SEMESTER QUESTION AND ANSWER:

UNIT-I

1. Explain about the Independent and Dependent sources in detail.

1)**Dependent source** : A dependent source is one whose value depends on some other variable in the circuit. The voltage or current values is proportional to some other voltage or current in the circuit. for example, in modelling the behavior of amplifiers.

Examples:

1)A bipolar junction transistor can be a dependent current source whose magnitude depends on the magnitude of the current fed into its controlling base terminal.

2)An operational amplifier can be described as a voltage source dependent on the differential input voltage between its input terminals.

Classification:

Dependent sources can be classified as follows:

Voltage-controlled voltage source: The source delivers the voltage as per the voltage of the dependent element. V=avx

Voltage-controlled current source: The source delivers the current as per the voltage of the dependent element. I=bvx

Current-controlled current source: The source delivers the current as per the current of the dependent element. I=cix

Current-controlled voltage source: The source delivers the voltage as per the current of the dependent element. V=Idx

-The proportionality constant between dependent and independent variables is dimensionless if they are both currents (or both voltages).

– A voltage controlled by a current has a proportionality factor expressed in units of resistance (ohm), and this constant is sometimes called “trans-resistance”.

– A current controlled by a voltage has the units of conductance , and is called “trans-conductance”.

-Trans-conductance is a commonly used specification for measuring the performance of field effect transistors and vacuum tubes.

2) **Independent sources:** Ideal Independent Source maintains same voltage or current regardless of the other elements present in the circuit.Its value is either constant (DC) or sinusoidal (AC). The strength of voltage or current is not changed by any variation in connected network.

Example: a Copper resistance along the circuit

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Classification:

1) *Ideal Independent Voltage Sources*

An ideal independent voltage source is a two-terminal circuit element where the voltage across it

a) is independent of the current through it

b) can be specified independently of any other variable in a circuit.

In a circuit, voltage across elements which are parallel with voltage sources are equal to the voltage of the corresponding voltage sources

2) *Ideal Independent Current Sources*

In contrast to ideal independent voltage sources, an ideal independent current source is a two-terminal circuit element where the current passing through it

a) is independent of the voltage across it

b) can be specified independently of any other variable in a circuit.

2. a) State and explain Kirchhoff's laws with examples.

• Kirchhoff‟s Laws

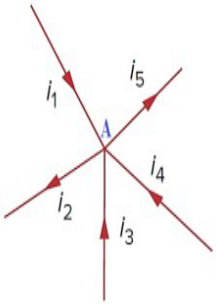
Kirchhoff‟s laws govern the conservation of charge and energy in electrical circuits.

1. Kirchhoff‟s current Law(KCL) or The junction rule (First law)
2. Kirchhoff‟s voltage Law(KVL) or The closed loop rule (Second law

Kirchhoff‟s Current Law(KCL): The sum of currents entering the node (junction) are equal to the sum of currents leaving that node. This implies that the current is conserved (no loss of current).

$$\sum I_{in} = \sum I_{out}$$

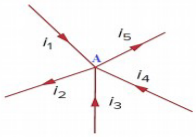
Fig. below shows that currents are entering and leaving the **Node A.**



- Before applying **KCL** sign convention is very important. The following sign convention is used:

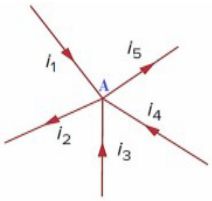
Current Entering node "-ve"
Current Leaving node "+ve"

- Applying **Kirchhoff's current law** with sign convention one has,



$$-I_1 + I_2 - I_3 - I_4 + I_5 = 0$$

$$\boxed{I_1 + I_3 + I_4 = I_2 + I_5}$$



- Alternatively **Kirchhoff's current law** is also stated as,

The sum of the currents entering a node is equal to the sum of the currents leaving the node.

<u>Kirchhoff‟s Voltage Law(KVL):</u>

Kirchhoff‟s voltage law (KVL) states that the algebraic sum of all voltages around any closed path (or loop) in a circuit is always zero.

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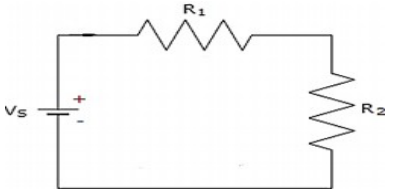
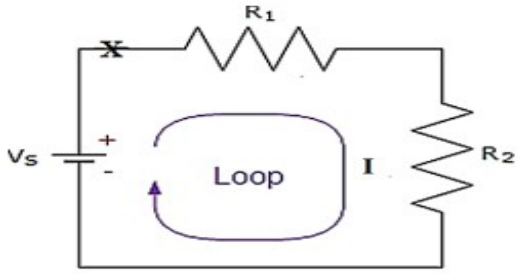
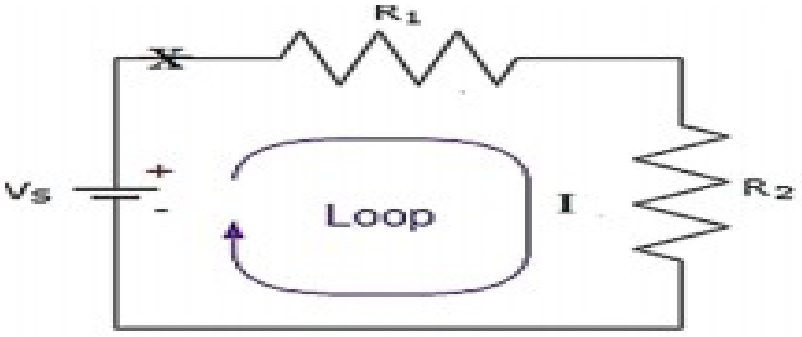
➢ To illustrate KVL, consider the circuit.



Step 1: Let us assume clockwise current in the loop.

Step 2: Moving in direction of current and writing KVL equation. Let us assume we start moving from location **X** towards right.





$$\boxed{V_S = IR_1 + IR_2}$$

If voltage drop across resistances are termed as V_1 and V_2 ,

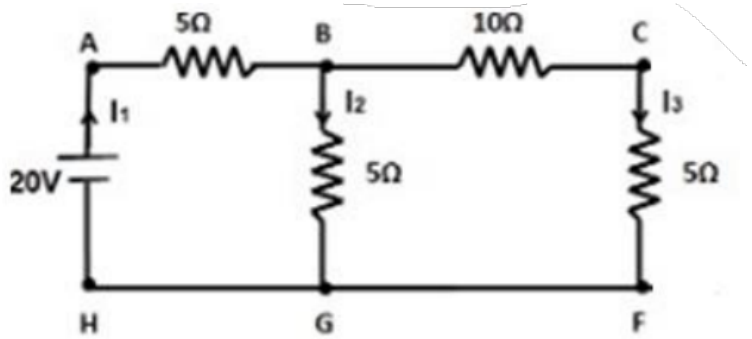
$$\boxed{V_S = V_1 + V_2}$$

Furthermore,

$$\boxed{V_S - V_1 - V_2 = 0}$$

shows total voltage is sum of drops across each resistances which is known as **Kirchhoff's Voltage Law.**

b) Find the current flowing through 10Ω resistor using KVL and KCL in the following circuit.



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A:

$$R_{eq} = \frac{5 \times (10+5)}{5+10+5} + 5$$

$$= \frac{75}{20} + 5$$

$$= 3.75 + 5$$

$$= 8.75\,\Omega$$

$$I_1 = \frac{20}{8.75} = 2.28\,A$$

$$I_{(10\Omega)} = I_1 \times \frac{5}{5+10+5}$$

$$= 2.28 \times \frac{5}{20}$$

$$= 0.57\,A$$

3. Explain about R, L and C parameters and derive the expression for energy stored by inductor and capacitor.

A: Resistance Parameter:

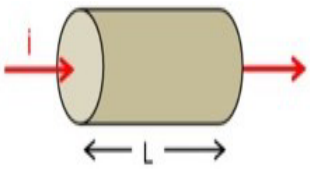
Resistance is the property of the material which opposes the flow of Electrons, denoted by R. The symbol for the resistor is shown in fig(a).

- The unit of resistance ohm or Ω.

One ohm is defined as the resistance offered by the material when a current of one ampere flows between two terminals with one volt applied across it.

The resistance of given material depends on the physical property of that material and is given by

$$R = rl / a$$



Where ,

R – resistance of the material in ohms

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r - resistivity of the material in ohm-mtr
l – length in meters
a – cross sectional area in sq.mtrs
The voltage – current relation is given by V=I*R

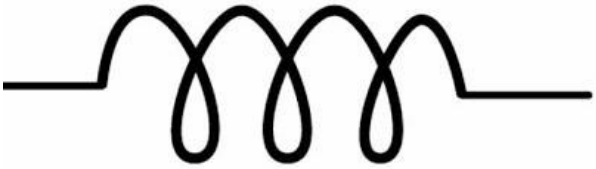
- Resistor dissipates the power in the form of heat.
- The power absorbed by the resistor is given by

P= v*i = iR*i = i^2*R = v^2/R Watts

- Energy lost in a resistance in time „t" is given by
  W= ò $^{pdt=\ pt}$ = i^2*Rt = (v^2/R)*t

Conductance :

- Conductance is defined as inverse or reciprocal of resistance, denoted by G.
- It is expressed in mho or Siemens (S) or .
  G = 1/R.
  Inductance Parameter:
- Inductance is the property of an inductor which always opposes sudden change in current, denoted by „L". The unit of inductance is henry or H. The symbol for an inductor is shown in fig(a).



- Inductor is an element in which the energy is stored in the form of electromagnetic field.
- The voltage – current relation of an inductor is given by,

$$v = L\frac{di}{dt}$$

Where,

v = Instantaneous voltage across the inductor

L = Inductance in Henrys

$\frac{di}{dt}$ = Instantaneous rate of current change (amps per second)

- **Power absorbed by an inductor is given by,**

$$P = v\,i = L\frac{di}{dt}i = \boxed{Li\frac{di}{dt}}$$

Energy stored in an inductor is given by,

$$w = \int p\,dt = \int v\,i\,dt = L\int_0^I \frac{di}{dt}i\,dt = \frac{1}{2}L\,I^2$$

Capacitance Parameter:

- Capacitance is the property of capacitor which always opposes sudden change in voltage across it, denoted by „C". The unit of capacitance is Farad or
- F. The symbol of capacitor is shown in fig(i).

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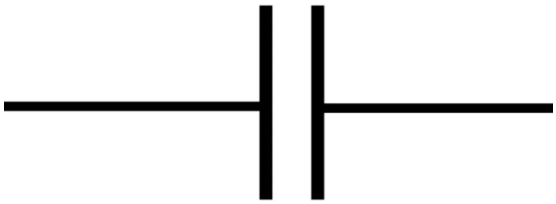

- Any two conducting surfaces separated by an insulating medium exhibit the property of a capacitor. The conducting surfaces are called electrodes and the insulating medium is called di-electric.
- A capacitor stores energy in the form of an electric field.
- The voltage – current relation of an inductor is given by,
- $$i = C\frac{dv}{dt}$$

  Where,

  i = Instantaneous current through the capacitor

  C = Capacitance in Farads

  $\frac{dv}{dt}$ = Instantaneous rate of voltage change (volts per second)
- Power absorbed by a capacitor is given by,

  $$\boxed{p = vi = Cv\frac{dv}{dt}}$$

  Energy stored in an capacitor is given by,

  $$w = \int_{-\infty}^{t} p\,dt = C\int_{-\infty}^{t} v\frac{dv}{dt}\,dt = C\int_{-\infty} v\,dv = \frac{1}{2}Cv^2$$
-

Element	Basic Relation	Voltage (V)	Current (Amp)	Power (Watt)	Energy (W-h)	Symbol
Resistor (R)	R = V/i	V = i * R	i = V/R	P= v*i = i^2*R = v^2/R	W = P * t	
Inductor (L)	$L = \frac{N\phi}{i}$	$V = L\frac{di}{dt}$	$i = \frac{1}{L}\int v\,dt$	P = vi $= Li\frac{di}{dt}$	$W = \frac{1}{2}Li^2$	
Capacitor (C)	$C = \frac{Q}{V}$	$V = \frac{1}{c}\int i\,dt$	$i = C\frac{dv}{dt}$	P = vi $= CV\frac{dv}{dt}$	$W = \frac{1}{2}CV^2$	

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4. Derive necessary expressions for star to delta and delta to star transformation.

