are called donor impurities.
Trivalent impurities (Indium, Gallium) have three valence electrons. They have tendency to accept one electron from adjacent atoms to complete lattice structure, therefore they are known as acceptor impurities

9.. **Define the different operating regions of transistor.**
Active region: It is defined in which transistor collector junction is biased in reverse direction and emitter junction in forward direction.
Cutoff region: The region in which the collector and emitter junctions are both reverse-biased
Saturation region: The region in which both the collector and emitter junctions are forward biased.

10. **Define: Base width modulation (Early effect)**
In a CB configuration, an increase in collector voltage increases the width of the depletion region at the output junction diode. This will decrease the effective width of the base. This is known as early effect. Due to this effect recombination rate reduces at the base region and

charge gradient is increased within the base.

11. **Explain the significance of Base width modulation (Early effect)**
It reduces the charges recombination of electrons with holes in the base region; hence the current gain increases with the increase in collector -base voltage. The charge gradient is increased within base; hence the current due to minority carriers injected across emitter junction increases.

12.. **What are the three types of transistor configuration?**
Common base configuration
Common emitter configuration
Common collector configuration

13.. **Among CB, CE, CC which is most important?**
The CE configuration is important. The reasons
i) High current gain
ii) Output to input impedance ratio is moderate therefore easy coupling is possible between various transistor stages
iii) It finds excellent usage in audio frequency applications hence used in receivers and transmitters.

Compare the performance of CE, CB, CC

Parameters	**CB**	**CE**	**CC**
Current gain (A_i)	Low	High	High
Voltage gain (V_i)	High	High	Low
Input resistance (R_i)	Low	Medium	High
Output resistance (R_o)	High	Medium	Low

14. **What is Zener breakdown?**
When a PN junction is heavily doped the depletion region is very narrow. So under reverse bias condition, the electric field across the depletion layer is very intense. Electric field is voltage per distance and due to narrow depletion region and high reverse voltage, it is intense. Such an intense field is enough to pull the electrons out of the valence bands of the stable atoms. So this is not due to the collision of carriers with atoms. Such a creation of free electrons is called Zener effect which is different that the avalanche effect. These minority carriers constitute very large current and mechanism is called Zener Breakdown.

15.Give the applications of Zener diode

* Used as a constant voltage source.
* Used as voltage regulator.

16. **Define PIV of a rectifier with an example.**
This is the maximum reverse voltage with which a diode can withstand without any damage. PIV of half wave rectifier is V_m, while that of center tapped FWR is $2V_m$.

17.. **Compare the performance analysis of HWR,FWR(Centre tapped) & bridge rectifier**

Performance factors	**HWR**	**FWR (Bridge)**	**FWR (Center tapped)**
Average current	I_m/π	$2I_m/\pi$	$2I_m/\pi$
Average dc voltage	E_m/π	$2V_m/\pi$	$2V_m/\pi$
rms load current	$I_m/2$	$I_m/\sqrt{2}$	$I_m/\sqrt{2}$
Efficiency	0.406	0.812	0.812
TUF	0.287	0.812	0.693
Ripple factor	1.21	0.48	0.48
PIV	V_m	V_m	$2V_m$

18.**What is avalanche breakdown in PN junction diode?**

The avalanche breakdown takes place when both sides of the junction are lightly doped and due to this the depletion layer is large. When the reverse bias voltage is increased the accelerated free electrons collide with the semiconductor atoms in the depletion region Due to collision, the covalent bonds are broken and electron hole pairs are generated. These new charge carriers so produced acquire energy from applied potential and in turn produce additional carriers. This forms a cumulative process called avalanche multiplication that causes the reverse current to increase rapidly. This leads to breakdown of the junction known as avalanche breakdown

19. **How a transistor is used as a switch?**

A transistor should be operated in saturation and cutoff regions to use it as a switch. While operating in saturation region, transistor carry heavy current hence considered as ON state. In cutoff it doesn't carry current and it is equivalent to open.

20.Which configuration is known as emitter follower and why it is named so?

CC configuration is known as emitter follower, whatever may be the signal applied at the input, may produce same signal at the output. In other words, the gain of the circuit is unity. So that the common collector circuit - the so called emitter follower is named as emitter follower (output follows the input).

PART-B

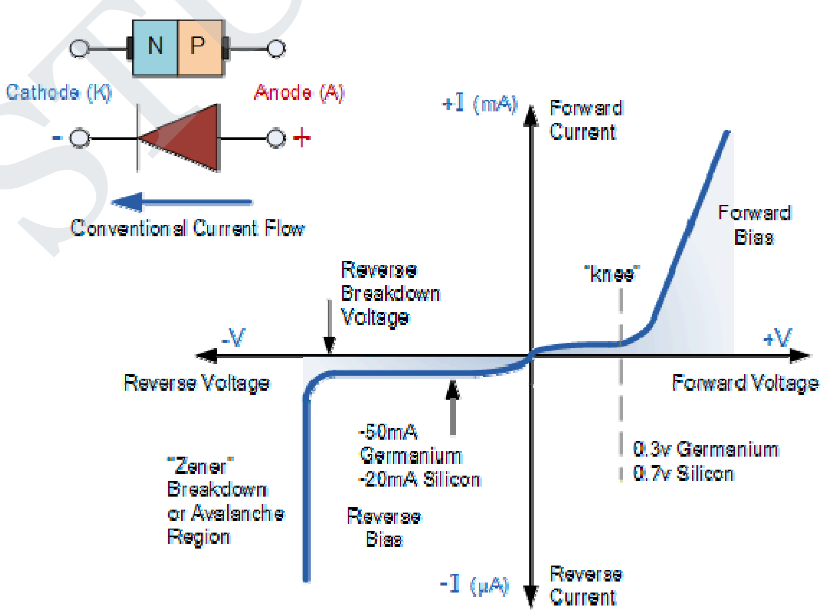
1. (i) With help of relevant circuit diagram explain the V-I characteristics of PN-Junction diode. (10)

A PN Junction Diode is one of the simplest Semiconductor Devices around, and which has the characteristic of passing current in only one direction only. However, unlike a resistor, a diode does not behave linearly with respect to the applied voltage as the diode has an exponential current-voltage (I-V) relationship and therefore we cannot described its operation by simply using an equation such as Ohm's law.

If a suitable positive voltage (forward bias) is applied between the two ends of the PN junction, it can supply free electrons and holes with the extra energy they require to cross the junction as the width of the depletion layer around the PN junction is decreased.

By applying a negative voltage (reverse bias) results in the free charges being pulled away from the junction resulting in the depletion layer width being increased. This has the effect of increasing or decreasing the effective resistance of the junction itself allowing or blocking current flow through the diode.

Then the depletion layer widens with an increase in the application of a reverse voltage and narrows with an increase in the application of a forward voltage. This is due to the differences in the electrical properties on the two sides of the PN junction resulting in physical changes taking place. One of the results produces rectification as seen in the PN junction diodes static I-V (current-voltage) characteristics. Rectification is shown by an asymmetrical current flow when the polarity of bias voltage is altered as shown below.



Forward Biased PN Junction Diode

When a diode is connected in a **Forward Bias** condition, a negative voltage is applied to the N-type material and a positive voltage is applied to the P-type material. If this external voltage becomes greater than the value of the

potential barrier, approx. 0.7 volts for silicon and 0.3 volts for germanium, the potential barriers opposition will be overcome and current will start to flow.
This is because the negative voltage pushes or repels electrons towards the junction giving them the energy to cross over and combine with the holes being pushed in the opposite direction towards the junction by the positive voltage. This results in a characteristics curve of zero current flowing up to this voltage point, called the "knee" on the static curves and then a high current flow through the diode with little increase in the external voltage.

Reverse Biased PN Junction Diode

When a diode is connected in a **Reverse Bias** condition, a positive voltage is applied to the N-type material and a negative voltage is applied to the P-type material.
The positive voltage applied to the N-type material attracts electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction towards the negative electrode.
The net result is that the depletion layer grows wider due to a lack of electrons and holes and presents a high impedance path, almost an insulator. The result is that a high potential barrier is created thus preventing current from flowing through the semiconductor material.

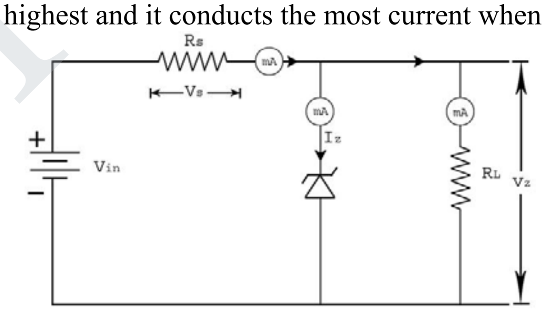
(ii) List out its major applications. (6)

- Can be used as rectifier in DC Power Supplies.
- In Demodulation or Detector Circuits.
- In clamping networks used as DC Restorers
- In clipping circuits used for waveform generation.
- As switches in digital logic circuits.

2.Draw and explain Zener Diode shunt voltage regulator with its line and load regulations.(16)

The function of a regulator is to provide a constant output voltage to a load connected in parallel with it in spite of the ripples in the supply voltage or the variation in the load current and the zener diode will continue to regulate the voltage until the diodes current falls below the minimum $I_{Z(min)}$ value in the reverse breakdown region. It permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above a certain value - the breakdown voltage known as the Zener voltage. The Zener diode specially made to have a reverse voltage breakdown at a specific voltage. Its characteristics are otherwise very similar to common diodes. In breakdown the voltage across the Zener diode is close to constant over a wide range of currents thus making it useful as a shunt voltage regulator.

The purpose of a voltage regulator is to maintain a constant voltage across a load regardless of variations in the applied input voltage and variations in the load current. A typical Zener diode shunt regulator is shown in Figure 3. The resistor is selected so that when the input voltage is at $V_{IN(min)}$ and the load current is at $I_{L(max)}$ that the current through the Zener diode is at least $I_{z(min)}$. Then for all other combinations of input voltage and load current the Zener diode conducts the excess current thus maintaining a constant voltage across the load. The Zener conducts the least current when the load current is the highest and it conducts the most current when the load current is the lowest.



a) Line Regulation

In this type of regulation, series resistance and load resistance are fixed, only input voltage is changing. Output voltage remains the same as long as the input voltage is maintained above a minimum value.

Percentage of line regulation can be calculated by = $\frac{\Delta V_0}{\Delta V_{IN}} * 100$

where V_0 is the output voltage and V_{IN} is the input voltage and ΔV_0 is the change in output voltage for a particular change in input voltage ΔV_{IN}.

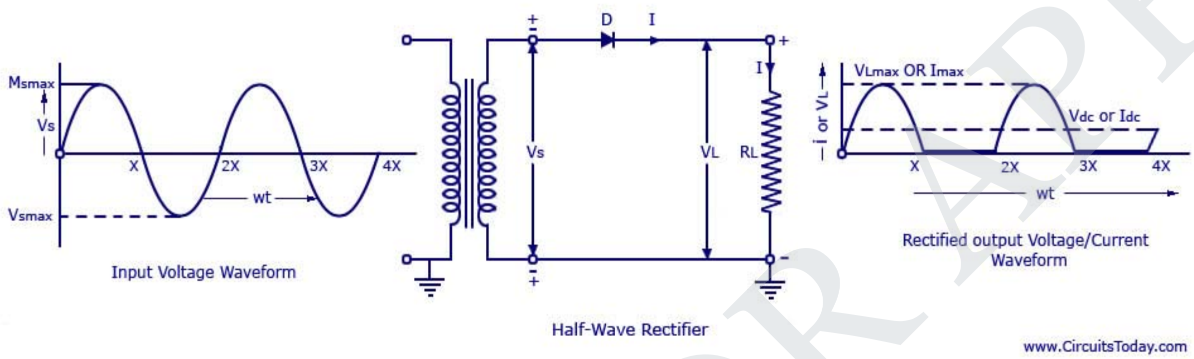
b) Load Regulation

In this type of regulation, input voltage is fixed and the load resistance is varying. Output volt remains same, as long as the load resistance is maintained above a minimum value.