A: Delta ( ) to Star (Y) transformation:

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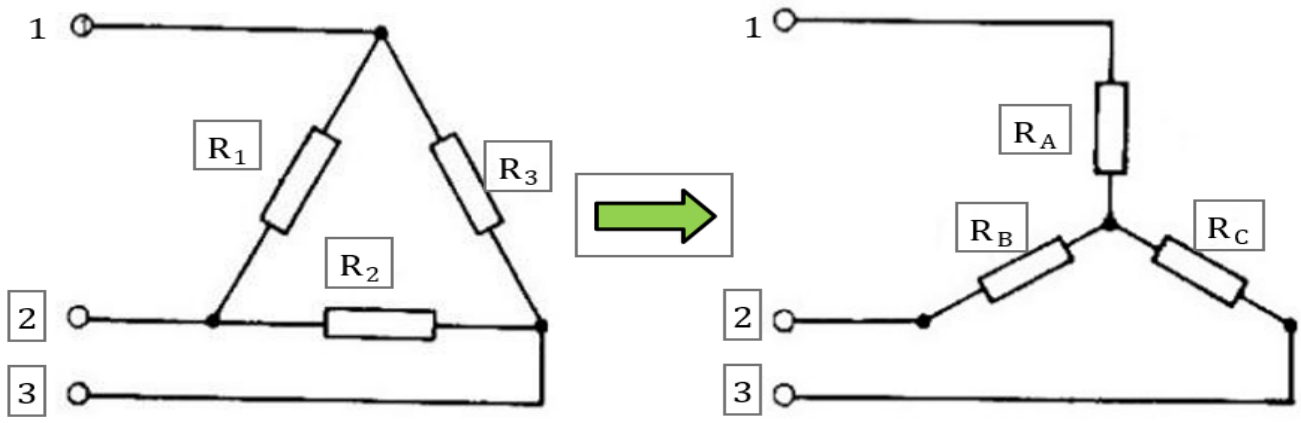

Fig(a): Delta connection

Fig(b): Star connection

In order that the above two networks are equal if their respective resistances from the terminals 1,2; 2,3; 3,1 are equal.

The resistance between 1 and 2 terminals in delta network

$$\boxed{=} \frac{R_1 (R_2 + R_3)}{R_1 + R_2 + R_3} \quad \text{-------} \quad (1)$$

The resistance between 1 and 2 terminals in star network

$$= R_A + R_B \quad \text{---------} \quad (2)$$

Therefore, eq(1) = eq(2) $\Rightarrow$ $$\frac{R_1 (R_2 + R_3)}{R_1 + R_2 + R_3} = R_A + R_B \quad \text{------} \quad (3)$$

The resistance between 2 and 3 terminals in delta network

$$= \frac{R_2 (R_3 + R_1)}{R_1 + R_2 + R_3} \quad \text{---------} \quad (4)$$

The resistance between 2 and 3 terminals in star network

$$= R_B + R_C \quad \text{---------} \quad (5)$$

Therefore, eq(4) = eq(5) $\Rightarrow$ $$\frac{R_2 (R_3 + R_1)}{R_1 + R_2 + R_3} = R_B + R_C \quad \text{------} \quad (6)$$

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The resistance between 3 and 1 terminals in delta network

$$= \frac{R_3 (R_1 + R_2)}{R_1 + R_2 + R_3} \quad \text{------} \quad (7)$$

The resistance between 3 and 1 terminals in star network

$$= R_A + R_C \quad \text{---------} \quad (8)$$

Therefore, eq(7) = eq(8) ⇒ $\frac{R_3 (R_1 + R_2)}{R_1 + R_2 + R_3} = R_A + R_C$ --------- (9)

Subtracting eq(6) from eq(3), we get

$$R_A + R_B - (R_B + R_C) = \frac{R_1 (R_2 + R_3)}{R_1 + R_2 + R_3} - \frac{R_2 (R_3 + R_1)}{R_1 + R_2 + R_3}$$

$$R_A - R_C = \frac{(R_1 * R_3) - (R_2 * R_3)}{R_1 + R_2 + R_3} \quad \text{--------} \quad (10)$$

Adding eq(10) and eq(9), we get

$$R_A - R_C + (R_A + R_C) = \frac{(R_1 * R_3) - (R_2 * R_3)}{R_1 + R_2 + R_3} + \frac{(R_1 * R_3) + (R_2 * R_3)}{R_1 + R_2 + R_3}$$

$$2 R_A = \frac{2 * (R_1 * R_3)}{R_1 + R_2 + R_3}$$

$$R_A = \frac{R_1 * R_3}{R_1 + R_2 + R_3} \quad \text{--------} \quad (11)$$

Similarly,

$$R_B = \frac{R_1 * R_2}{R_1 + R_2 + R_3} \quad \text{---------} \quad (12)$$

$$R_C = \frac{R_2 * R_3}{R_1 + R_2 + R_3} \quad \text{---------} \quad (13)$$

Star (Y) to Delta ( ) transformation:

The same general approach may be used to convert from star to delta transformation of network. We have,

$$R_A = \frac{R_1 * R_3}{R_1 + R_2 + R_3} \quad \text{--------} \quad (11)$$

$$R_B = \frac{R_1 * R_2}{R_1 + R_2 + R_3} \quad \text{---------} \quad (12)$$

$$R_C = \frac{R_2 * R_3}{R_1 + R_2 + R_3} \quad \text{---------} \quad (13)$$

If R_A is divide by R_B , we have

$$R_3 = \frac{R_A}{R_B} * R_2 \quad \text{---------} \quad (14)$$

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If R_A is divide by R_C, we have

$$R_1 = \frac{R_A}{R_C} * R_2 \quad \text{---------} \quad (15)$$

On substituting eq (14), eq (15) in eq (11), we get

$$R_A = \frac{\frac{R_A}{R_C} * R_2 * \frac{R_A}{R_B} * R_2}{\left(\frac{R_A}{R_C} * R_2\right) + R_2 + \left(\frac{R_A}{R_B} * R_2\right)}$$

On solving, we get

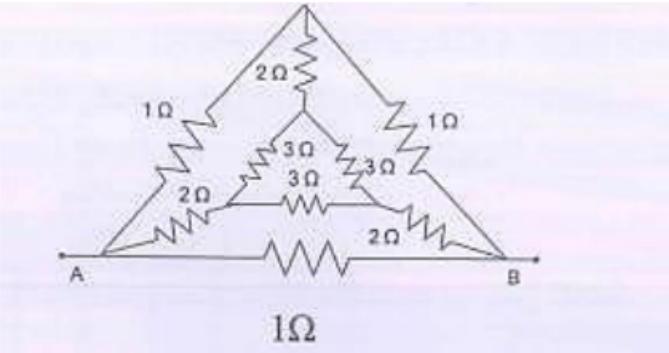
$$R_2 = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A} \quad \text{---------} \quad (16)$$

Similarly,

$$R_3 = \frac{R_A R_B + R_B R_C + R_C R_A}{R_B} \quad \text{---------} \quad (17)$$

$$R_1 = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C} \quad \text{---------} \quad (18)$$

5. Determine the equivalent resistance across AB terminals.



A:

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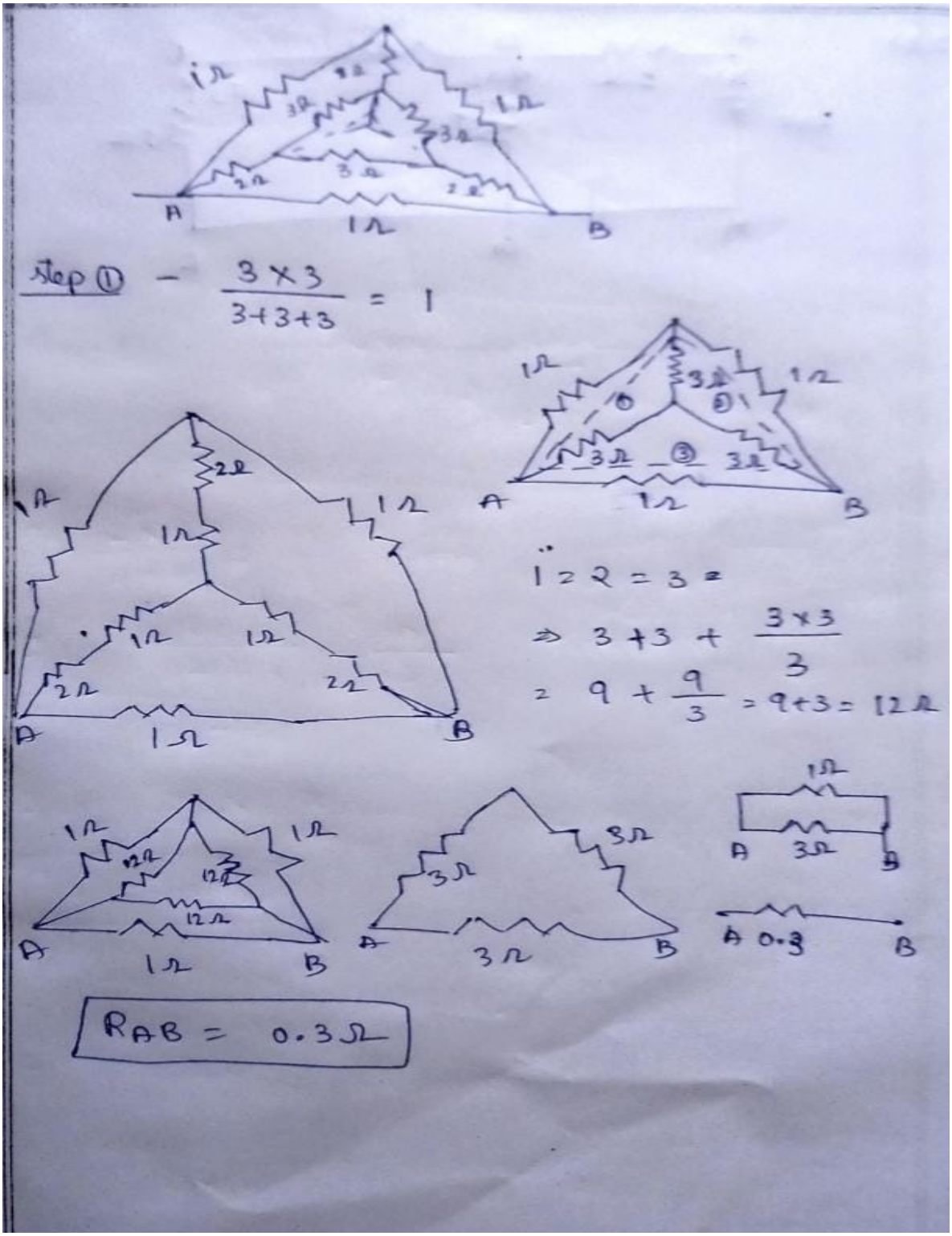

6. a) State and explain Thevenin's theorem with an example.