Percentage of load regulation = $\left[\dfrac{V_{NL}-V_{FL}}{V_{NL}}\right]*100$

where V_{NL} is the null load resistor voltage (ie. remove the load resistance and measure the voltage across the Zener Diode) and V_{FL} is the full load resistor voltage

3.Explain Half wave rectifier with suitable circuit diagram and derive its efficiency, ripple factor, TUF and PIV. (16)



The process of rectification is converting alternating current (AC) to direct current (DC). A pn junction diode conducts current only when it is forward biased. The same principle is made use of in a half wave rectifier to convert AC to DC. This input voltage is stepped down using a transformer. The reduced voltage is fed to the diode 'D' and load resistance RL. During the positive half cycles of the input wave, the diode 'D' will be forward biased and during the negative half cycles of input wave, the diode 'D' will be reverse biased. We take the output across load resistor RL. Since the diode passes current only during one half cycle of the input wave, we get an output as shown in diagram. The output is positive and significant during the positive half cycles of input wave. At the same time output is zero or insignificant during negative half cycles of input wave. This is called ***half wave rectification.***

1.**Peak Inverse Voltage (PIV)**

Peak Inverse Voltage (PIV) rating of a diode is the maximum voltage that the rectifying diode has to withstand, during the reverse biased period.When the diode is reverse biased, during the negative half cycle, there will be no current flow through the load resistor RL. Hence, there will be no voltage drop through the load resistance RL which causes the entire input voltage to appear across the diode. Thus V_{SMAX}, the peak secondary voltage, appears across the diode. Therefore,Peak Inverse Voltage (PIV) of half wave rectifier = V_{SMAX}

2. Average and Peak Currents in the diode

By assuming that the voltage across the transformer secondary be sinusoidal of peak values V_{SMAX}, instantaneous value of the voltage given to the rectifier can be written as

$$Vs = V_{SMAX} \operatorname{Sin} wt$$

Instantaneous value of voltage applied to Half Wave Rectifier

Assuming that the diode has a forward resistance of RF ohms and infinite reverse resistance value, the current flowing through the output load resistance RL is

$i = I_{MAX} \sin wt$ for the period $0 <= wt <= \pi$

$i = 0$ for the period $\pi \le wt \le 2\pi$

Current flowing through the diode

$I_{MAX} = V_{SMAX}/(R_F + R_L)$

3. DC Output Current

The dc output current is given as

$I_{dc} = 1/2pi \int_0^{2\pi} i\, d(wt) = 1/2\pi\, [\int_0^{\pi} Imax\, Sin\, wt d(wt) + \int_0^{2\pi} 0\, d(wt)]$

$= I_{MAX}/pi = 0.318\, I_{MAX}$

DC Output Current of Half Wave Rectifier

Substituting the value of I_{MAX} for the equation $I_{MAX} = V_{SMAX}/(R_F + R_L)$, we have

$I_{dc} = V_{SMAX}/ = V_{SMAX}/ R_L$ **if** $R_L >> R_F$

4. DC Output Voltage

Dc value of voltage across the load is given by

$V_{dc} = I_{dc} R_L = V_{SMAX}/\mathbf{pi}(R_F + R_L) X R_L = V_{SMAX}/\{1+R_{F/RL}\}$

If $R_L >> R_F$, $V_{dc} = V_{SMAX}/\mathbf{pi}$

5. Root Mean Square (RMS) Value of Current

RMS value of current flowing through the diode is given as

$I^2_{rms} = 1/2\pi \int_0^{2\pi} i2\, d(wt) = I^2_{MAX}/4$ or $I_{rms} = I_{max}/2$

Substituting the value of I_{max} for the equation $I_{MAX} = V_{SMAX}/(R_F + R_L)$, we get

$I_{rms} = V_{SMAX}/2(R_F + R_L)$

RMS value of current flowing through diode in half wave rectifier

6. Root Mean Square (RMS) Value of Output Voltage

RMS value of voltage across the load is given as

$V_{Lrms} = I_{rms} R_L = V_{SMAX} R_L /2(R_F + R_L) = V_{SMAX}/\mathbf{2}\{1+R_{F/RL}\}$

If $R_L >> R_F$, $V_{Lrms} = V_{SMAX}/\mathbf{2}$

7. Rectification Efficiency

Rectification efficiency is defined as the ratio between the output power to the ac input power.

Efficiency, η = DC power delivered to the load/AC input power from the transformer = P_{dc}/P_{ac}

DC power delivered to the load, $P_{dc} = I^2_{dc} R_L = (I_{max/pi})^2 R_L$

AC power input to the transformer, P_{ac} = Power dissipated in diode junction + Power dissipated in load resistance R_L

$= I^2_{rms} R_F + I^2_{rms} R_L = \{I^2_{MAX}/4\}[R_F + R_L]$

So, Rectification Efficiency, $\eta = P_{dc}/P_{ac} = \mathbf{\{4/^2\}}[R_L/(R_F + R_L)] = \mathbf{0.406}/\{1+R_{F/RL}\}$

The maximum efficiency that can be obtained by the half wave rectifier is 40.6%. This is obtained if R_F is neglected.

8. Ripple Factor

Ripple factor is the measure of remaining alternating components in a filtered rectifier output. It is the ratio of the effective value of the ac components of voltage (or current) present in the output from the rectifier to the dc component in output voltage (or current).

The effective value of the load current is given as

$I^2 = I^2_{dc} + I^2_1 + I^2_2 + I^2_4 = I^2_{dc} + I^2_{ac}$

Where, I_1, I_2, I_4 and so on are the rms values of fundamental, second, fourth and so on harmonics and I^2_{ac} is the sum of the squares if the rms values of the ac components.

So, ripple factor, $\gamma = I_{ac}/ I_{dc} = I^2 - I^2_{dc})/ I_{dc} = \{(I_{rms}/ I_{dc}{}^2)-1\} = K_f^2 - 1)$

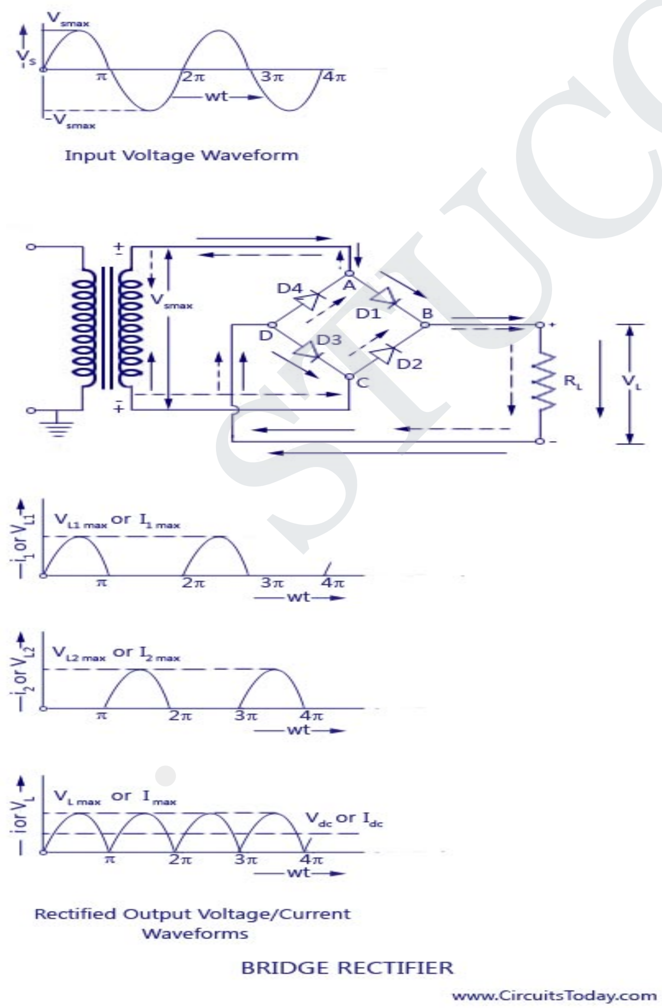
Where K_f is the form factor of the input voltage. For half wave rectifier, form factor is given as
$K_f = I_{rms} / I_{avg} = (I_{max}/2) / (I_{max}/pi) = pi/2 = 1.57$
So, ripple factor, $\gamma = (1.57^2 - 1) = 1.21$
Transformer Utilization Factor:
Transformer Utilization Factor (TUF)While designing any power supply, it is necessary to determine the rating or the transformer. It can be done provided TUF is known. The value of TUF depends on the amount of power to be delivered to the load and the type of rectifier circuit to be used.

$$TUF = \text{dc power delivered to the load / ac rating of transformer secondary}$$
$$= P_{dc}/P_{ac.rated}$$
$$= P_{dc}/P_{in.rated}$$

The rating of the transformer secondary is different from the actual power delivered by the secondary.
$P_{dc} = V_{L(dc)}.I_{L(dc)}$
$= V_{LM}/\pi \,.\, VLM/R_L$
$= V_{LM}^2 / \pi R_L$
$= V_{sm}^2 / \pi R_L$ – if drop over R_0 is neglected
Now, the rated voltage of transformer secondary is $V_{sm}/\sqrt{2}$ but actual current flowing through the secondary is $I_L = I_{LM}/2$ (and not $I_{LM}/\sqrt{2}$) since it is a Half-Wave rectifier current.

$$P_{ac.rated} = V_{sm}/\sqrt{2} \,.I_{LM}/2$$
$$= V_{sm}/\sqrt{2} \,.\, V_{LM}/2R_L$$
$$= V_{sm}/2\sqrt{2}R_L$$
$$TUF = (V_{sm}^2/\pi R_L)/(V_{sm}^2/2\sqrt{2}R_L)$$
$$= 2\sqrt{2}/\pi$$
$$= 0.287$$

4. Explain Bridge rectifier with suitable circuit diagram and derive its efficiency, ripple factor, TUF and PIV. (16)



During first half cycle of the input voltage, the upper end of the transformer secondary winding is positive with respect to the lower end. Thus during the first half cycle diodes D1 and D_3 are forward biased and current flows through arm AB, enters the load resistance R_L, and returns back flowing through arm DC. During this half of each input cycle, the diodes D_2 and D_4 are reverse biased and current is not allowed to flow in arms AD and BC.
During second half cycle of the input voltage, the lower end of the transformer secondary winding is positive with respect to the upper end. Thus diodes D_2 and D_4 become forward biased and current flows through arm CB, enters the load resistance R_L, and returns back to the source flowing through arm DA. Thus the direction of flow of current through the load resistance R_L remains the same during both half cycles of the input supply voltage. **1.PIV:**
PIV of a bridge rectifier = Vmax (max of secondary voltage)

Output Current

Since the current is the same through the load resistance RL in the two halves of the ac cycle, magnitude od dc current Idc, which is equal to the average value of ac current, can be obtained by integrating the current i1 between 0 and pi or current i2 between pi and 2pi.

$$\text{So } I_{dc} = 1/\pi \int_0^{\pi} i1\, d(wt) = 1/\pi \left[\int_0^{\pi} Imax\, Sin wt d(wt)\right] = 2I_{MAX}/\pi$$

Output Current of Full Wave Rectifier

3. DC Output Voltage

Average or dc value of voltage across the load is given as

$$Vdc = Idc\, R_L = 2/\pi\, Imax\, R_L$$

DC Output Voltage of Full Wave Rectifier

4. Root Mean Square (RMS) Value of Current

RMS or effective value of current flowing through the load resistance R_L is given as

$$I^2_{rms} = 1/\pi \int_0^{\pi} i1^2\, d(wt) = I^2_{MAX}/2 \text{ or } I_{rms} = I_{max}/\sqrt{2}$$

RMS Value of Current of Full Wave Rectifier

5. Root Mean Square (RMS) Value of Output Voltage

RMS value of voltage across the load is given as

$$V_L rms = Irms\, R_L = [Imax/\sqrt{2}]\, R_L$$

RMS Value of Output Voltage of Full Wave Rectifier

6. Rectification Efficiency

Power delivered to load,

$P_{dc} = I^2_{dc} R_L = (2I_{max}/\pi)^2 R_L = (4/\pi^2) I^2_{MAX} R_L$

AC power input to the transformer, P_{ac} = Power dissipated in diode junction + Power dissipated in load resistance R_L

$= I^2_{rms} R_F + I^2_{rms} R_L = \{I^2_{MAX}/2\}[R_F + R_L]$

So, Rectification Efficiency, $\eta = P_{dc}/P_{ac} = \{(4/\pi^2) I^2_{MAX} R_L\}/\{I^2_{MAX}/2\}[R_F + R_L]$

$= \{0.812/(1 + R_F/R_L)\}$

In case of bridge rectifier, $\eta = \{0.812/(1 + 2R_F/R_L)\}$

Rectification Efficiency of Full Wave Rectifier

7. Ripple Factor

Form factor of the rectified output voltage of a full wave rectifier is given as

$$K_f = I_{rms}/I_{avg} = (I_{max}/\sqrt{2})/(2I_{max}/\pi) = \frac{\pi}{2\sqrt{2}} = 1.11$$

Ripple Factor of Full Wave Rectifier

So, ripple factor, $\gamma = 1.11^2 - 1) = 0.482$

8.TUF

TUF = dc power delivered to the load/ac rating of transformer secondary

$= P_{dc}/P_{ac\,.\,rated}$

$= P_{dc}/P_{in.rated}$

$P_{dc} = V_{L(dc)}.I_{L(dc)}$

$= V_{LM}/\pi\ .\ VLM/R_L$

$= V_{LM}^2/\pi R_L$

$= V_{sm}^2/\pi R_L$ _ if drop over R_0 is neglected

Now, the rated voltage of transformer secondary is $\mathbf{V_{sm}/\sqrt{2}}$ but actual current flowing through the secondary is $\mathbf{I_L = I_{LM}/2}$ (and not $\mathbf{I_{LM}/\sqrt{2}}$) since it is a Half-Wave rectifier current.

$P_{ac.rated} = V_{sm}/\sqrt{2}\ .I_{LM}/2$

$= V_{sm}/\sqrt{2}\ .\ V_{LM}/2R_L$

$= V_{sm}/2\sqrt{2}R_L$

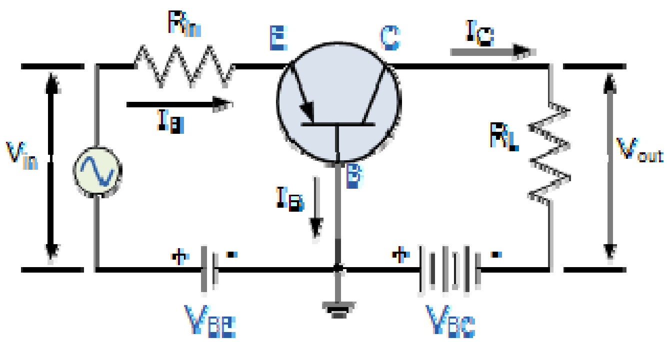
Its value is found by considering the primary and secondary winding of the transformer separately. Its value is **0.812** (as compared to **0.287** for a half-wave rectifier). In such a rectifier, there is no problem due to dc saturation of flux in the core because the dc current in the two halves of the secondary flow in opposite directions.

5.Draw the three configurations of a bipolar junction transistor and Compare CE , CB and CC configuration.(16)

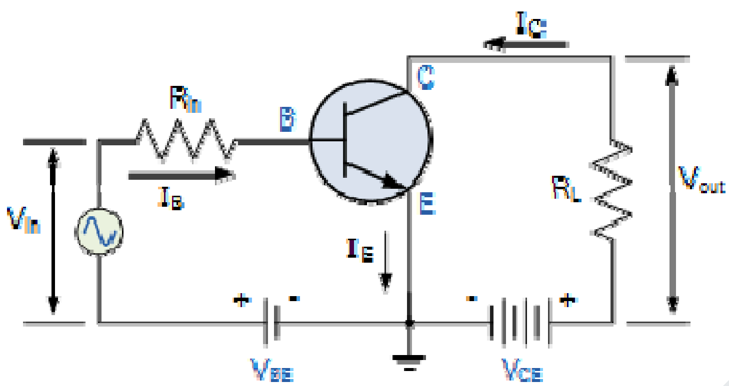
The **Bipolar Transistor** is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output.

- Common Base Configuration – has Voltage Gain but no Current Gain.
- Common Emitter Configuration – has both Current and Voltage Gain.
- Common Collector Configuration – has Current Gain but no Voltage Gain.

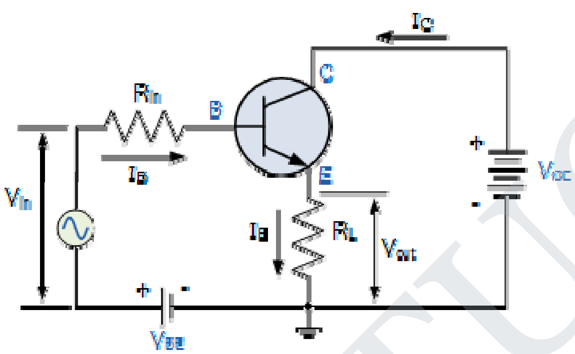
COMMOM BASE CONFIGURATION:



COMMOM EMITTER CONFIGURATION:

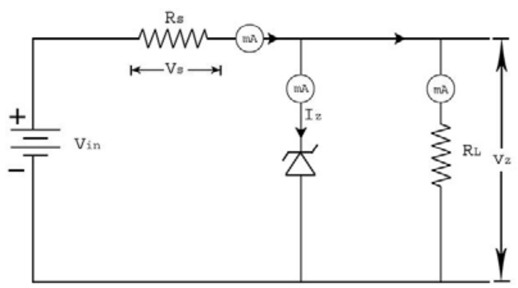


COMMOM COLLECTOR CONFIGURATION:



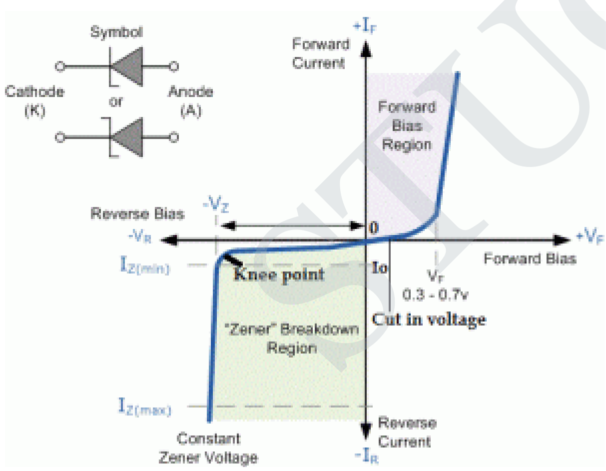
Characteristics	Common Base	Common Emitter	Common Collector
Input Dynamic Resistance	Very Low(less than 100 ohm)	Low(less than 1K)	Very High(750K)
Output dynamic resistance	Very High(less than 1M)	High(less than 45K)	Low(50 ohm)
Current Gain	Less than 1	High(100)	Very High(greater than 100)
Leakage Current	Very Small	Very Large	Very Large
Voltage Gain	About 150	About 500	Less than 1
Power Gain	Medium	Highest	Medium
Phase relation b/w i/p and o/p	In Phase	Out of Phase(180¤)	In Phase
Applications	For High Freq. apps	For Audio Freq. Apps	For impedence Matching Apps.

6. With help of relevant circuit diagram and V-I characteristics, show how a zener diode is used as a voltage regulator.



The function of a regulator is to provide a constant output voltage to a load connected in parallel with it in spite of the ripples in the supply voltage or the variation in the load current and the zener diode will continue to regulate the voltage until the diodes current falls below the minimum $I_{Z(min)}$ value in the reverse breakdown region. It permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above a certain value - the breakdown voltage known as the Zener voltage. The Zener diode specially made to have a reverse voltage breakdown at a specific voltage. Its characteristics are otherwise very similar to common diodes. In breakdown the voltage across the Zener diode is close to constant over a wide range of currents thus making it useful as a shunt voltage regulator.

The purpose of a voltage regulator is to maintain a constant voltage across a load regardless of variations in the applied input voltage and variations in the load current. . The resistor is selected so that when the input voltage is at $V_{IN(min)}$ and the load current is at $I_{L(max)}$ that the current through the Zener diode is at least $I_{z(min)}$. Then for all other combinations of input voltage and load current the Zener diode conducts the excess current thus maintaining a constant voltage across the load. The Zener conducts the least current when the load current is the highest and it conducts the most current when the load current is the lowest.



Reverse breakdown of the Zener Diode operates in a region called Zener region. In this region the voltage across Zener diode remains constant but current changes depending on the supply voltage. Zener diode is operated in this region when it is being used as a voltage regulator.

7. Explain the mechanism of avalanche breakdown and zener breakdown.

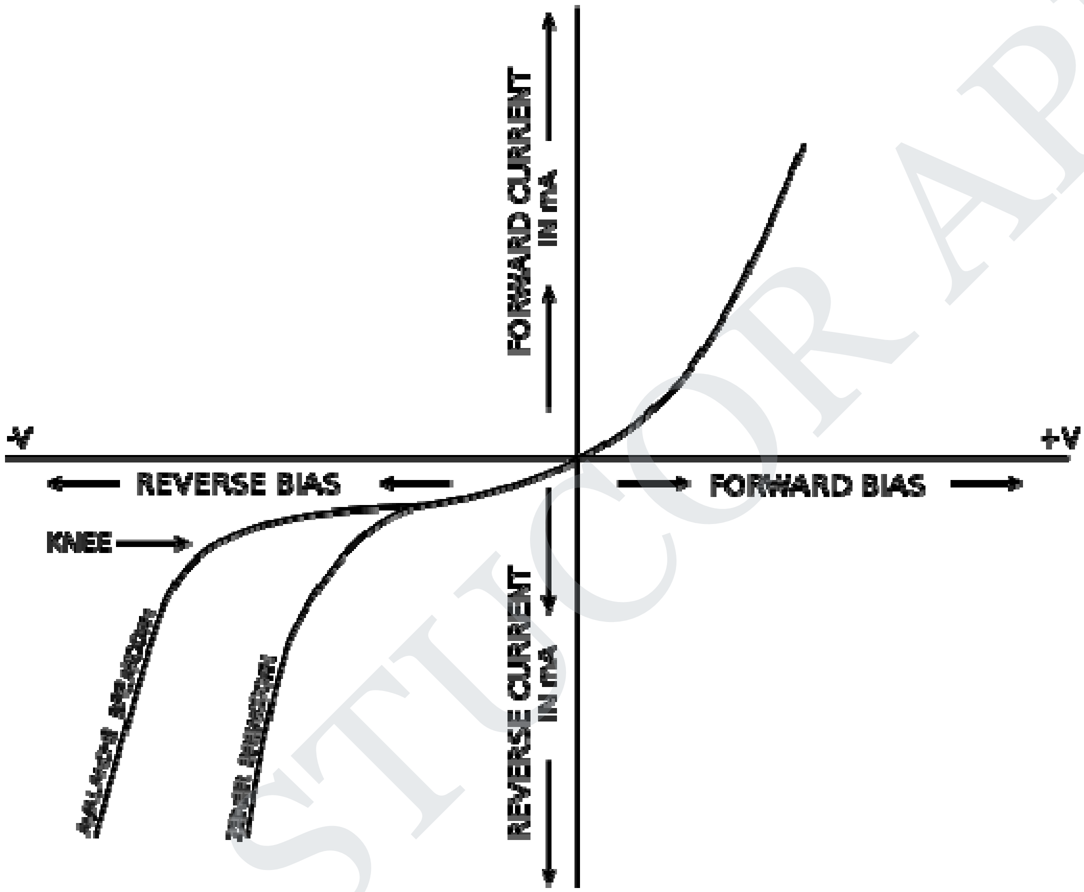
Avalanche Breakdown:

The avalanche breakdown takes place when both sides of the junction are lightly doped and due to this the depletion layer is large. When the reverse bias voltage is increased the accelerated free electrons collide with the semiconductor atoms in the depletion region Due to collision, the covalent bonds are broken and electron hole pairs are generated. These new charge carriers so produce acquire energy from applied potential and in turn produce additional carriers. This forms a cumulative process called avalanche multiplication ,this causes the reverse current to increase rapidly . This leads to breakdown of the junction known as avalanche breakdown.

Zener Breakdown:

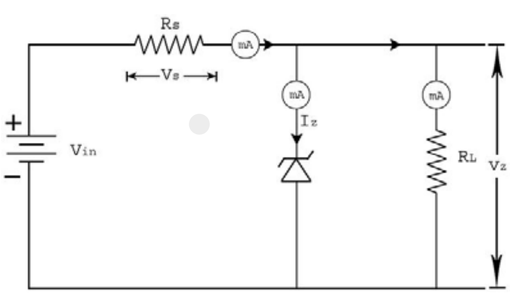
The **Zener effect** is a type of electrical breakdown in a reverse biased p-n diode in which the electric field enables tunneling of electrons from the valence to the conduction band of a semiconductor, leading to a large number of freeminority carriers, which suddenly increase the reverse current.[1] Zener breakdown is employed in a Zener diode.

Characteristics shows Avalanche and Zener Breakdown:



8. With neat diagrams explain how a voltage regulator circuits regulates the output voltage under the following conditions: (June 2013)

(i) Load resistance increases. (ii) Input voltage decreases.



The function of a regulator is to provide a constant output voltage to a load connected in parallel with it in spite of the ripples in the supply voltage or the variation in the load current and the zener diode will continue to regulate the voltage until the diodes current falls below the minimum $I_{Z(min)}$ value in the reverse breakdown region. It permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above a certain value - the breakdown voltage known as the Zener voltage. The Zener diode specially made to have a reverse voltage breakdown at a specific voltage. Its characteristics are otherwise very similar to common diodes. In breakdown the voltage across the Zener diode is close to constant over a wide range of currents thus making it useful as a shunt voltage regulator.

The purpose of a voltage regulator is to maintain a constant voltage across a load regardless of variations in the applied input voltage and variations in the load current. A typical Zener diode shunt regulator is shown in Figure 3. The resistor is selected so that when the input voltage is at $V_{IN(min)}$ and the load current is at $I_{L(max)}$ that the current through the Zener diode is at least $I_{z(min)}$. Then for all other combinations of input voltage and load current the Zener diode conducts the excess current thus maintaining a constant voltage across the load. The Zener conducts the least current when the load current is the highest and it conducts the most current when the load current is the lowest.

a) Line Regulation

In this type of regulation, series resistance and load resistance are fixed, only input voltage is changing. Output voltage remains the same as long as the input voltage is maintained above a minimum value.

Percentage of line regulation can be calculated by = $\frac{\Delta V_0}{\Delta V_{IN}} * 100$

where V_0 is the output voltage and V_{IN} is the input voltage and ΔV_0 is the change in output voltage for a particular change in input voltage ΔV_{IN}.

b) Load Regulation

In this type of regulation, input voltage is fixed and the load resistance is varying. Output volt remains same, as long as the load resistance is maintained above a minimum value.