A: Thevenin's Theorem:

Thevenin's Theorem states that "*Any two terminal linear circuit or network having a umber of voltage, current sources and resistances can be replaced by simple equivalent circuit consisting of a single voltage source in series with a single resistance connected across the load*". Where the value of the voltage source is equal to the open circuit voltage across the two terminal of the network and resistance is equal to the equivalent resistance measured between the terminals with all the energy sources are replaced by their internal resistances.

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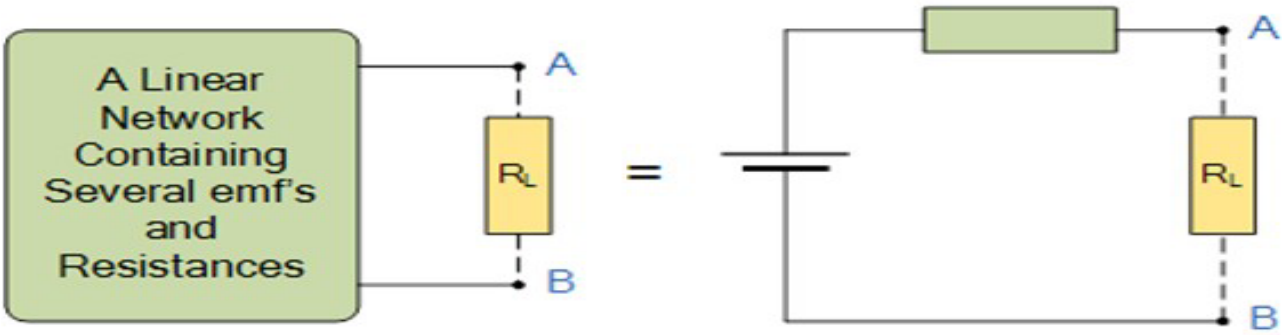
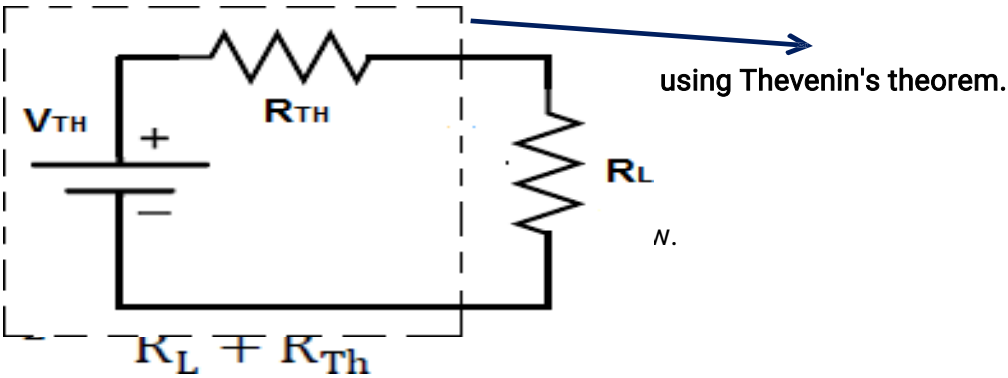
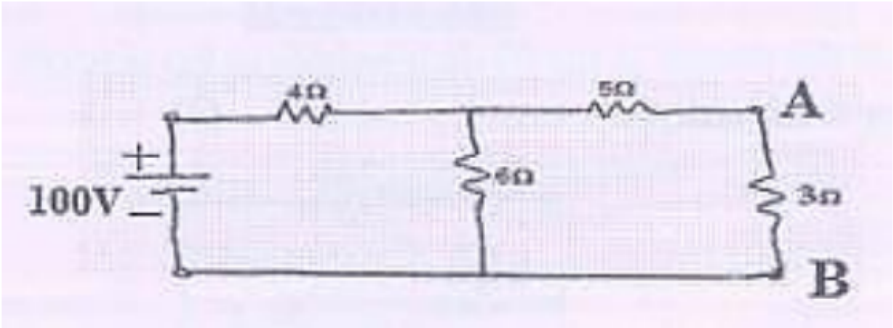


Steps to be followed in Thevenin"s theorem:

1. Remove the load resistance „R_L" and let the terminals be open circuited.
2. Find the open circuit voltage „V_{Th}" across the points A & B terminals.
3. Open current sources and short voltage sources.
4. Find the resistance „R_{Th}" as seen from the points A & B.
5. Replace the network by a voltage source „V_{Th}" in series with the resistance „R_{Th}".



b) Determine the current through 3 ohms resistor using Thevenin's theorem?



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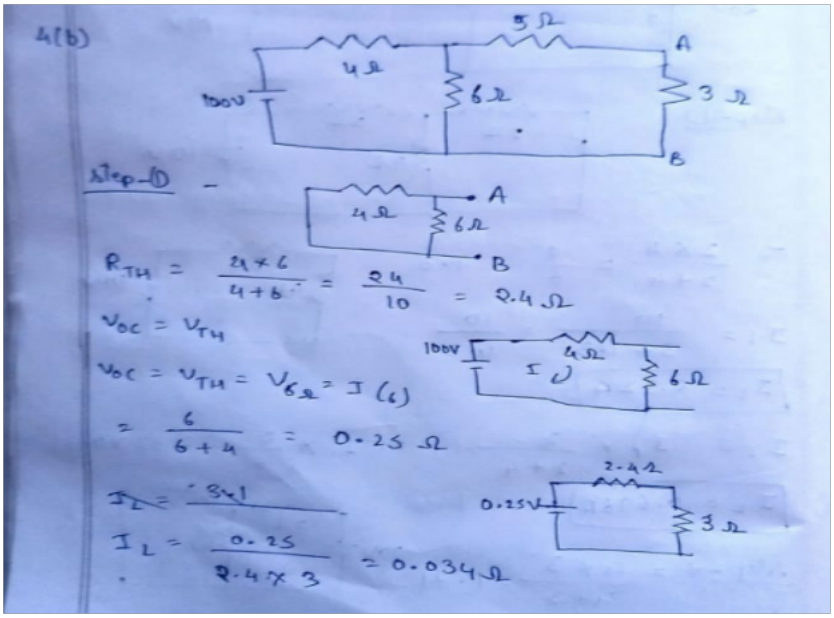
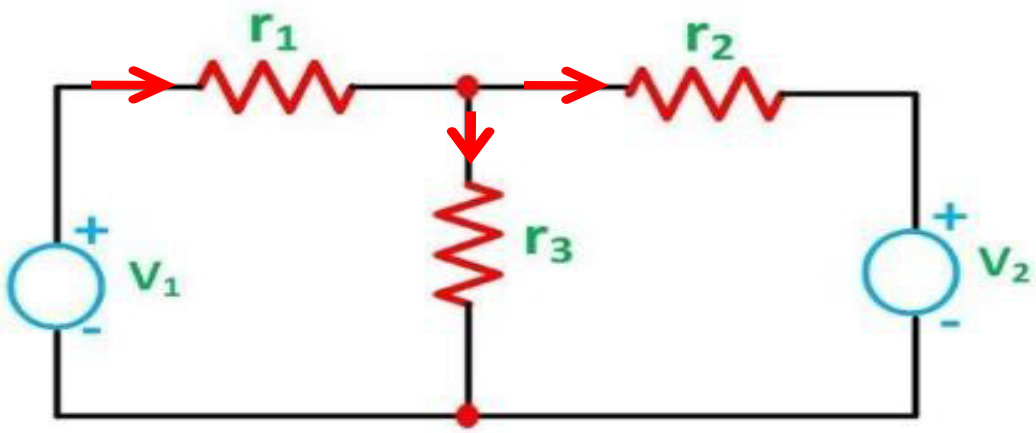


7. a) State and explain superposition theorem with an example

A: Superposition Theorem:

Superposition theorem states that in any linear, active, bilateral network having two or more sources, the response in any element is equal to the algebraic sum of the response caused by individual sources acting alone, while the other sources are non-operative i.e., while considering the effect of individual sources, other ideal voltage sources and current sources in the network is replaced by short circuit and open circuit across their terminals.

- The superposition theorem is used to solve the network where two or more sources are present and connected.
- Valid only for linear networks.
- Let us understand the superposition theorem with the help of an example. The circuit diagram is shown below consists of two voltage sources V_1 and V_2.



by the following equations:

$$i_1' = \frac{V_1}{\frac{r_2 r_3}{r_2 + r_3} + r_1} \quad \ldots\ldots\ldots\ldots (1)$$

$$i_2' = i_1' \frac{r_3}{r_2 + r_3} \quad \ldots\ldots\ldots\ldots (2)$$

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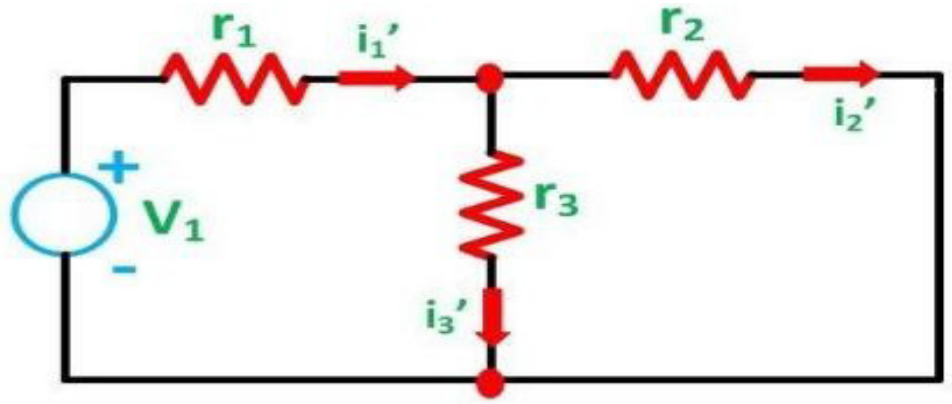
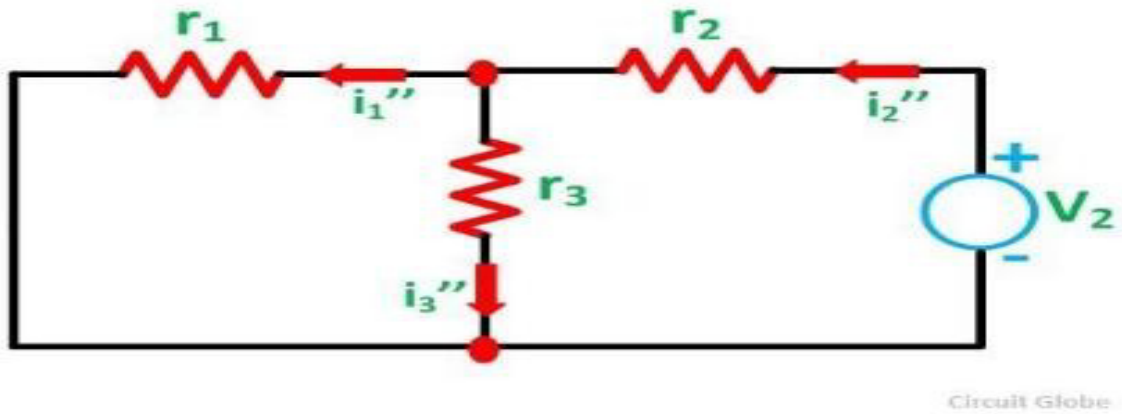


The difference between the above two equations gives the value of the current i3"

$$i_3' = i_1' - i_2' \quad \text{----------} \quad (3)$$

Now, activating the voltage source V_2 and deactivating the voltage source V_1 by short-circuiting it, find the various currents, i.e. i_1'', i_2'', i_3'' flowing in the circuit diagram shown below:



Here,

$$i_2'' = \frac{V_2}{\frac{r_1 r_3}{r_1 + r_3} + r_2} \quad \text{and} \quad i_1'' = i_2'' \frac{r_3}{r_1 + r_3}$$