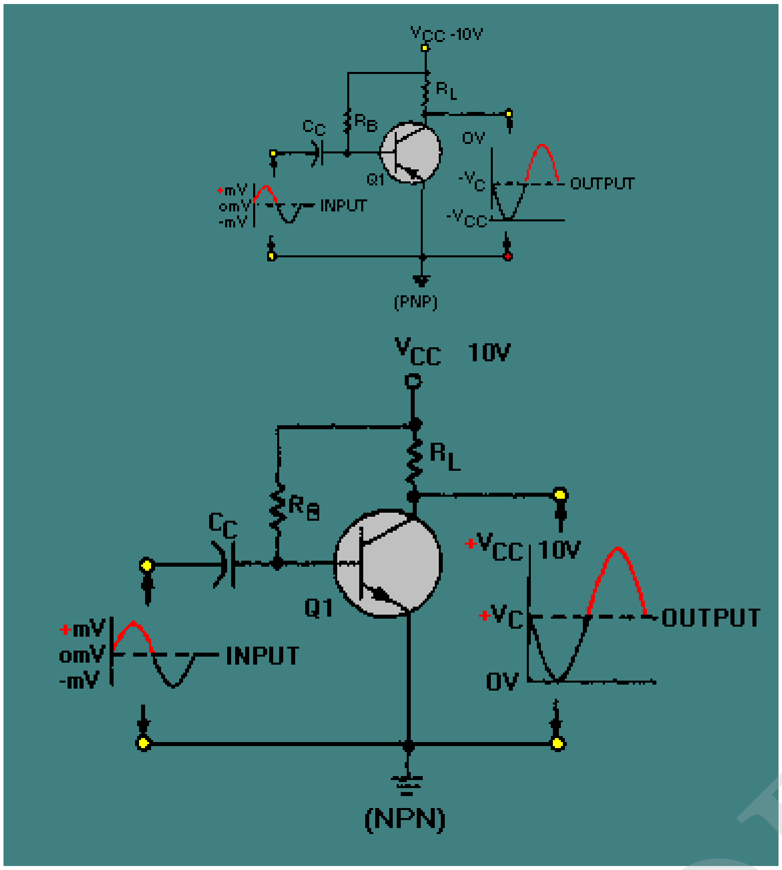
Percentage of load regulation = $\left[\frac{V_{NL} - V_{FL}}{V_{NL}}\right] * 100$

where V_{NL} is the null load resistor voltage (ie. remove the load resistance and measure the voltage across the Zener Diode) and V_{FL} is the full load resistor voltage

9.(i) Explain the amplifying action of a transistor. **(June 2013)**

Amplification is the process of increasing the strength of a SIGNAL. A signal is just a general term used to refer to any particular current, voltage, or power in a circuit. An amplifier is the device that provides amplification (the increase in current, voltage, or power of a signal) without appreciably altering the original signal.

Transistors are frequently used as amplifiers. Some transistor circuits are CURRENT amplifiers, with a small load resistance; other circuits are designed for VOLTAGE amplification and have a high load resistance; others amplify POWER.



With Q1 properly biased, direct current flows continuously, with or without an input signal, throughout the entire circuit. The direct current flowing through the circuit develops more than just base bias; it also develops the collector voltage (V_C) as it flows through Q1 and R_L. Notice the collector voltage on the output graph. Since it is present in the circuit without an input signal, the output signal starts at the V_C level and either increases or decreases. These dc voltages and currents that exist in the circuit before the application of a signal are known as QUIESCENT voltages and currents (the quiescent state of the circuit).
Resistor R_L, the collector load resistor, is placed in the circuit to keep the full effect of the collector supply voltage off the collector. This permits the collector voltage (V_C) to change with an input signal, which in turn allows the transistor to amplify voltage. Without R_L in the circuit, the voltage on the collector would always be equal to V_{CC}.
The coupling capacitor (C_C) is another new addition to the transistor circuit. It is used to pass the ac input signal and block the dc voltage from the preceding circuit. This prevents dc in the circuitry on the left of the coupling capacitor from affecting the bias on Q1. The coupling capacitor also blocks the bias of Q1 from reaching the input signal source.
The input to the amplifier is a sine wave that varies a few millivolts above and below zero. It is introduced into the circuit by the coupling capacitor and is applied between the base and emitter. As the input signal goes positive, the voltage across the emitter-base junction becomes more positive. This in effect increases forward bias, which causes base current to increase at the same rate as that of the input sine wave. Emitter and collector currents also increase but much more than the base current. With an increase in collector current, more voltage is developed across R_L. Since the voltage across R_L and the voltage across Q1 (collector to emitter) must add up to V_{CC}, an increase in voltage across R_L results in an equal decrease in voltage across Q1. Therefore, the output voltage from the amplifier, taken at the collector of Q1 with respect to the emitter, is a <u>negative</u> alternation of voltage that is <u>larger</u> than the input, but has the same sine wave characteristics.
During the negative alternation of the input, the input signal opposes the forward bias. This action decreases base current, which results in a decrease in both emitter and collector currents. The decrease in current through R_L decreases its voltage drop and causes the voltage across the transistor to rise along with the output voltage. Therefore, the output for the negative alternation of the input is a <u>positive</u> alternation of voltage that is <u>larger</u> than the input but has the same sine wave characteristics.
By examining both input and output signals for one complete alternation of the input, we can see that the output of the amplifier is an exact reproduction of the input except for the <u>reversal in polarity</u> and the <u>increased amplitude</u> (a few millivolts as compared to a few volts).

(ii) In a CE I_B changes from 100µA to 150µA which causes a change in I_c from 5mA to 7.5mA.if V_{CE} held constant at 10 volt, find β_{ac} (h_{fe}). **(June 2013)**

Hfe = I_c / I_b

Ib = 150uA – 100uA

= 50uA

Ic = 7.5mA – 5mA

= 2.5mA

Hfe = 2.5 x10^{-3} / 50 x 10^{-6}

= 50

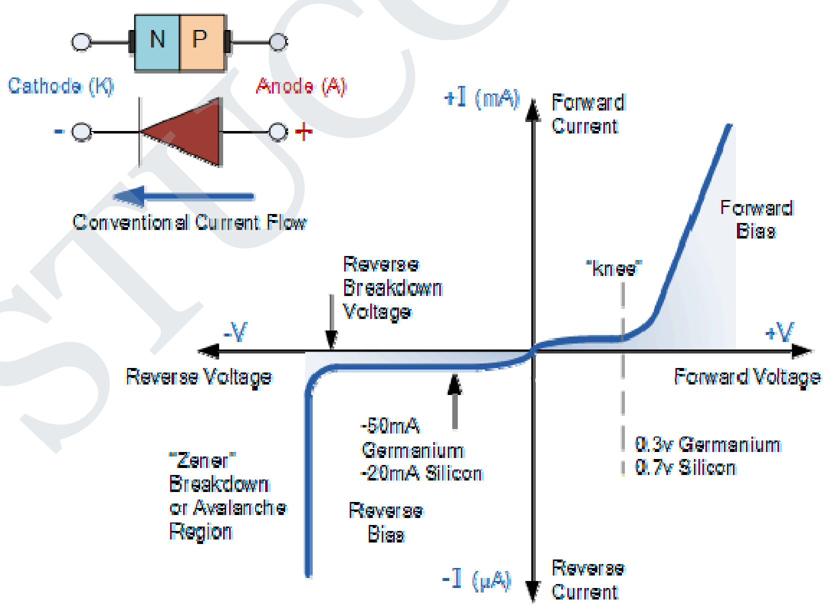
10. Describe the working of a PN junction diode with neat diagrams. Also explain its V-I characteristics.

A PN Junction Diode is one of the simplest Semiconductor Devices around, and which has the characteristic of passing current in only one direction only. However, unlike a resistor, a diode does not behave linearly with respect to the applied voltage as the diode has an exponential current-voltage (I-V) relationship and therefore we cannot described its operation by simply using an equation such as Ohm's law.

If a suitable positive voltage (forward bias) is applied between the two ends of the PN junction, it can supply free electrons and holes with the extra energy they require to cross the junction as the width of the depletion layer around the PN junction is decreased.

By applying a negative voltage (reverse bias) results in the free charges being pulled away from the junction resulting in the depletion layer width being increased. This has the effect of increasing or decreasing the effective resistance of the junction itself allowing or blocking current flow through the diode.

Then the depletion layer widens with an increase in the application of a reverse voltage and narrows with an increase in the application of a forward voltage. This is due to the differences in the electrical properties on the two sides of the PN junction resulting in physical changes taking place. One of the results produces rectification as seen in the PN junction diodes static I-V (current-voltage) characteristics. Rectification is shown by an asymmetrical current flow when the polarity of bias voltage is altered as shown below.



Forward Biased PN Junction Diode

When a diode is connected in a **Forward Bias** condition, a negative voltage is applied to the N-type material and a positive voltage is applied to the P-type material. If this external voltage becomes greater than the value of the potential barrier, approx. 0.7 volts for silicon and 0.3 volts for germanium, the potential barriers opposition will be overcome and current will start to flow.

This is because the negative voltage pushes or repels electrons towards the junction giving them the energy to cross over and combine with the holes being pushed in the opposite direction towards the junction by the positive voltage. This results in a characteristics curve of zero current flowing up to this voltage point, called the "knee" on the static curves and then a high current flow through the diode with little increase in the external voltage.

Reverse Biased PN Junction Diode

When a diode is connected in a **Reverse Bias** condition, a positive voltage is applied to the N-type material and a negative voltage is applied to the P-type material.
The positive voltage applied to the N-type material attracts electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction towards the negative electrode.
The net result is that the depletion layer grows wider due to a lack of electrons and holes and presents a high impedance path, almost an insulator. The result is that a high potential barrier is created thus preventing current from flowing through the semiconductor material.

Unit – IV Digital Electronics

PART A

1. **Convert $(1375)_{10} = (?)_8$**

ANS:

8| 1375
8| 171 – 7
8| 21 - 3
2 - 5

$= (2537)_8$

2. **Convert the following Hexadecimal to Decimal (a) 4C5 (b) 0.9E8**

ANS: (a)

$= 4 * 16^2 + 12 * 16^1 + 5 * 16^0$
$= (1217)_{10}$

(b)

$= 9 * 16^{-1} + 14 * 16^{-2} + 8 * 16^{-3}$
$= (1.18164)_{10}$

3. **Convert $(412)_{10}$ into Octal**

ANS:

8 | 412
8 | 51 – 4
6 – 3

$= (634)_8$

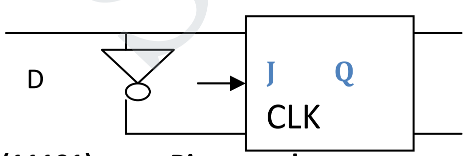
4. **Convert $(1259)_{10}$ into Hexadecimal**

ANS

16 | 1259
16 | 78 – 11
3 – 14

$= (3EB)_1$

5. **Show how JK Flip-flop can be converted to D flip-flop.**



6. **Convert $(11101)_{gray}$ to Binary code**

ANS: Binary Equivalent $= (10110)_2$

7. **What are Universal Gates? Why are they called so?**

Universal gates are NAND and NOR, they are called so because using these codes any logical gate or logical expression can be derived.

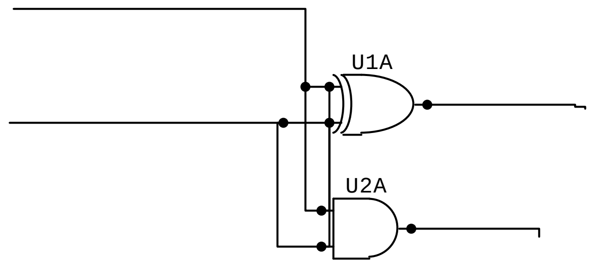
8. **Convert $FACE_{16}$ into Octal**

1111 1010 1100 1110
1 7 5 3 1 6

9 . **Draw the logic diagram and truth table for a half adder.**

AB	S	C
00	0	0
01	1	0
10	1	0
11	0	1

S = AB'+A'B
C = AB



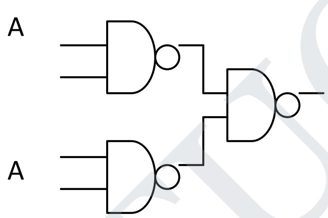
10. **Given that (456)$_r$ = (237)$_{10}$. Find r.**

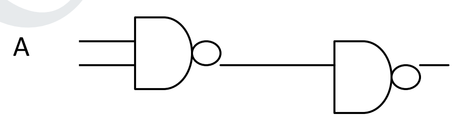
$4 X r^2+5 X r^1+6 X r^0 = 237$
$4r^2+5r+6 = 237$
$4r^2+5r-231 = 0$ r = $(-5\pm\sqrt{25+3696})/8 = (-5\pm61)/8 = 7,-8.25$ (roots)
The valid root is 7. So r = 7

11. **Reduce the expression** _
(AB)AB + AB

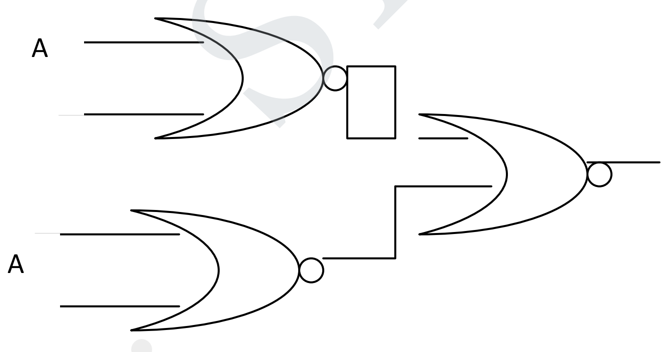
$=\bar{A}ABB + AB$ =0.B + AB =AB

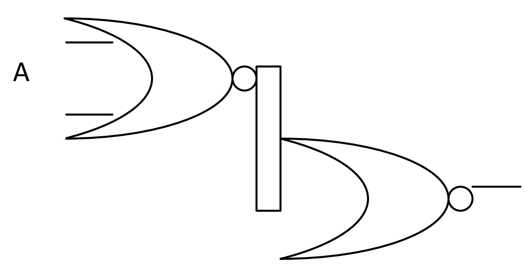
12. **Realise AND and OR gates using NAND gates**





13. **Realise AND and OR gates using NOR gates only**





AND Gate Implementation OR Gate Implementation

14. **State Distributive law**

The distributive law allows the factoring or multiplying out of expression.