And the value of the current i_3'' will be calculated by the equation shown below:

$$i_3'' = i_2'' - i_1'' \quad \text{----------} \quad (4)$$

As per the superposition theorem, the value of current i_3 is the algebraic sum of the currents flowing through r_3 when individual sources acting alone and is given as:

$$i_3 = i_3' + i_3''$$

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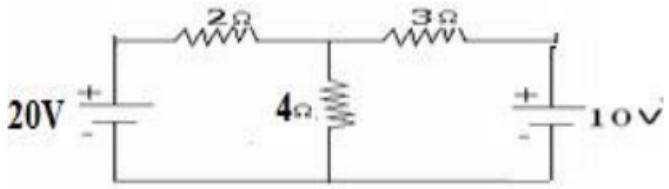
As per the superposition theorem, the value of current i_1, i_2, i_3 is now calculated as:

$$i_3 = i_3' + i_3''$$

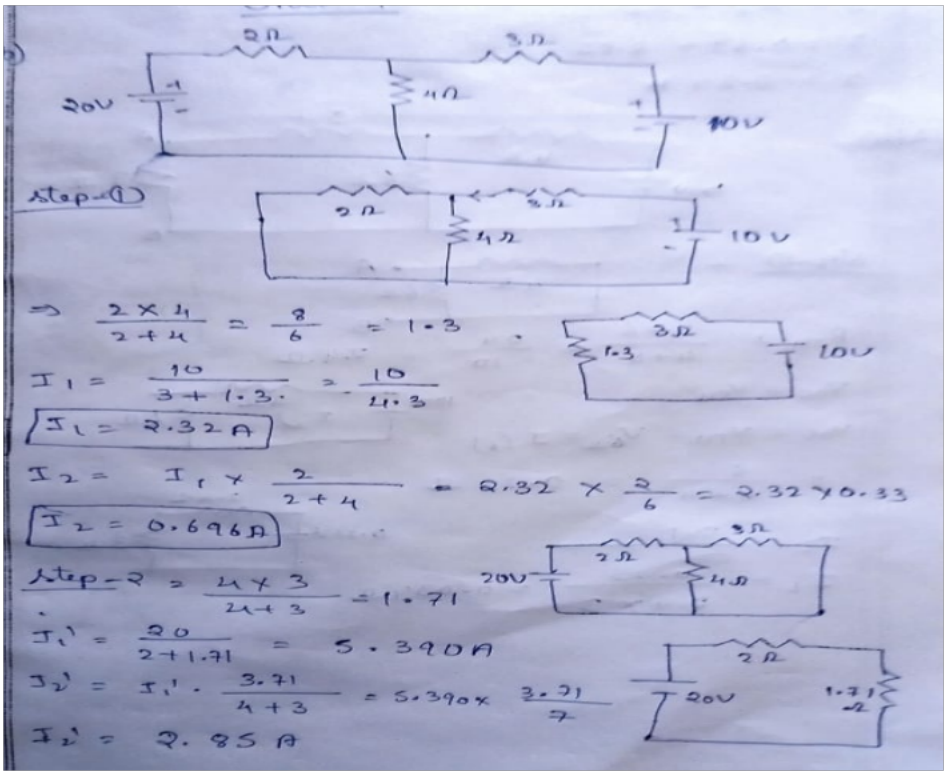
$$i_2 = i_2' - i_2''$$

$$i_1 = i_1' - i_1''$$

b) Find the current through 4 ohms resistor by using superposition theorem.



A:



UNIT-II

1. a) Explain the principle of operation of DC generator.

A: DC Generator: It is a machine which converts the mechanical energy into the electrical energy in the form

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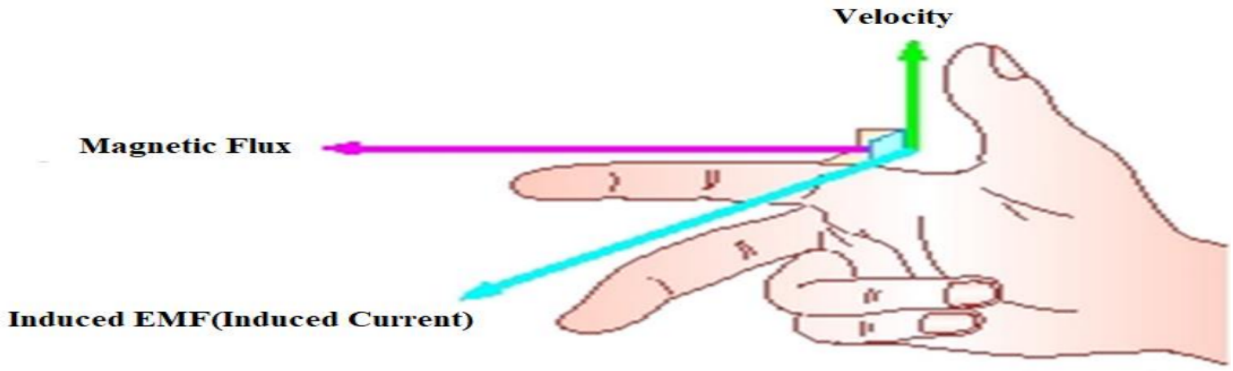
of DC voltage.
Working Principle:
A DC generator works based on the principle of Faraday's laws of electromagnetic induction.
Faraday's laws are.
1) Faraday's First Law
2) Faraday's Second Law
Faraday's First Law:
Whenever a conductor cuts the magnetic flux, an EMF is induced in the conductor.
Faraday's Second Law:
The induced EMF in the conductor is directly proportional to the rate of change of flux cutting or flux linkage. The type of the induced EMF in DC generator is dynamically induced EMF, where the conductor is rotating and the flux is stationary
The magnitude of dynamically induced EMF is given by
EMF (E) = BVlsinθ
Where,
B= Magnetic flux density.
B=Φ/A.
Φ=Magnetic flux.
A=Area of the magnetic path.
V = Velocity of the conductor.
l= Active length of conductor.
θ= Angle between the magnetic flux and the velocity.
The direction of dynamically induced EMF is given by Fleming's right hand rule.

Fleming's Right Hand Rule:



If middle finger, fore finger and thumb of the right hand are kept perpendicular to each other.
Fore finger indicates the direction of magnetic field.
Thumb indicates the direction of velocity.
Middle finger indicates the direction of the induced EMF or induced current.

b) Explain the principle of operation of DC motor.

A: DC Motor: It is a machine which converts the electrical energy (in the form of DC Voltage) into the mechanical energy.
Working Principle
A DC motor works based on the principle of Lorentz's force law.
Lorentz's Force Law:
Whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force.
The magnitude of force acting on the conductor is given by
F= Bilsinθ
Where,
B= Magnetic flux density.
B=Φ/A.
Φ=Magnetic flux.

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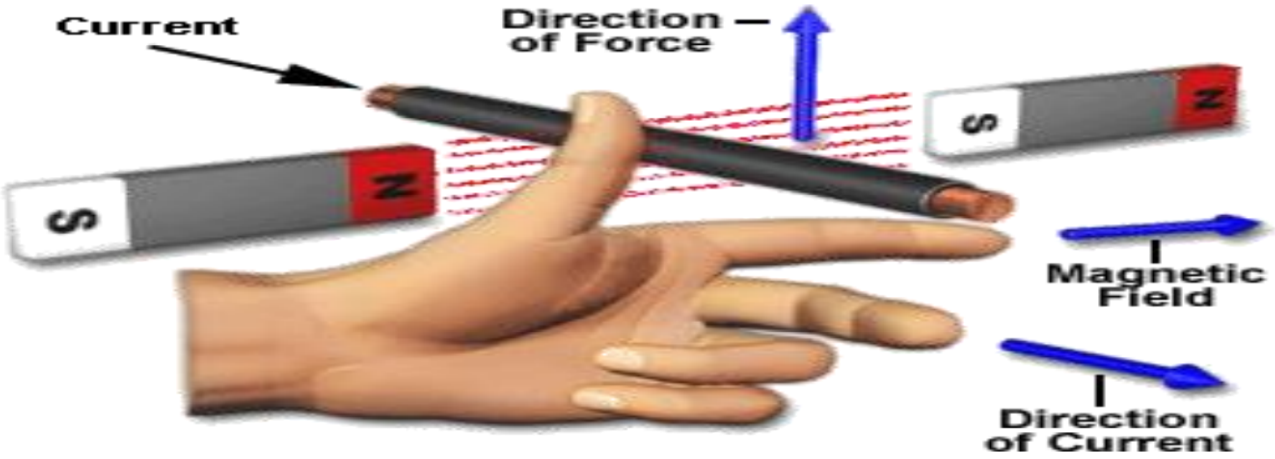
A=Area of the magnetic path.
I = Current flowing through the conductor.
l= Active length of conductor.
θ= Angle between the magnetic flux and the current.
The direction of the force is given by Fleming's Left Hand Rule.
Fleming's Left Hand Rule:



If the middle finger, fore finger and thumb of the left hand are kept perpendicular to each other.
The middle finger indicates the direction of current.
The fore finger indicates the direction of magnetic field.
The thumb indicates the direction of force acting on the conductor.

2. a) Derive the EMF equation of DC generator.

A: EMF Equation of DC Generator:

Let,
Φ = flux per pole in webers.
Z = Total number of conductors in the armature.
P = Number of poles in the generator.
A = Number of parallel paths in the armature winding.
N = Speed of the armature in revolutions per minute (rpm).
Eg = Total EMF generated in the generator.
E = Average EMF generated in one armature conductor.
Average EMF generated in one armature conductor is given by

$E = d\Phi/dt$…….. (1)
Total EMF generated in the generator is given by
Eg = (Average EMF generated in one armature conductor) ×
(Number of conductors per parallel path)
$Eg = E \times Z/A$…….. (2)
Flux cut by one conductor in one revolution is given by
$d\Phi = P\Phi$……(3)
Time required to complete one revolution is given by
$dt = 1/N$ (minutes)
$dt = 60/N$ (sec)……..(4)
Substituting eq.(3) and eq.(4) in eq.(1),we get
The Average EMF generated in one armature conductor is given by
$E = (P\Phi)/(60/N)$
$= P\Phi N/60$……(5)
Substituting eq.(5) in eq. (2),we get
The total EMF generated (Eg)= $(P\Phi N/60) \times (Z/A)$
$Eg = \Phi ZNP/60A$

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Case(1): For lap winding (A=P)

$E_g = \Phi ZNP/60P$

$E_g = \Phi ZN/60$

Case (2): For wave winding (A=2)

$E_g = \Phi ZNP/(60\times2)$

$E_g = \Phi ZNP/120$

b) The armature of a 4-pole D.C. generator has a lap winding containing 600 conductors.

Calculate the generated EMF when the flux per pole is 0.06 Wb and the speed is 400 rpm.

A: Given Data

Flux per pole (Φ) = 0.06Wb

Total number of conductors (Z) =600

Number of poles (P) = 4

Number of parallel paths (A) =P= 4

Speed of the armature (N) = 400 rpm

EMF Equation of DC generator is given by

$E_g = \Phi ZNP/60A$

For lap winding (A=P)

$E_g = \Phi ZNP/60P$

$E_g = \Phi ZN/60$

$= (0.06\times600\times400)/60$

$= 240V$

3. a) Derive the torque equation of DC motor.

A: Torque Equation of DC Motor

Let,

T_a = Torque developed by the armature.

F = Force acting on the armature.

R= Radius of the armature.

I_a = Armature current.

= Angular velocity.

$= 2\Pi N/60$

E_b = Back EMF induced in the armature.

$= \Phi ZNP/60A$

The torque developed by the armature is given by

$T_a = F\times R$…… (1)

The mechanical power developed by the armature is given by

Pm= (Work done in one revolution/Time required to complete one revolution) …….(2)

Work done in one revolution = Force × Distance travelled in one revolution

$= F \times 2\Pi R$…….. (3)

Time required to complete one revolution =60/N (sec)……. (4)

Substituting eq.(3) and eq.(4) in eq.(2),we get

$P_m = (F \times 2\Pi R)/(60/N)$

$= (F \times R) \times (2\Pi N/60)$

$= T_a \times$ ……(5)

The electrical equivalent of mechanical power developed by the armature is given by

$P_m = E_b \times I_a$…….. (6)

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From eq.(5) and Eq.(6),eq.(5)= eq.(6)

$T_a \times \; = E_b \times I_a$

$T_a \times (2\Pi N/60) = (\Phi ZNP/60A) \times I_a$

$T_a = (1/ 2\Pi) \times (ZP/A) \times \Phi I_a$

$T_a = 0.159 \times (ZP/A) \times \Phi I_a$

$T_a = K\Phi I_a$

Where, $K = 0.159 \times (ZP/A)$

= Constant.

$T_a \alpha \Phi I_a$

b) A DC motor takes an armature current of 110A at 480V.The armature circuit resistance is 0.2 ohms. The machine has 6 poles and the armature is lap connected with 864 conductors. The flux per pole is 0. 05wb.Caluclate (i) The speed (ii) The gross torque developed by the motor.

A:

Given that,

$I_a = 110A$ $\quad P = 6$

$E_b = 480V$ $\quad$ Lap winding $A = P = 6$

$R_a = 0.2\Omega$ $\quad Z = 864$

$\phi = 0.05$

(i) $N - ?$ $\quad$ (ii) $T - ?$

(i) $E_b = \frac{\phi Z N P}{60A}$

$N = \frac{E_b \times 60 \times A}{\phi Z P}$

$= \frac{480 \times 60}{0.05 \times 864} \Rightarrow \frac{28800}{43.2}$

$N = 666.66$ rpm

(ii) $T = 0.159 \times \frac{ZP}{A} \times \phi \times I_a$

$= 0.159 \times 864 \times 0.05 \times 110$

$T = 755.568$

4. Explain about speed control methods of DC Shunt Motor.

A: Methods of Speed Control:

1) Flux control method
2) Armature resistance control method
3) Armature voltage control method

Flux Control Method:

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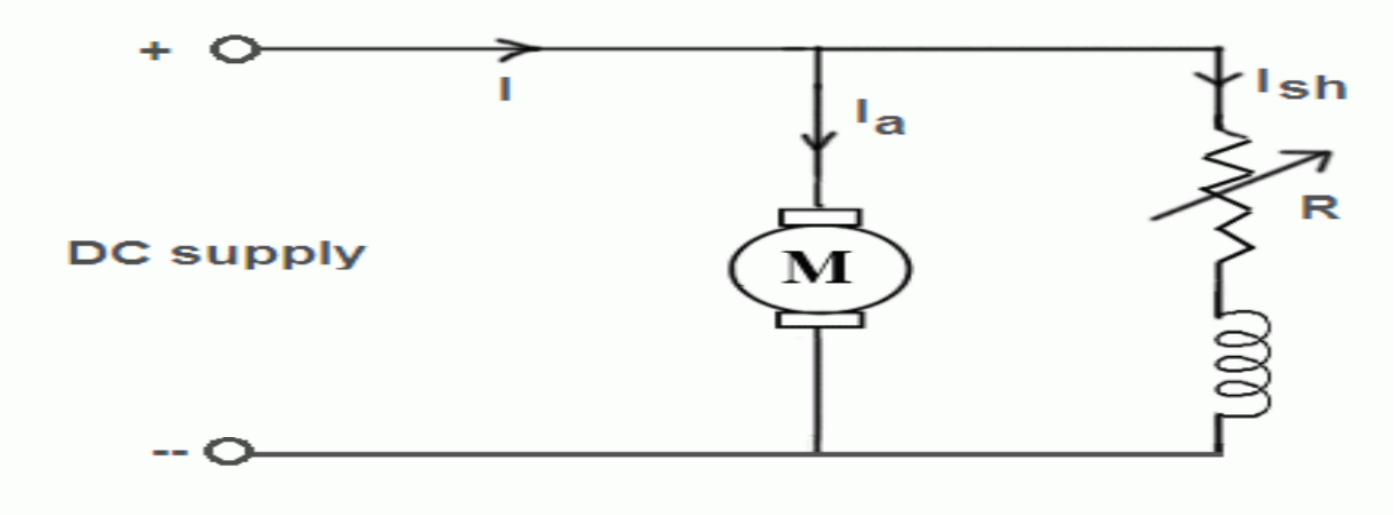


The speed equation of DC shunt motor is given by

N = K(V -Ia Ra)/ Φ

When the armature current is constant, the above equation can be written as

N α 1 / Φ

The speed of the DC shunt motor is inversely proportional to the flux.

Hence, the speed can be varied by changing the flux.

Higher the flux lower will be the speed.

Lower the flux higher will be the speed.

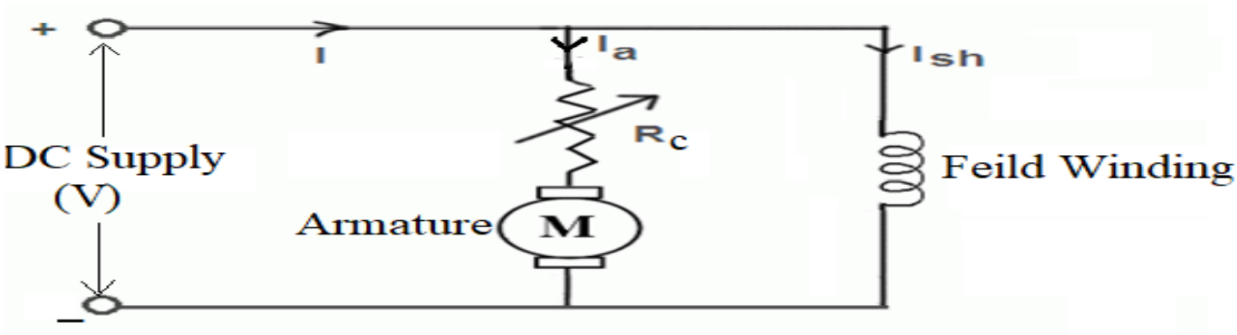
A variable resistance (shunt field rheostat) is placed in series with the shunt field winding as shown in above fig.

Shunt field rheostat reduces the shunt field current and hence the field flux.

Reduction in flux increases the speed of the motor.

Here, the speeds above the rated value are obtained.

Armature Resistance Control Method:



The speed equation of DC shunt motor is given by

N =K (V – IaRa)/ Φ

When the flux is constant, the above equation can be written as

N =K (V – IaRa)

N α (V – IaRa)

N α Eb

Variation of voltage across the armature varies the back EMF and hence the speed.

The voltage across the armature is varied by connecting a control resistance (Rc) in series with the armature.

Hence, the speed equation can be written as

N = K (V – Ia(Ra +Rc))

N α (V – Ia(Ra +Rc))

Because of Rc the voltage drop increases. So, back EMF reduces and hence the speed reduces.

Here, the speeds below the rated value are obtained.

Armature Voltage Control Method:

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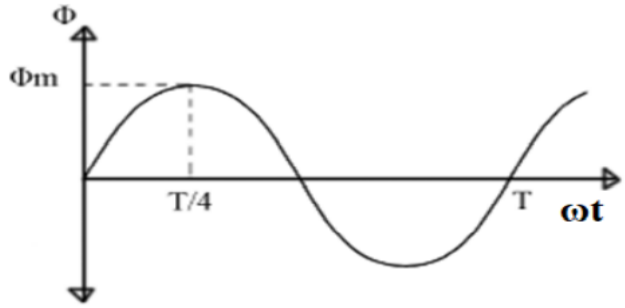
The armature is supplied with different voltages by using suitable switchgear.
The speed of the motor is approximately proportional to the voltage across the armature.
The speed of the motor is varied by applying the different voltages to the armature.
This method is rarely used.

UNIT-III

1. a) Derive the EMF equation of transformer.

A: EMF Equation of Transformer:



Let,
N1 = Number of turns in the primary winding.
N2 = Number of turns in the secondary winding.
Φm = Maximum flux in the core (in Wb).
= (Bm x A)
f = frequency of the AC supply (in Hz).
T= Time period (in Sec)
According to the Faraday's second law, the average EMF induced in the primary winding is given by
E1= N1dΦ/dt……(1)
As shown in the fig., the flux rises sinusoidally to its maximum value Φm from 0.
Therefore, the change in flux (dΦ) = Φm …….(2)
Flux reaches to the maximum value in one quarter of the cycle i.e. in T/4 sec.
Therefore, the change in time(dt)= T/4 …….(3)
Substituting eq.(2) and eq.(3) in eq.(1),we get
E1 = N1Φm / (T/4)
= 4N1Φm /T
= 4fΦmN1 …….(4)
Where, Time period (T) = 1/f
We know, Form factor = RMS value / Average value
Therefore, RMS value of EMF
= Form factor × Average EMF
= 1.11× Average EMF
RMS value of induced EMF in the primary winding is given by
E1 =1.11×4f ΦmN1
E1 = 4.44Φm f N1
……(5)
Similarly, RMS value of induced EMF in the secondary winding is given by
E2 = 4.44 Φm f N2
…… (6)
Voltage Transformation Ratio (K):
From the equations (5) and (6), we get

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$$\frac{E_2}{E_1} = \frac{4.44\ \Phi_m\ f\ N_2}{4.44\Phi_m\ f\ N_1}$$

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

Where, K = Constant.

This constant K is known as voltage transformation ratio.

If N2 > N1, i.e. K > 1, then the transformer is called as step-up transformer.

If N2 < N1, i.e. K < 1, then the transformer is called as step-down transformer.

b) 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 (i) The secondary EMF (ii) The maximum flux in the core (iii) The primary and secondary currents.

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A:

(b)

(i) At full load,

$$I_1 = \frac{25 \cdot 10^3}{3000}$$

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

Now $\frac{I_1}{I_2} = \frac{E_2}{E_1} = \frac{N_2}{N_1}$

Secondary current,

$$I_2 = \frac{N_1}{N_2} \cdot I_1$$

$$= \frac{500}{400} \cdot 8.33$$

$$\boxed{I_2 = 104.15A}$$

(ii) Secondary Emf,

$$E_2 = \frac{N_2}{N_1} \cdot E_1$$

$$= \frac{40}{500} \cdot 3000$$

$$\boxed{E_2 = 240V}$$

(iii) Using relation,

$$E_1 = 4.44 N_1 f \phi_m$$

$$3000 = 4.44 \times (500)(50)(\phi_m)$$

$$\phi_m = \frac{3000}{4.44(500)(50)}$$

$$\boxed{\phi_m = 27mWb}$$

2. a) Explain about the working principle and operation of single-phase Transformer.

A: Working Principle

A transformer works based on the principle of mutual induction.