The laws are a + (b.c) = (a+b).(a+c)
A(b+c) = (A.b) + (A.c)
a + (a'.b) = (a + b)

15. **Distinguish between combinational logic and sequential logic.**

Combinational Logic	Sequential Logic
A combinational circuit consists of logic gates whose outputs at ant time are determined directly from the present combination of inputs without regard to previous inputs.	Sequential circuits employ memory elements (binary cells) in addition to logic gates. Their outputs are a function of the inputs and the state of the memory elements
A combinational circuit performs a specific information – processing operation fully specified logically by a set of Boolean functions.	The state of the memory elements, in turn, is a function of previous inputs. As a consequence, the outputs of sequential circuit depend not only on present inputs, but also on past inputs, and the behavior must be specified by a time sequence of inputs and internal states

16.What is combinational and sequential circuit?

Combinational circuit is a system in which the output occurs directly and immediate Response to the input.

Sequential circuit includes the memory elements. So the present o/p depends not only on the present input and also on the previous o/p.

17. **Give the truth table of T flip flop.**

Q	T	Q(t+1)
0	0	0
0	1	1
1	0	1
1	1	0

18. **Mention the difference between asynchronous and synchronous counters.**

In an asynchronous counter, the flip flop o/p transition serves as a source for triggering other flip flops.

In a synchronous counter, the input pulses are applied to all cp inputs of all flip flops.

19. **What is a ripple counter?**

A ripple counter is one in which the FF o/p transition serves as a source for triggering other flip-flops.

20. **Mention the uses of shift register.**

1. To introduce time delay
2. Serial to parallel converter
3. Parallel to serial conversion
4. Sequence generator
5. Ring counter

PART-B

1. **What is a sequential circuit? Explain the operation of Clocked RS flip flop and JK flip flop with suitable logic diagram.** (16m)

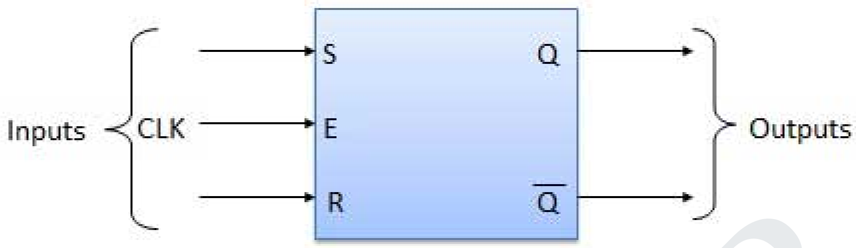
Sequential Circuit

A sequential circuit can be defined as a circuit whose output depends not only on the present inputs but also on the past history of inputs. (2m)

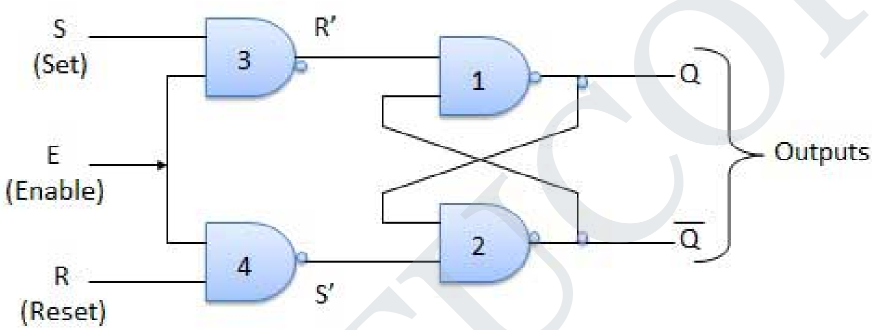
S-R Flip Flop(7m)

It is basically S-R latch using NAND gates with an additional enable input. It is also called as level triggered SR-FF. For this circuit in output will take place if and only if the enable input (E) is made active. In short this circuit will operate as an S-R latch if E= 1 but there is no change in the output if E = 0.

BLOCK DIAGRAM



CIRCUIT DIAGRAM



TRUTH TABLE

Inputs			Outputs		Comments
E	S	R	Q_{n+1}	$\overline{Q}_{n+1}$	
1	0	0	Q_n	$\overline{Q}_n$	No change
1	0	1	0	1	Rset
1	1	0	1	0	Set
1	1	1	x	x	Indeterminate

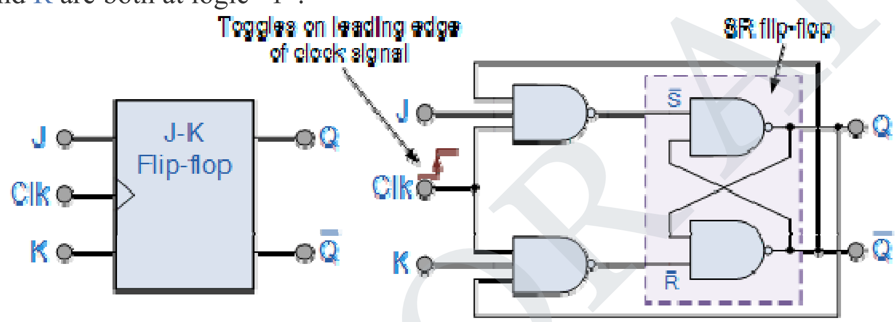
OPERATION

S.N.	Condition	Operation
1	**S = R = 0 : No change**	If S = R = 0 then output of NAND gates 3 and 4 are forced to become 1. Hence R' and S' both will be equal to 1. Since S' and R' are the input of the basic S-R latch using NAND gates, there will be no

		change in the state of outputs.
2	**S = 0, R = 1, E = 1**	Since S = 0, output of NAND-3 i.e. R' = 1 and E = 1 the output of NAND-4 i.e. S' = 0. Hence Q_{n+1} = 0 and Q_{n+1} bar = 1. This is reset condition.
3	**S = 1, R = 0, E = 1**	Output of NAND-3 i.e. R' = 0 and output of NAND-4 i.e. S' = 1. Hence output of S-R NAND latch is Q_{n+1} = 1 and Q_{n+1} bar = 0. This is the reset condition.
4	**S = 1, R = 1, E = 1**	As S = 1, R = 1 and E = 1, the output of NAND gates 3 and 4 both are 0 i.e. S' = R' = 0. Hence the **Race** condition will occur in the basic NAND latch.

JK Flip Flop(7m)

JK flip Flop is the most widely used of all the flip-flop designs and is considered to be a universal flip-flop circuit. The sequential operation of the JK flip flop is exactly the same as for the previous SR flip-flop with the same "Set" and "Reset" inputs. The difference this time is that the "JK flip flop" has no invalid or forbidden input states of the SR Latch even when S and R are both at logic "1".



Symbol Circuit

Inputs			Outputs		Comments
E	J	K	Q_{n+1}	$\bar{Q}_{n+1}$	
1	0	0	Q_n	$\bar{Q}_n$	No change
1	0	1	0	1	Rset
1	1	0	1	0	Set
1	1	1	$\bar{Q}_n$	Q_n	Toggle

OPERATION

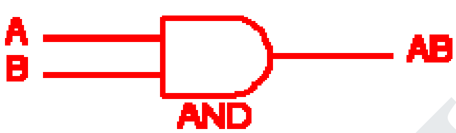
S.N.	Condition	Operation
1	**J = K = 0 (No change)**	When clock = 0, the slave becomes active and master is inactive. But since the S and R inputs have not changed, the slave outputs will also remain unchanged. Therefore outputs will not change if J = K =0.
2	**J = 0 and K = 1 (Reset)**	Clock = 1: Master active, slave inactive. Therefore outputs of the master become Q_1 = 0 and Q_1 bar = 1. That means S = 0 and R =1. Clock = 0: Slave active, master inactive Therefore outputs of the slave become Q = 0 and Q bar = 1. Again clock = 1: Master active, slave inactive. Therefore even with the changed outputs Q = 0 and Q bar = 1 fed back to master, its outputs will Q1 = 0 and Q1 bar = 1. That means S = 0 and R = 1.

		Hence with clock = 0 and slave becoming active the outputs of slave will remain Q = 0 and Q bar = 1. Thus we get a stable output from the Master slave.
3	**J = 1 and K = 0 (Set)**	Clock = 1: Master active, slave inactive. Therefore outputs of the master become Q_1 = 1 and Q_1 bar = 0. That means S = 1 and R =0. Clock = 0: Slave active, master inactive Therefore outputs of the slave become Q = 1 and Q bar = 0. Again clock = 1: then it can be shown that the outputs of the slave are stabilized to Q = 1 and Q bar = 0.
4	**J = K = 1 (Toggle)**	Clock = 1: Master active, slave inactive. Outputs of master will toggle. So S and R also will be inverted. Clock = 0: Slave active, master inactive. Outputs of slave will toggle. These changed output are returned back to the master inputs. But since clock = 0, the master is still inactive. So it does not respond to these changed outputs. This avoids the multiple toggling which leads to the race around condition. The master slave flip flop will avoid the race around condition.

2. Explain about various logic gate with suitable symbols and truth tables. (16m)

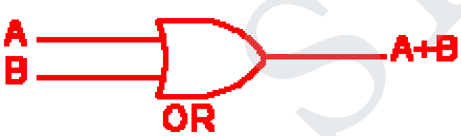
Logic gates

AND gate(2m)



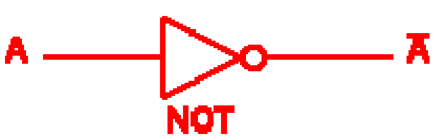
2 Input AND gate		
A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

OR gate(2m)



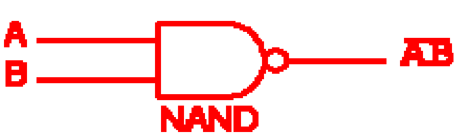
2 Input OR gate		
A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

NOT gate(2m)



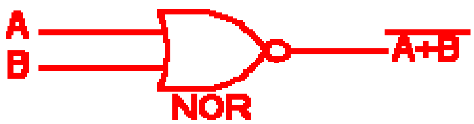
NOT gate	
A	$\overline{A}$
0	1
1	0

NAND gate(3m)



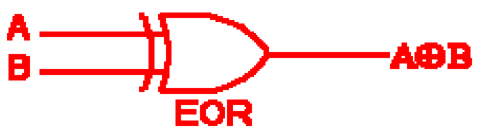
2 Input NAND gate		
A	B	$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

NOR gate(3m)



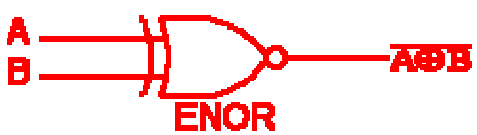
2 Input NOR gate		
A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

EXOR gate(2m)



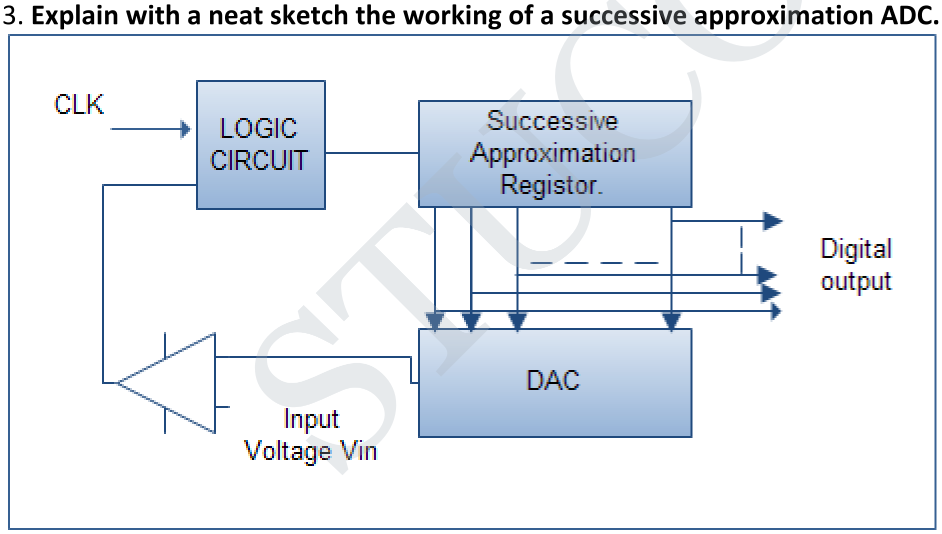
2 Input EXOR gate		
A	B	$A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

EXNOR gate(2m)



2 Input EXNOR gate		
A	B	$\overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

3. **Explain with a neat sketch the working of a successive approximation ADC. (16m)**



(8m)

Explain the working operation of suucessive approximation ADC (8m).

4. Use De – Morgan's theorem to simplify the following expression Y = ((AB)'+ A'+ AB)' = 0. (8m)

SOLUTION:

((AB)'+A'+AB)' = ((AB)')' ((A)')' (AB)'

= (AB) (A) (A'+B')

= B (A.A) (A'+B')

= AB (A'+B')

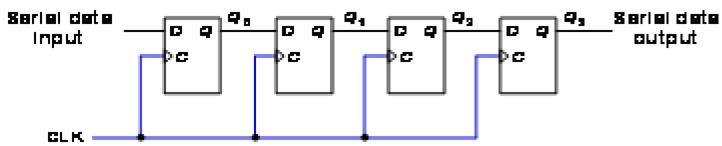
=ABA'+ABB'

=0 (8m)

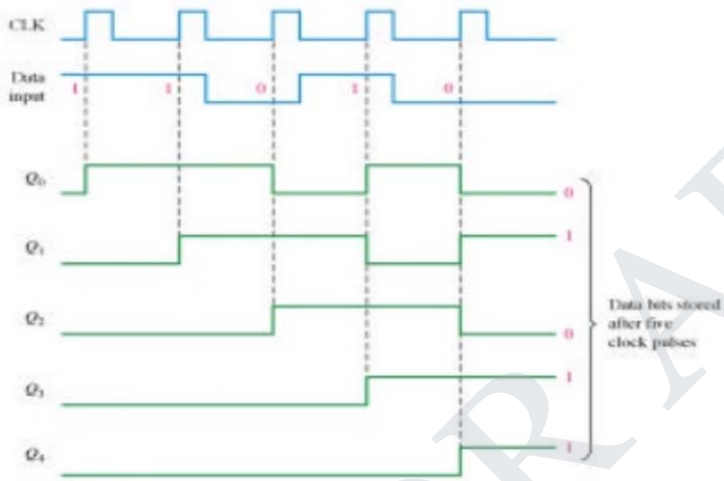
5. **With neat logic & timing diagrams explain the operation of a 4 – bit SISO Shift register. (8m)**

Serial In/Serial Out Shift Registers

- Accepts data serially – one bit at a time – and also produces output serially.



(4m)



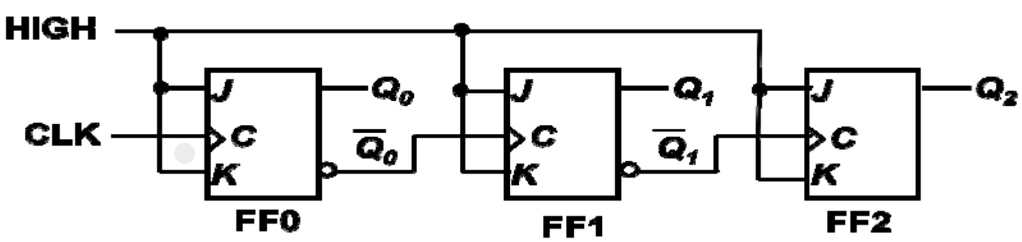
(4m)

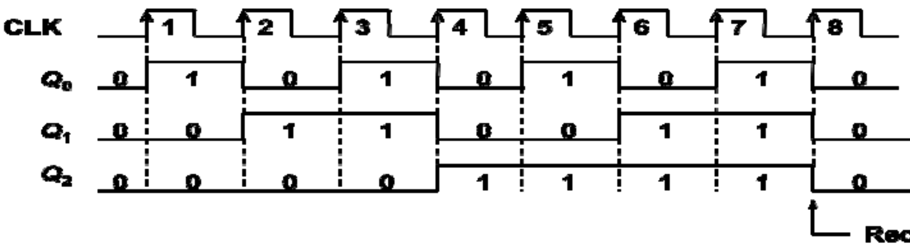
6. With neat diagrams explain the operation of a 4 – bit asynchronous counter. (8m)

- Counters are circuits that cycle through a specified number of states.
- Two types of counters:
  - synchronous (parallel) counters
  - asynchronous (ripple) counters
- Ripple counters allow some flip-flop outputs to be used as a source of clock for other flip-flops.
- Synchronous counters apply the same clock to all flip-flops. (2m)

- Asynchronous counters: the flip-flops do not change states at exactly the same time as they do not have a common clock pulse.
- Also known as ripple counters, as the input clock pulse "ripples" through the counter – cumulative delay is a drawback.
- *n* flip-flops → a MOD (modulus) 2^n counter. (Note: A MOD-*x* counter cycles through *x* states.)
- Output of the last flip-flop (MSB) divides the input clock frequency by the MOD number of the counter, hence a counter is also a *frequency divider*.

  Example: 3-bit ripple binary counter (2m)





(4m)

7. **Draw a logic circuit for the function F=AB+ABC+AB (D+E) and simplify the expression. (8m)**

$F = AB + ABC + AB(D+E)$

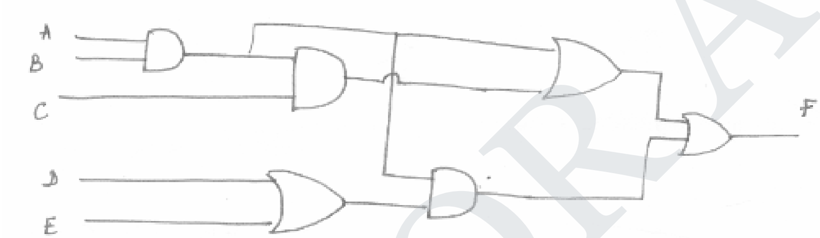
$= AB(1+C) + AB(D+E)$

$= ABC + AB(D+E)$

$= AB[C+D+E]$

(4m)

Logic circuit for $F = AB + ABC + AB(D+E)$

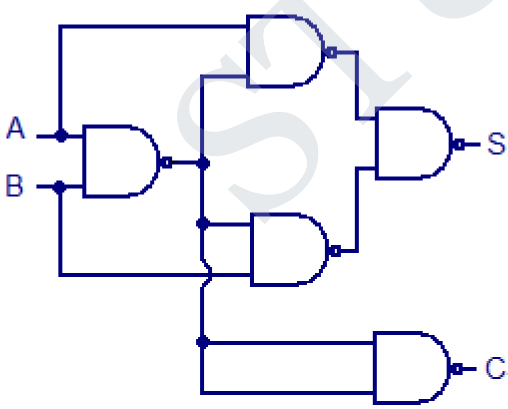


(4m)

8. **What is a combinational circuit? Explain the operation of Half and Full Adder circuit and Implement the sum and carry using NAND gate. (16m) (May2013)**

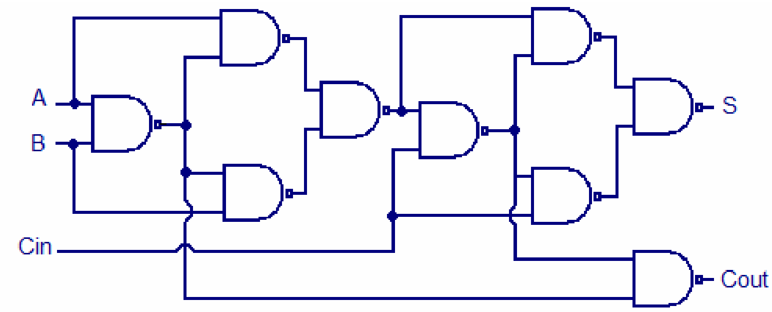
Combinational Circuit (4m)

A combinational circuit can be defined as a circuit whose output is dependent only on the inputs at the same instant of time



Half adder using NAND logic

(4m)



Full adder using NAND logic (8m)

9. **(i) Reduce the following expressions using Boolean Algebra.** **(June 2013)**

Y=A'B'C'+A'B'C+AB'C'+ABC.

Y= [(A+B)'+C']'. (8m)

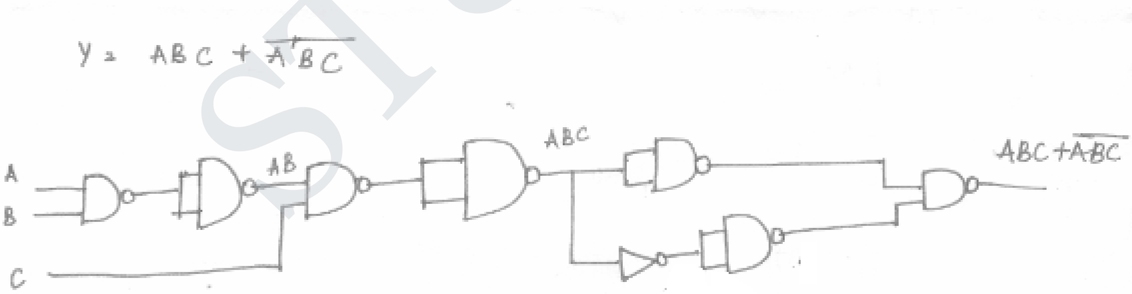
SOLUTION:

i. Y=A'B'C'+A'B'C+AB'C'+ABC
   =A'B' (C+C') + A (B'C'+BC)
   Y=A'B'+A (4m)

ii. Y= [(A+B)'+C']'
   = [(A+B)']' [C']'
   = (A+B) C (4m)

(ii)**Realize the given expression using only NAND gates and Inverters.** **(June 2013)**

Y=ABC+A'B'C'. (8m)



(8m)

(iii) Design a Full Adder, construct the truth table, simplify the output equations and draw the Logic Diagram. (8m)

Truth Table:

X	Y	CIn	S	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

(4m)

K-MAP:

Sum

YZ \ X	0	1
00	0_0	1_4
01	1_1	0_5
11	0_3	1_7
10	1_2	0_6

Carry

YZ \ X	0	1
00	0_0	0_4
01	0_1	1_5
11	1_3	1_7
10	0_2	1_6

Z

(4m)

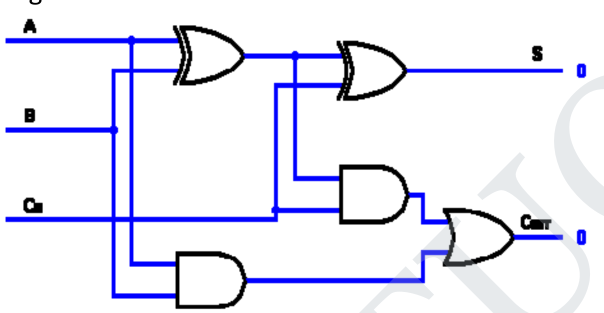
- **Using K-map, simplified SOP form is:**

$$C = XY + XZ + YZ$$

$$S = X'Y'Z + X'YZ' + XY'Z' + XYZ$$

(4m)

Logic Circuit:



(4m)

10. **(i) Give a brief explanation of an A/D Conversion and the need for the A/D conversions. (8m)**

An analog-to-digital converter (ADC, A/D, or A to D) is a device that converts a continuous physical quantity (usually voltage) to a digital number that represents the quantity's amplitude.

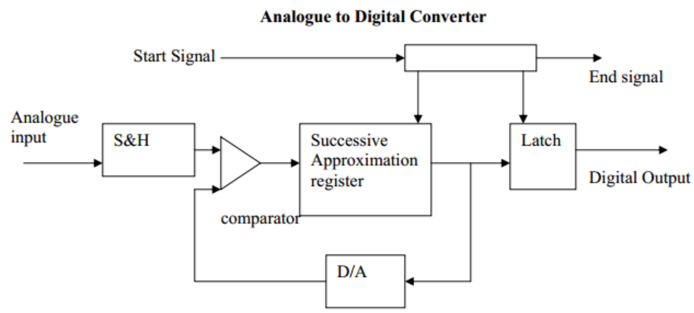
Types

- Flash ADC
- Dual Slope (integrating) ADC
- Successive Approximation ADC (4m)

A/D Applications

- Microphones
- Thermocouple – temperature measuring device converts thermal energy to electric energy
- Voltmeters
- Digital Multimeters

Example of an A/D converter:



(4m)

(ii) Convert 95.0625_{10} to binary. (8m) **(June 2013)**

SOLUTION:

i. 95 is divided progressively by 2 until the quotient zero is obtained. Then the remainders after each division in the reverse order gives the binary number.
   (i.e). $(95)_{10} = (1011111)_2$
   $(0.0625)_{10}$
   0.0625 x 2 = 0.125
   0.125 x 2 = 0.25
   0.25 x 2 = 0.5
   0.5 x 2 = 1.00
   Thus $(0.0625)_{10} = (0.0001)_2$
   $95.0625_{10} = (1011111.0001)_2$

Unit V- Communication Engineering

PART-A

1. Define Modulation.
   The process of varying any one parameter of the high frequency carrier wave in accordance with the modulating or message signal is known as modulation.
2. What is the need for modulation?
   Reduction in height of the antenna, Multiplexing, Adjustment of bandwidth, Avoid mixing of signals, Easy to transmit.
3. Distinguish between AM and FM.

Sl.No	AM	FM
1	Amplitude of the carrier is varied in accordance to the amplitude of the modulating signal.	Frequency of the carrier is varied in accordance to the amplitude of the modulating signal.
2	AM has very poor fidelity due to narrow bandwidth.	Since the bandwidth is larger fidelity is better.
3	In AM only carrier and two side bands are present.	Infinite number of side bands are present.