Mutual Induction:

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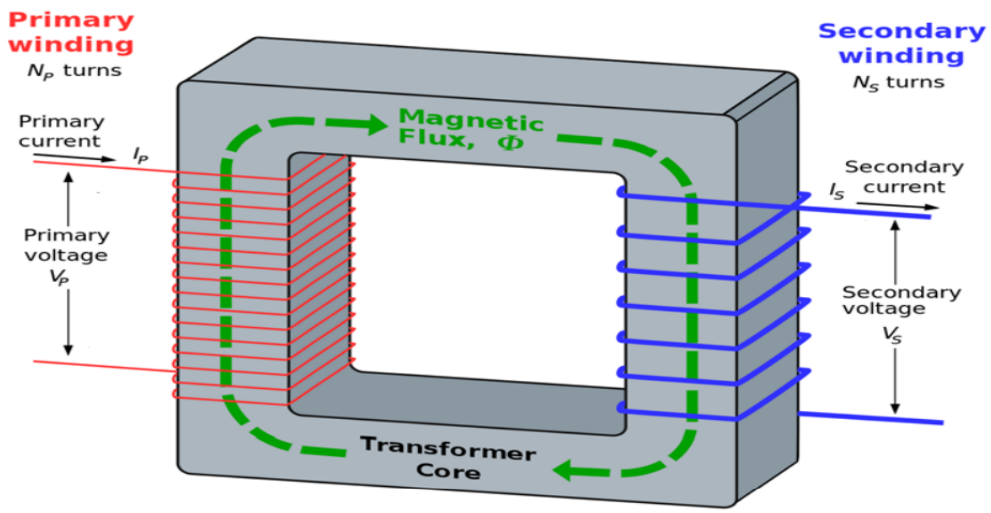
The principle of mutual induction states that when the two coils are inductively coupled and if the current in one coil changes uniformly then an EMF is induced in the other coil as per the

Faraday's laws of electromagnetic induction.

According to the faraday's laws of electromagnetic induction ,whenever a conductor cuts the magnetic flux then an EMF induced in the conductor.



The type of EMF induced in the transformer is statically induced EMF.

Statically Induced EMF:

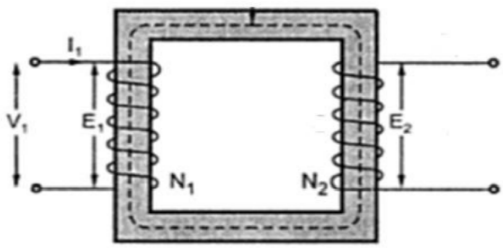
It is the EMF induced in the conductor when a stationary conductor cuts (or) links the alternating flux.

➢The magnitude of the Statically induced EMF is given by Faraday's Second Law.

Faraday's Second Law:

➢The induced EMF in the conductor is directly proportional to the rate of change of flux linkages.

$$EMF(E) \alpha d\Phi/dt$$



➢The direction of the statically induced EMF is given by Lenz's law.

➢Lenz's Law: Induced EMF in the conductor gives a current which produces a magnetic flux to oppose the change in main field flux.

$$EMF(E) = - Nd\Phi/dt$$

➢ Where, minus sign from Lenz's Law.

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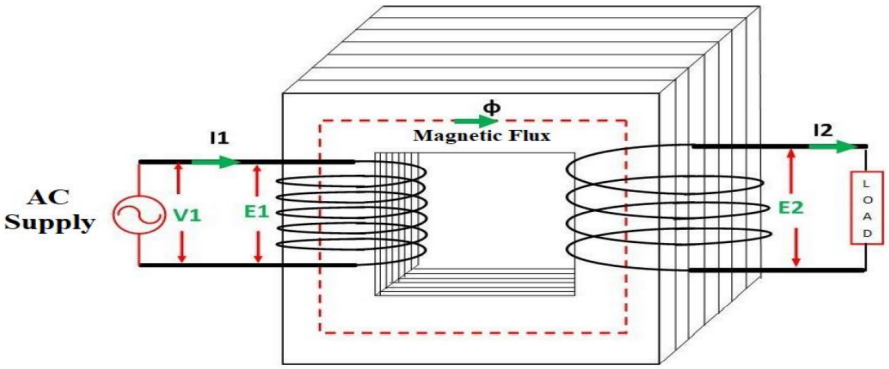
Operation of Transformer



When the AC supply is applied across the primary winding, an alternating current is flowing through the winding which produces a time varying magnetic flux.

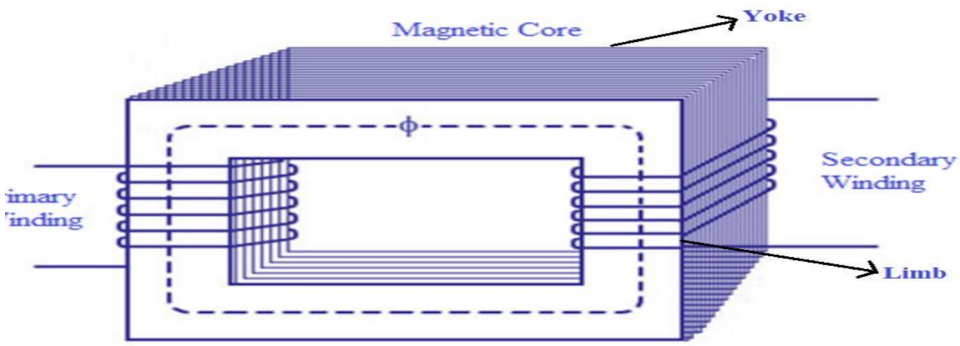
This time varying magnetic flux gets associated with the secondary winding through the magnetic core.

Hence, the magnetic flux which is linked with the secondary coil changes.

When the secondary winding cuts the magnetic flux then an EMF is induced in the secondary winding.

b) Explain about the construction of single-phase Transformer.

Construction of Transformer



A:

The main parts of the transformer are

1) Magnetic Core

2) Windings or Coils

Magnetic Core:

The core of the transformer is either square or rectangular type in shape.

The vertical part of the core is called as limb and the horizontal part of the core is called as yoke.

Primary and secondary coils(windings) are wound on the limb.

Core is made of laminated type of construction to reduce the eddy current losses.

Core is made up of Cast Iron (or) Cast Steel (or) Silicon steel.

Generally high grade Silicon steel of laminations (0.3 mm to 0.5 mm) is used.

Windings:

Conducting material is used in the windings of transformer.

The coils(windings) are wound on the limbs and insulated from each other.

Two different windings are wound on two different limbs.

Windings are made up of copper or aluminum.

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To reduce the leakage flux it is necessary that the windings should be very close to each other.
As the leakage flux decreases then the efficiency of the transformer increases.

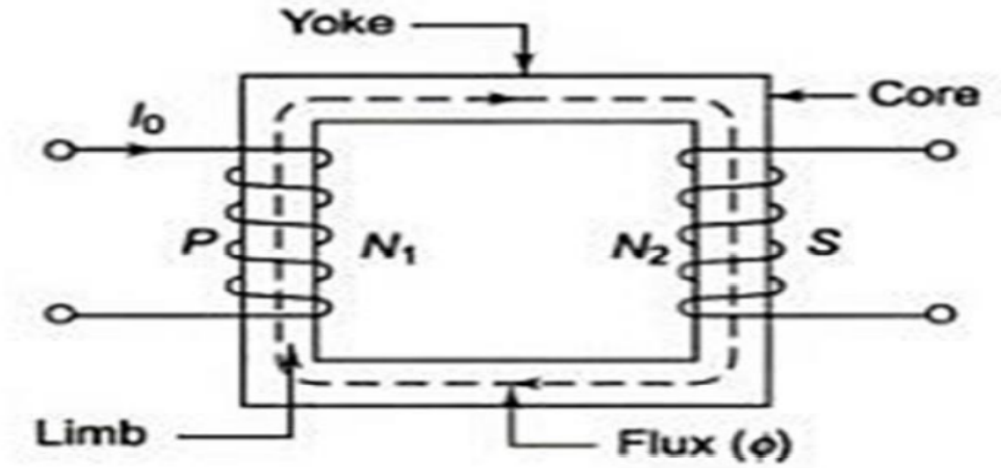
Types of Transformers:

Based on the construction the transformers are divided in to

Core type transformer

Shell type transformer

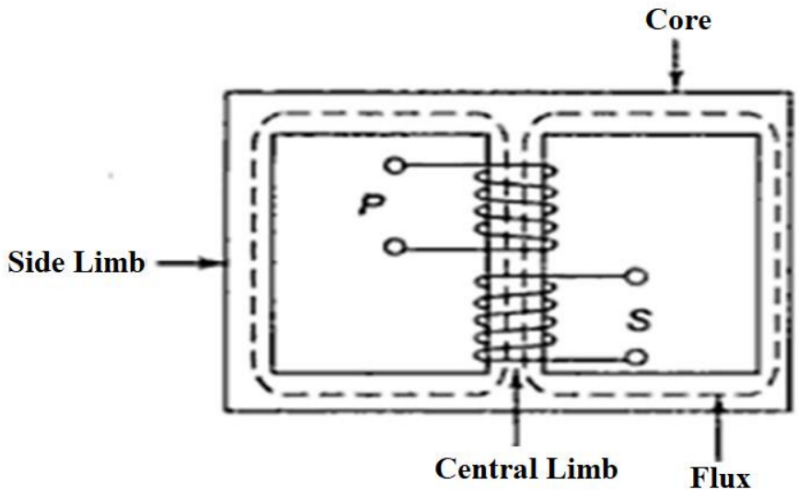
Core Type Transformer



In core type transformer winding surrounds the core of the transformer.

- ➢ This transformer has two limbs.
- ➢ There is more leakage flux.
- ➢ There are more copper losses and less core losses.
- ➢ It requires less insulation.
- ➢ There is a low mechanical strength.
- ➢ It is used for high voltage and low current applications

Shell Type Transformer



In shell type transformer core surrounds the windings.

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➢ It has three limbs and coils(windings) are wound on the central limb.
➢ There is less leakage flux.
➢ There are less copper losses and more core losses.
➢ It requires more insulation.
➢ There is high mechanical strength.
➢ It is used for low voltage and high current applications.

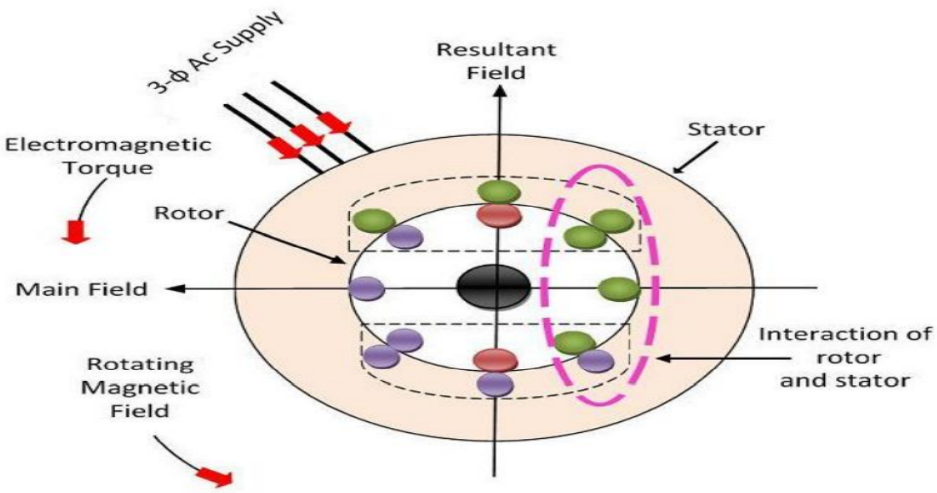
3. a) Explain working principle and operation of Induction motor.

A: Induction Motor:

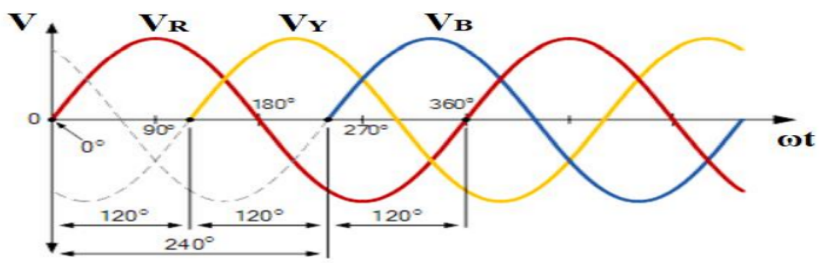
It is a machine which converts the electrical energy (in the form of AC voltage) to mechanical energy.

In an induction motor, the electric current in the rotor needed to produce torque is obtained via electromagnetic induction from the rotating magnetic field of the stator winding

Principle of Operation



3-Phase Supply



An induction motor works based on principle of electromagnetic induction.

When a balanced three phase supply (Displaced 120 degrees form each other) is given to the three phase stator winding of the induction motor, a rotating magnetic field of constant magnitude is developed around the stator which rotates at synchronous speed.

$$N_s = \frac{120f}{P} \quad rpm$$

Where ,
f = Supply frequency.
P = Number of poles.
NS =Synchronous speed in rpm.
The rotating magnetic field passes through the air gap and cuts the rotor conductors which are stationary.

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Due to the relative speed between the stationary rotor conductors and the rotating magnetic field, an EMF induced in the rotor conductors according to the Faraday's laws of electromagnetic induction.

As the rotor conductors are short circuited, current starts flowing through it.

As the current carrying rotor conductors are placed in the magnetic field produced by the stator, they experiences a mechanical force i.e torque.

This torque moves the rotor in the same direction as that of the rotating magnetic field.

b) Explain working principle and operation of Alternator.

A: Alternator

The machine which produces 3 phase power from mechanical power is called an alternator or synchronous generator. The working of an alternator is based on the principle that when the flux linking a conductor changes, an emf is induced in the conductor.

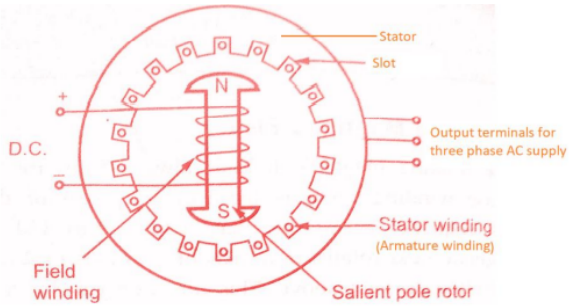
Alternators are the primary source of all the electrical energy we consume. These machines are the largest energy converters found in the world. They convert mechanical energy into AC energy.

Working Principle of an Alternator

An alternator operates on the same fundamental principle of faraday's law of electromagnetic induction as a DC generator. Like a DC generator, an alternator also has an armature winding and a field winding. But there is one important difference between the two. Whereas in d.c. generators, the armature rotates and the field system is stationary, the arrangement in alternators is just the reverse of it. In their case, standard construction consists of armature winding mounted on a stationary element called stator and field windings on a rotating element called rotor.

Principle of operation of an Alternator:

The stator consists of a cast-iron frame, which supports the armature core, having slots on its inner periphery for housing the armature conductors. The rotor is like a flywheel having alternate N and S poles fixed to its outer rim. The magnetic poles are excited (or magnetised) from direct current supplied by a D.C. source at 125 to 600 volts. In most cases, necessary exciting (or magnetising) current is obtained from a small D.C. shunt generator which is belted or mounted on the shaft of the alternator itself. Because the field magnets are rotating, this current is supplied through two sliprings. As the exciting voltage is relatively small, the slip-rings and brush gear are of light construction. Recently, brushless excitation systems have been developed in which a 3-phase A.C. exciter and a group of rectifiers supply D.C. to the alternator. Hence, brushes, slip-rings and commutator are eliminated.



Fig(i): Three phase alternator

When the rotor rotates, the stator conductors(being stationary) are cut by the magnetic flux, hence they have induced E.M.F. produced in them. Because the magnetic poles are alternately N and S, they induce an e.m.f. and hence current in armature conductors, which first flows in one direction and then in the other. Hence, an alternating e.m.f. is produced in the stator conductors(i) whose frequency depends on the number of N and S poles moving past a conductor in one second and (ii) whose direction is given by Fleming's Right-hand rule and frequency is given by;

$f = PNS / 120$

where, NS = speed of the rotor in r.p.m.

P = number of rotor poles

The magnitude of the voltage induced in each phase depends upon the rotor flux, the number and position of the conductors in the phase and the speed of the rotor.

When the rotor is rotated, a 3-phase voltage is induced in the armature winding. The magnitude of induced

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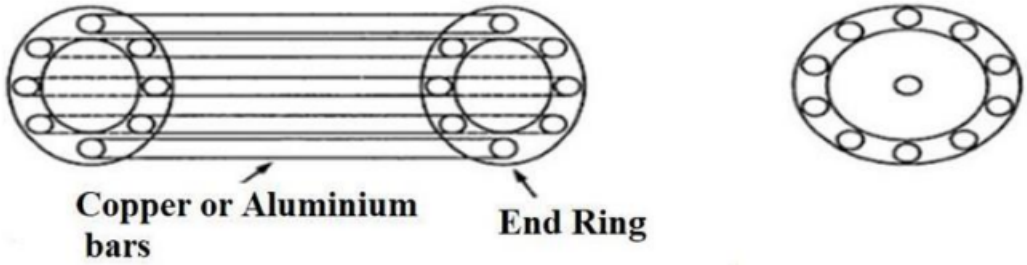
e.m.f. depends upon the speed of rotation and the DC exciting current. The magnitude of e.m.f. in each phase of the armature winding is the same. However, they differ in phase by 120° electrical.

4. a) Explain about squirrel cage and slip-ring induction motors.

A:) Squirrel Cage Rotor:

Motors employing this type of rotor are known as squirrel cage induction motor. Almost 90 percentage of induction motors are squirrel cage type, because this type of rotor has the simplest and most rugged construction. The Rotor consists of cylindrical laminated core with parallel slots for carrying the rotor conductors. Rotor consists of heavy bars of copper or aluminium.

The Rotor bars are permanently short circuited on themselves. Hence, it is not possible to add any external Resistance in series with the Rotor circuit for starting purposes.



Fig(a): Structure of cage type rotor Fig(b): Symbolic representation

The rotor slots are not quite parallel to the shaft but are purposely given a slight skew. This is useful in two ways.

(i) It helps to make the motor run quietly by reducing the magnetic hum.

(ii) It helps in reducing the locking tendency of the rotor.

Advantages of squirrel cage rotor:

1. The cage rotor is cheaper and the construction is robust.
2. The absence of the brushes reduces the risk of sparking.
3. It's Maintenance is less.
4. The efficiency of the cage rotor is higher.

Phase Wound or Slip Ring Rotor:

Motors employing this type of rotor are widely known as "Phase Wound" induction motors or "Slip Ring" induction motors. This type of rotor is provided with 3-phase, double layer, distributed winding consisting of coils. The Rotor is wound for as many poles as the number of stator poles. The three phases are shorted internally. The other three winding terminals are slip rings mounted on the shaft with brushes resting on them. These three brushes are further externally connected to a 3-phase star connected rheostat. This makes possible the introduction of additional resistance in the rotor circuit during the starting period for increasing the starting torque of the motor. When running under normal conditions, sliprings are automatically short circuited.

Advantages of Phase Wound Rotor:

i) High starting torque and low starting current.

ii) For controlling the speed of the motor, an external resistance can be added in the circuit.

b) Explain about Salient pole and cylindrical rotor alternators.

A: 1. Salient pole type: In this type, salient or projecting poles are mounted on a large circular steel frame which is fixed to the shaft of the alternator as shown in Fig. (1). The individual field pole windings are connected in series in such a way that when the field winding is energized by the d.c. exciter, adjacent poles have opposite polarities.

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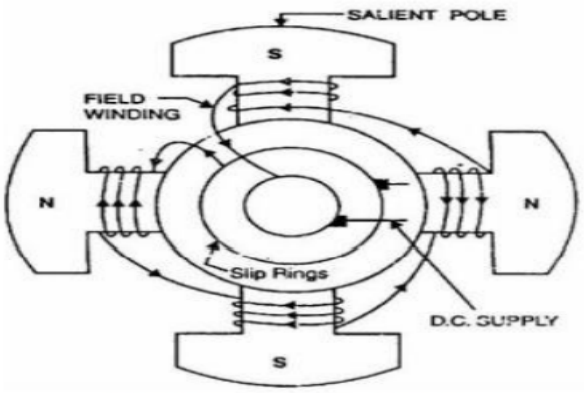

Fig. 1. Salient Pole Rotor

Low and medium-speed alternators (120-400 r.p.m.) such as those driven by diesel engines or water turbines have salient pole type rotors due to the following reasons: (a) The salient field poles would cause an excessive windage loss if driven at high speed and would tend to produce noise. (b) Salient-pole construction cannot be made strong enough to withstand the mechanical stresses to which they may be subjected at higher speeds. Since a frequency of 50 Hz is required, we must use a large number of poles on the rotor of slow-speed alternators (Used in hydro turbines and Diesel Engines). Low- speed rotors always possess a large diameter to provide the necessary spate for the poles. Consequently, salient-pole type rotors have large diameters and short axial lengths.

2.Non-salient pole type: In this type, the rotor is made of smooth solid forged-steel radial cylinder having a number of slots along the outer periphery. The field windings are embedded in these slots and are connected in series to the slip rings through which they are energized by the d.c. exciter. The regions forming the poles are usually left unslotted as shown in Fig. (2). It is clear that the poles formed are non-salient i.e., they do not project out from the rotor surface.

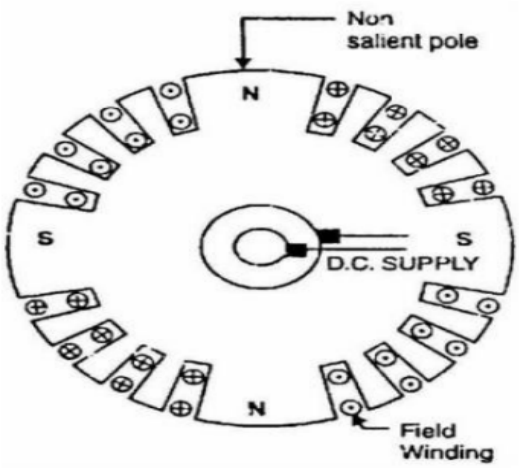

Fig. 2. Cylinderical Rotor

High-speed alternators (1500 or 3000 r.p.m.) are driven by steam turbines and use non-salient type rotors due to the following reasons: a. This type of construction has mechanical robustness and gives noiseless operation at high speeds. b. The flux distribution around the periphery is nearly a sine wave and hence a better e.m.f. waveform is obtained than in the case of salient pole type. Since steam turbines run at high speed and a frequency of 50 Hz is required, we need a small number of poles on the rotor of highspeed alternators (also called turboalternators) (Used with steam tubines). We can use not less than 2 poles and this fixes the highest possible speed. For a frequency of 50 Hz, it is 3000 r.p.m. The next lower speed is 1500 r.p.m. for a 4-pole machine. Consequently, turboalternators possess 2 or 4 poles and have small diameters and very long axial lengths

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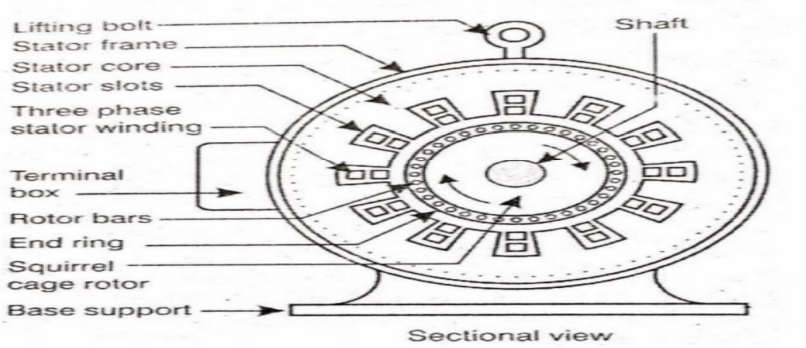
5. Explain about the construction of Induction motor and Alternator.