4. Define AM.
   The process by which Amplitude of the carrier wave is varied in accordance with the amplitude if the modulating or message signal.
5. Define modulation index for an AM wave.
   In AM wave, the modulation index(ma) is defined as the ratio of maximum amplitude of modulating signal to maximum amplitude of carrier signal.

$$m_a = V_m/V_c$$

Here the envelope of the modulated signal just reaches the zero amplitude axis. Hence the message signal is fully preserved in the envelope of the AM wave. An envelope detector can recover the message without any distortion.

AM wave with $m_a <$ I,e.,$V_m < V_C$

6.What is over modulation?

$M_a > 1$ when $V_m > V_C$

Here both positive and negative extensions of the modulating signals are cancelled (or) clipped out.

The envelope of the message signal are not same.Due to this envelope detector provides distorted message signal.

AM wave with $m_a > 1$ I,e., over modulation ($V_m > V_C$)

7.Write the expression for carrier power of an AM wave.

The average power dissipated in a load by an unmodulated carrier is equal to the rms carrier voltage squared divided by the load resistance.

$PC = V_C^2/2R$

Where PC- Carrier power (watts)

V_c- Peak carrier voltage (volts)

R – Load resistance (Ohms)

8. **With reference to FM, define modulation index.**

Modulation index is the ratio of frequency deviation and modulating signal frequency

$m = \Delta f / f_m$

Δf = frequency deviation in Hz

f_m = modulating signal frequency in Hz

9.Define deviation ratio.

It is the **worst-case modulation index** which is the ratio of maximum permitted frequency deviation and maximum modulating signal frequency.

Deviation ratio = $\Delta f_{(max)} / f_{m(max)}$

10.A carrier is frequency is frequency modulated with a sinusoidal signal of 2 KHz resulting in a maximum frequency deviation of 5 KHz. Find the approximate band width of the modulated signal.

Δf = frequency deviation in Hz = 5 KHz

$f_{m(max)}$ = highest modulating signal frequency in Hz = 2 KHz

Band Width = 2 [$\Delta f + f_{m(max)}$] Hz = 14 KHz

11.Distinguish between narrow band FM and wide band FM.

Narrow band FM	Wide band FM
Frequency deviation in carrier frequency is very small	Frequency deviation in carrier frequency is large
Band width is twice the highest modulating frequency	Band width is calculated as per Carson's rule

12.What are the advantages of FM over AM?

a. The amplitude of FM is constant. Hence transmitter power remains constant in FM where as it varies in AM.
b. Since amplitude of FM is constant, the noise interference is minimum in FM. Any noise superimposing on modulated carrier can be removed with the help of amplitude limiter.
c. The depth of modulation has limitation in AM. But in FM, the depth of modulation can be increased to any value.
d. Since guard bands are provided in FM, there is less possibility of adjacent channel interference.
e. Since space waves are used for FM, the radius of propagation is limited to line of sight (LOS). Hence it is possible to operate several independent transmitters on same frequency with minimum interference.
f. Since FM uses UHF and VHF ranges, the noise interference is minimum compared to AM which uses MF and HF ranges.

13.What is the purpose of a limiter in a FM receiver?

During transmission, noise and interference add to the FM signal and produce unwanted amplitude variations. In the receiver, the unwanted amplitude variations produce unwanted distortion in the recovered information signal.

A **limiter** is a circuit that produces a constant amplitude output for all input signals above a prescribed minimum input level, which is often called the threshold level. A limiter is used before detector in FM receiver to remove unwanted amplitude variations.

With limiters, the signal to noise ratio at the output of demodulator(post detection) can be improved by 20 dB or more over the input (pre detection) signal to noise ratio.

14. **What is a telephone network ?**

A telephone network establishes the voice communication between two people who Are separated by long distance. It also provides other services. It is being widely used for interne E-mail applications.

15.State Kepler's first law.

a. Kepler's first law states that the satellite will follow an elliptical path in its orbit around the primary body. An ellipse has two focal points as F1 and F2.

16.State Kepler's second & third law.

b. It states that for equal time intervals the satellite sweeps out equal areas in the orbital plane, focused at the bay center.

c. Third law states that the square of the periodic time of orbit is proportional to the cube of the mean distance between the two bodies.

17.Define satellite.

d. Satellite is a celestial body that orbits around a planet. In aerospace terms, a satellite is a space vehicle launched by humans and orbits earth or another celestial body.

18.What are the classification of satellites?

e. Satellites are generally classified as a low earth orbit (LEO),Medium earth orbit (MEO),or Geosynchronous earth orbit(GEO) .

19.Define a fiber optic system.

f. An optical communications system is an electronic communication system that uses light as the carrier of information. Optical fiber communication systems use glass or plastic fibers to contain light waves and guide them in a manner similar to the way electromagnetic waves are guided through a waveguide.

20.What are the advantages of optical fiber communication?

g. Greater information capacity or large bandwidth capacity
h. Immunity to crosstalk
i. Immunity to static interference
j. Very small attenuation
k. Safety & Security

PART-B

1. With neat diagrams explain any one method of amplitude modulation and its corresponding demodulation?

AM signal generation

The generation of AM signals consists simply of the addition of the carrier waveform to the DSB signal, for this reason AM modulation is referred to as DSB-LC (DSB with large carrier). The *message* signal $x(t)$ is modulated by a *carrier* waveform $A_c \cos(2¼f_ct)$. The amplitude modulated waveform $x_c(t)$ is

$x_c(t) = A_c x(t) \cos(2¼f_ct) + A_c \cos(2¼f_ct)$ (1)

$= A_c[1 + x(t)] \cos(2¼f_ct)$ (2)

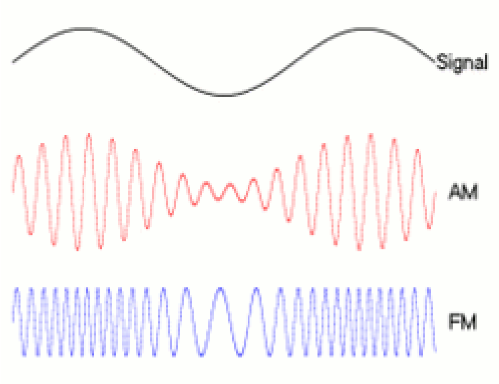
$= A(t) \cos(2¼f_ct)$ (3)

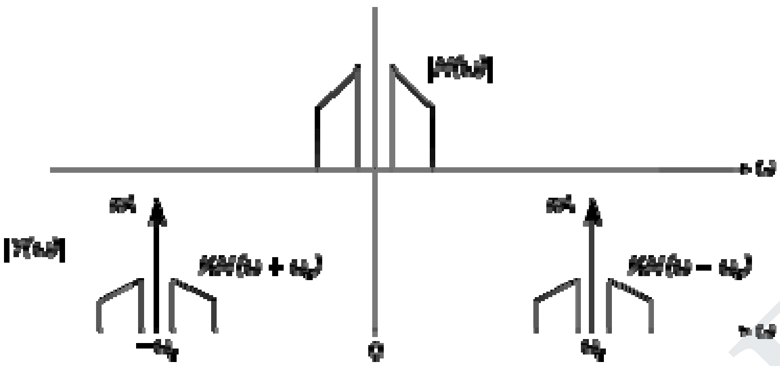
(6)

AM signal power and bandwidth

The (one-sided) spectrum of the AM signal consists of two sidebands that occupy the frequency range $f_c¡f_x$

to $f_c + f_x$ plus the carrier component at f_c, hence the bandwidth B_T required for transmission is
$B_T = 2f_x$ (7)





1.4 Demodulation of AM signals

The recovery of the message signal can be performed coherently just like in DSB demodulation. The transmission of a carrier component in AM alleviates the need for complex carrier recovery circuits necessary for DSB demodulation. However, a simpler demodulator for AM signals is the *envelope detector*.

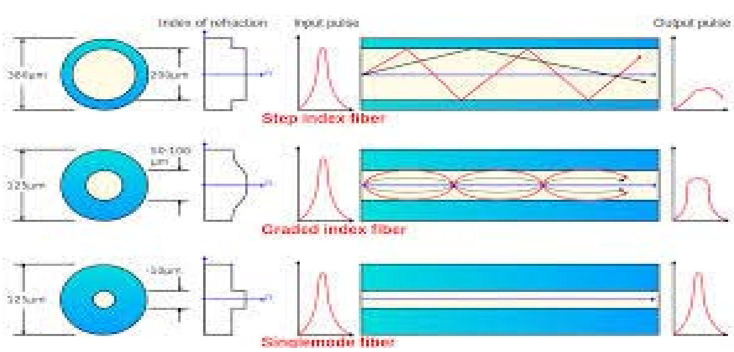
Demodulation with envelope detector

Since the envelope of the modulated signal has the shape of the message signal (as long as $jx(t)j < 1$ and has no DC component), the received signal can be rectified by a diode and the rectified signal can then be smoothed by an RC network in order to recover the message signal. Fig. 2 shows the *envelope detector* circuit for AM demodulation.

2. Write short notes on

a) Optical fiber

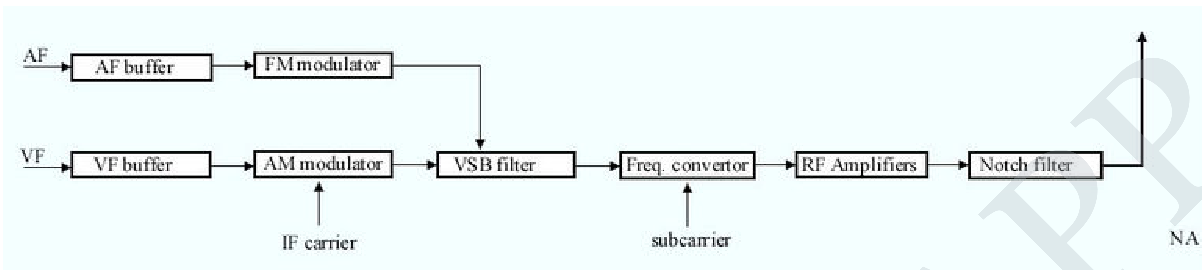
An **optical fiber** (**optical fibre**) is a flexible, transparent fiber made of extruded glass (silica) or plastic, slightly thicker than a human hair. It can function as a waveguide, or "light pipe",[1] to transmit light between the two ends of the fiber. The field of applied science and engineering concerned with the design and application of optical fibers is known as **fiber optics**.



Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide. Fibers that support many propagation paths or transverse modes are called multi-mode fibers (MMF), while those that only support a single mode are called single-mode fibers (SMF). Multi-mode fibers generally have a wider core diameter, and are used for short-distance communication links and for applications where high power must be transmitted. Single-mode fibers are used for most communication links longer than 1,000 meters (3,300 ft).

b) TV transmitter and receiver

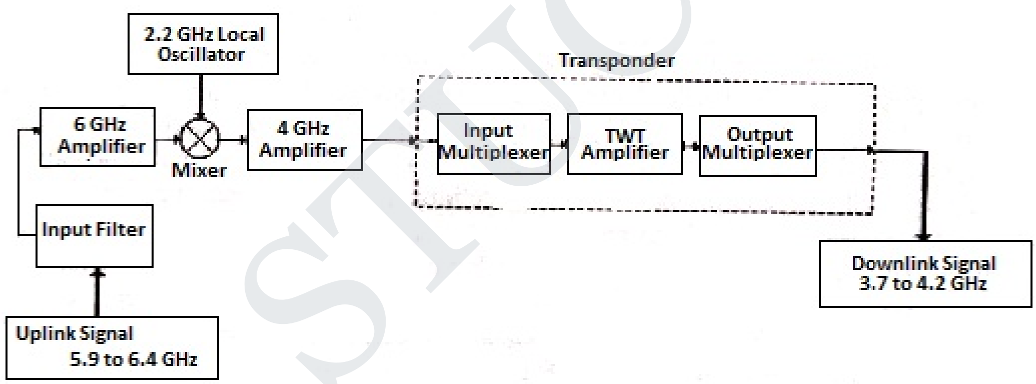
Split sound system: Actually there are two parallel transmitters one for aural and one for visual signal. The two signals are combined at the output via a high power combiner. In addition to a combiner, this system requires separate mixer and amplifiers for aural and visual signals. This is the system used in most high power applications.



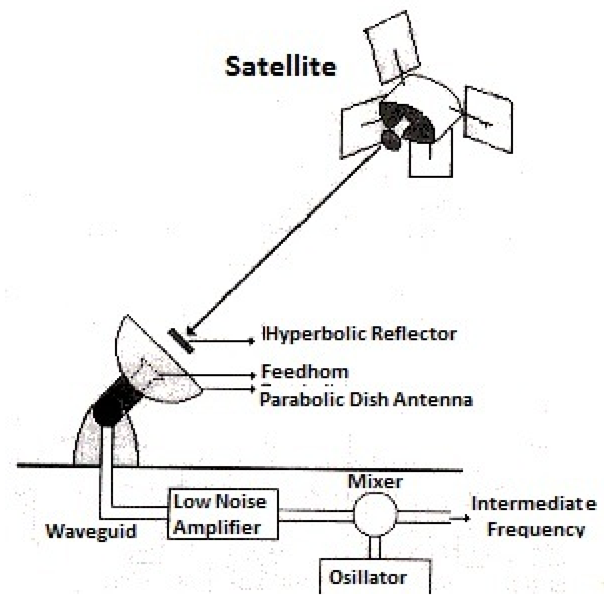
Intercarrier system : There are two input stages one for **AF** and one for **VF**. But the two signals are combined in low power **IF** circuits (i.e., after modulators) The mixer and the amplifiers are common to both signals and the system needs no high power combiners. So both the price of the transmitter and the power consumption is considerably lower than that of split sound system of the same power level. But two signals passing through amplifiers produce some intermodulation products. So intercarrier system is not suitable for high power applications and even at lower power transmitters a notch filter to reject the cross modulation products must be used at the output.

c) Satellite Communication System

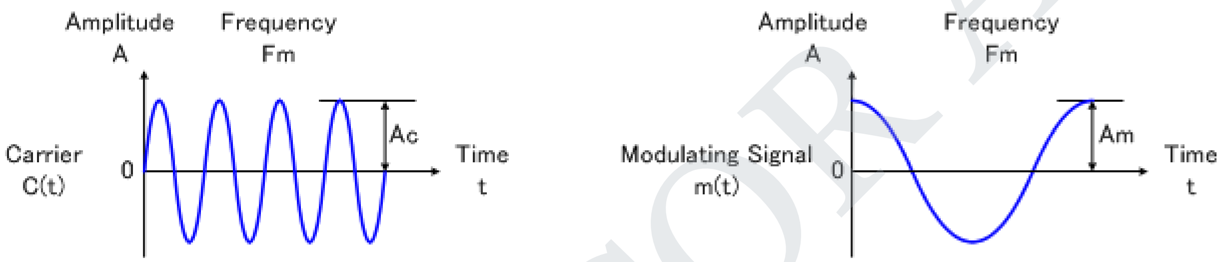
Block Diagram of Satellite Communication System



Satellite Communication Earth Station

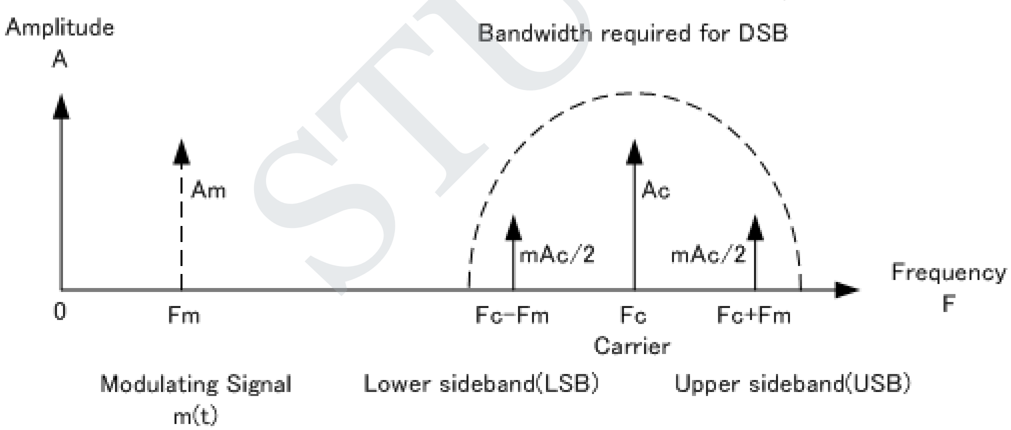


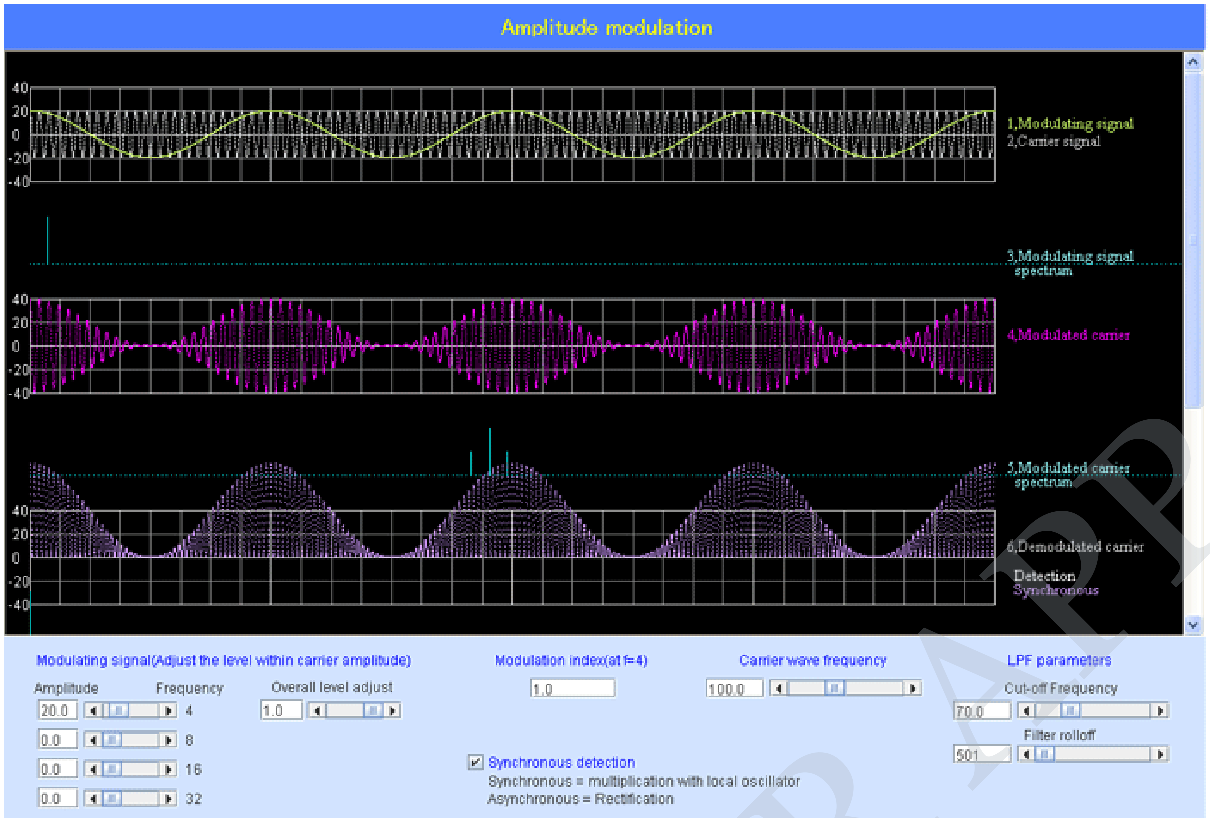
The equipment used in satellite earth station are shown in fig , the earth station consist of a dish antenna transmitter which can transmit a high frequencies (5.9—6.4GHZ) micro wave signals, some earth stations also called ground station , which can transmit and receive the signals while others can only receive signals.



$$C(t) = A_c \cdot \cos(2\pi \cdot F_c \cdot t + \phi_c)$$

$$S_{am}(t) = A_c[1 + K_{am} \cdot m(t)] \cdot \cos(2\pi \cdot F_c \cdot t + \phi_c)$$ Kam: Constant

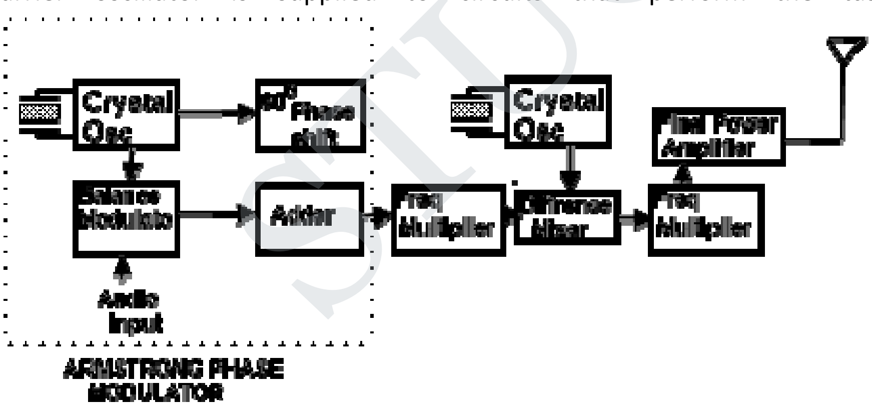


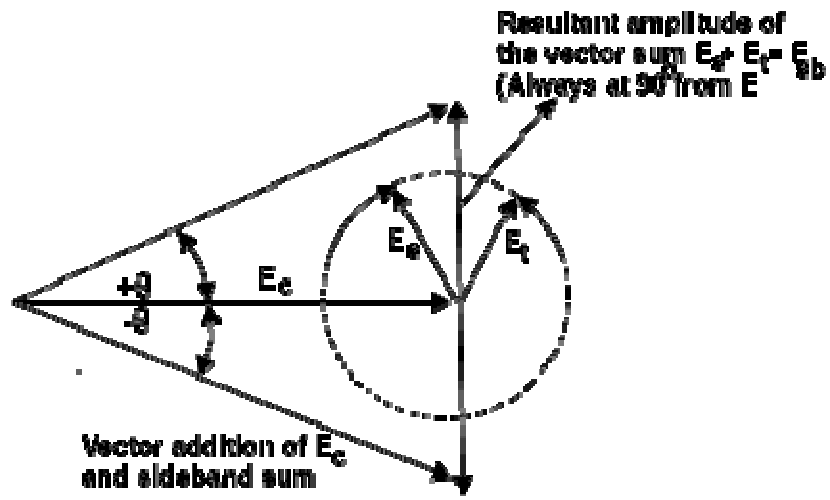


3. Explain the with neat diagram the principle and working of AM and FM transmitter

Armstrong FM transmitter

The part of the Armstrong FM transmitter (Armstrong phase modulator) which is expressed in dotted lines describes the principle of operation of an Armstrong phase modulator. It should be noted, first that the output signal from the carrier oscillator is supplied to circuits that perform the task of modulating the carrier signal.

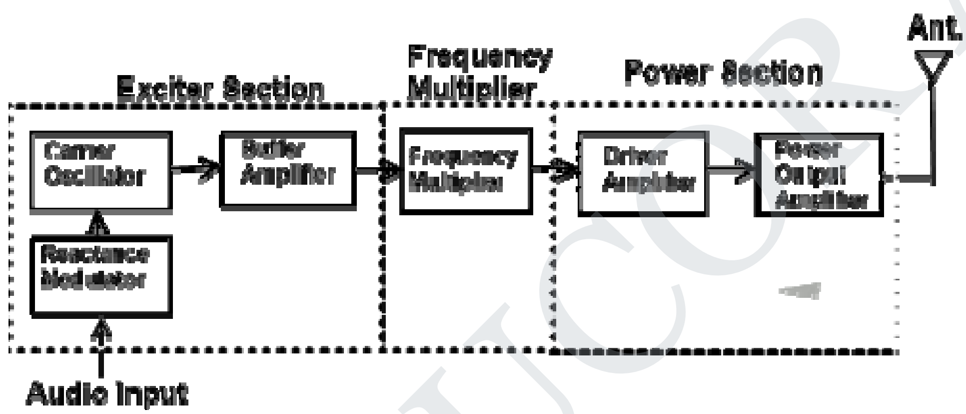




$$\% \text{ of modulation} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100$$

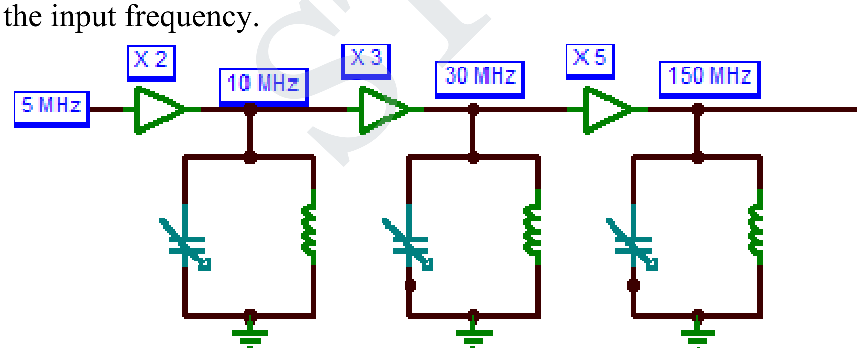
$$\% \text{ of modulation} = \frac{E_o - 1}{E_o + 1} \times 100$$

FM transmitter



FREQUENCY MULTIPLIER

A special form of class C amplifier is the frequency. multiplier. Any class C amplifier is capable of performing frequency multiplidàtion if the tuned circuit in the collector resonates at some integer multiple of the input frequency.



4.Explain frequency modulation. Obtain the mathematical representation of frequency modulation.

5.What is the need for modulation. Explain the principles behind amplitude modulation and frequency modulation. Compare and contrast the two types of modulation.(10)

6.Draw a typical TV signal. Explain how this is converted into an image on a TV screen.(6)

7..Withn a neat block diagram explain the operation of Microwave communication.(8)

8.Draw the block diagram of optic fibre communication system and explain the function of each block.(8)

9. Explain satellite communication system&Draw the block diagram of radio broadcasting and reception system and explain the function of each block.

10.With a neat block diagram explain principle of operation of FAX.