A: Construction of an Induction motor:

An induction motor essentially consists of two main parts:

a) Stator and b) Rotor.



Construction of Stator:

It has three main parts,

i) Stator frame (or) Outer frame

ii) Stator core

iii) Stator winding

i) Stator frame (or) Outer frame:

It is the outer body of the motor and made up of cast Iron. It gives the mechanical support to the stator core and protects the inner parts of the machine.

ii) Stator core:

The stator core is made up of thin sheets of silicon steel laminations. The laminated stator core has slots to carry the three-phase stator winding. The laminations are insulated from each other usually by a varnish layer. The thickness of the lamination usually varies from 0.3mm to 0.5mm.

iii) Stator winding:

The core of the stator carries three phase windings which are usually supplied from a threephase supply system. The six terminals of the windings (two of each phase) are connected in the terminal box of the machine. The stator winding of the motor is wound for a definite number of poles, depending on the speed of the motor. If the number of poles is greater, the speed of the motor will be less and if the number of poles is less than the speed will be high. When a balanced three phase is given to the three-phase stator winding, a rotating magnetic field is produced.

Construction of Rotor:

The rotor is built of thin laminations of silicon steel material. The laminated cylindrical core is mounted directly on the shaft. These laminations are slotted on the outer side to receive the rotor conductors. There are two types of rotors mentioned as follows:

(i) Squirrel Cage Rotor

(ii) Phase Wound (or) Slip Ring Rotor

i) Squirrel Cage Rotor:

Motors employing this type of rotor are known as squirrel cage induction motor. Almost 90 percentage of

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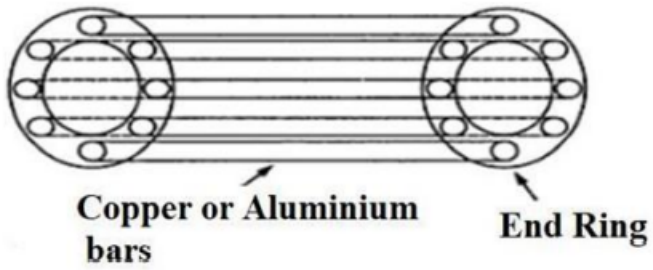
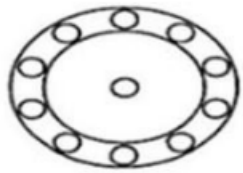
induction motors are squirrel cage type, because this type of rotor has the simplest and most rugged construction. The Rotor consists of cylindrical laminated core with parallel slots for carrying the rotor conductors. Rotor consists of heavy bars of copper or aluminium.

The Rotor bars are permanently short circuited on themselves. Hence, it is not possible to addany external Resistance in series with the Rotor circuit for starting purposes.



Fig(a): Structure of cage type rotor



Fig(b): Symbolic representation

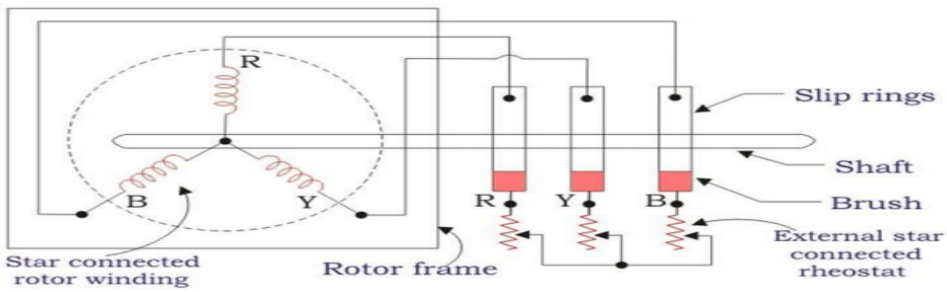
Fig(a): Structure of cage type rotor Fig(b): Symbolic representation

The rotor slots are not quite parallel to the shaft but are purposely given a slight skew. This is useful in two ways.

(i) It helps to make the motor run quietly by reducing the magnetic hum.

(ii) It helps in reducing the locking tendency of the rotor.

ii) Phase Wound or Slip Ring Rotor:



Motors employing this type of rotor are widely known as “Phase Wound” induction motors or “Slip Ring” induction motors. This type of rotor is provided with 3-phase, double layer, distributed winding consisting of coils. The Rotor is wound for as many poles as the number of stator poles. The three phases are shorted internally. The other three winding terminals are slip rings mounted on the shaft with brushes resting on them. These three brushes are further externally connected to a 3-phase star connected rheostat.

This makes possible the introduction of additional resistance in the rotor circuit during the Starting period for increasing the starting torque of the motor. When running under normal conditions, sliprings are automatically short circuited.

Construction of an Alternator:

An alternator has 3-phase winding on the stator and a d.c. field winding on the rotor.

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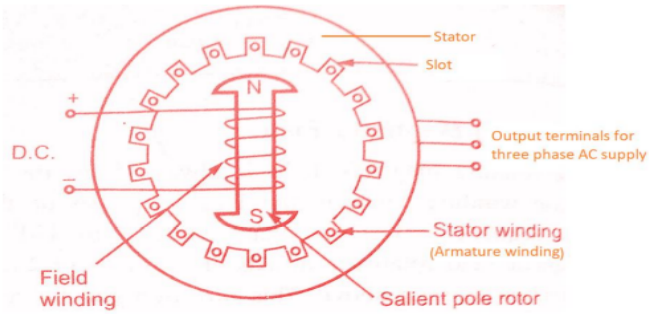
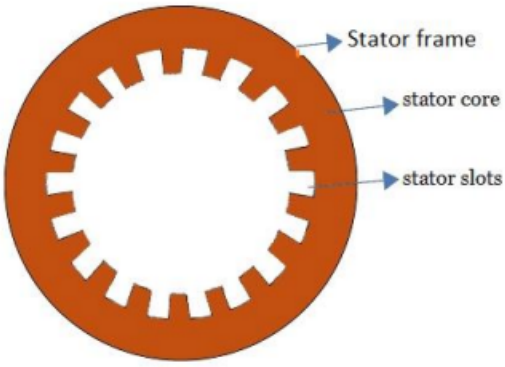


Fig(ii): Construction of an alternator

Fig(ii): Construction of an alternator

a. Stator:

It is the stationary part of the machine and is built up of silicon steel laminations having slots on its inner periphery. A 3-phase winding is placed in these slots and serves as the armature winding of the alternator. The armature winding is always connected in star and the neutral is connected to ground.



Fig(iii): Staor

Fig(iii): Stator

b. Rotor:

The rotor carries a field winding which is supplied with direct current through two slip rings by a separate d.c. source. This d.c. source (called exciter) is generally a small d.c. shunt or compound generator mounted on the shaft of the alternator. Rotor construction is of two types, namely;

1. Salient (or projecting) pole type

2. Non-salient (or cylindrical) pole type.

1. Salient pole type: In this type, salient or projecting poles are mounted on a large circular steel frame which is fixed to the shaft of the alternator as shown in Fig. (1). The individual field pole windings are connected in series in such a way that when the field winding is energized by the d.c. exciter, adjacent poles have opposite polarities.

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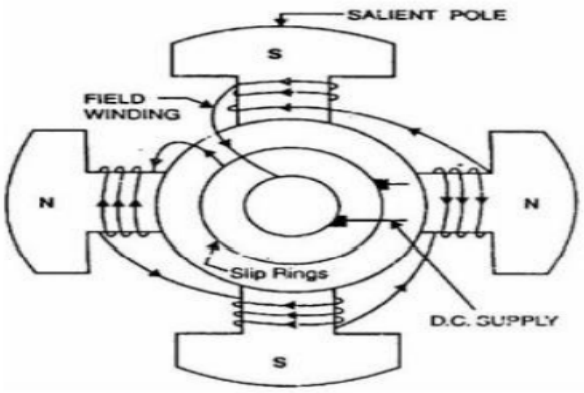

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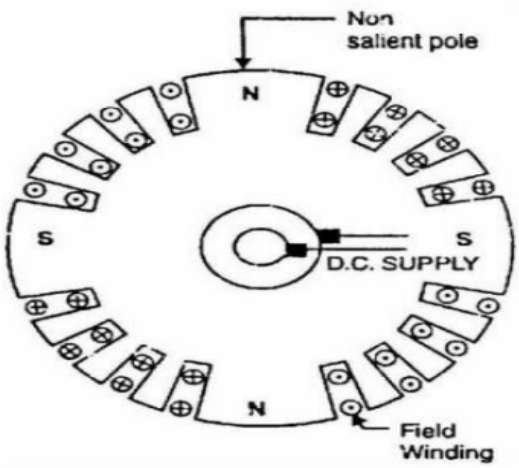

Fig. 2. Cylinderical Rotor

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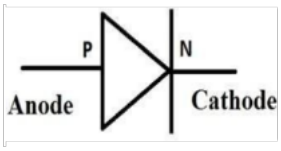
UNIT-IV

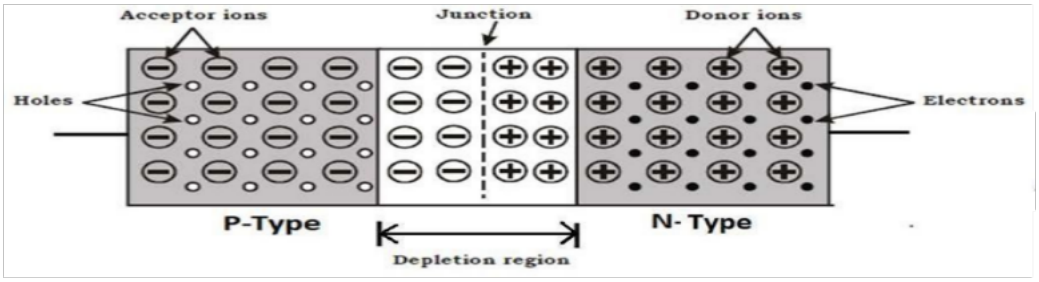
1. a) Explain the construction, operation and V-I characteristics of P-N Junction diode.

Ans: P-N JUNCTION DIODE

A P-N junction diode is two-terminal or two- electrode semiconductor device. When a P-Type semiconductor is suitably joined to N-Type semiconductor, the contact surface is called as P-N Junction.



Construction:



When the P-Type and N-Type semiconductors are joined, at the junction, there is a tendency for the free electrons to diffuse from N-side to P-side and holes from P-side to N-side.

Once holes enter into the N-region, they will recombine with donor ions.

The electrons spreading from N-region to P-region recombine with the acceptor ions in P-region.

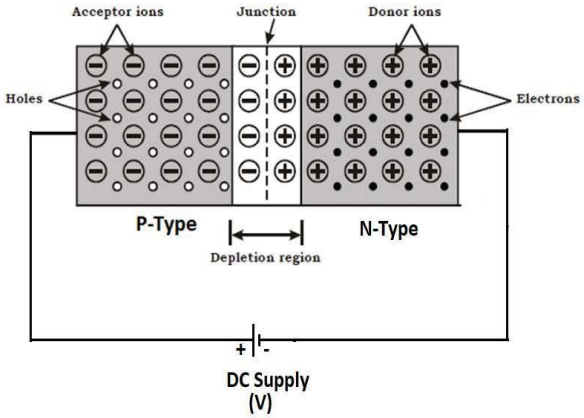
As a result, a large number of positively charged ions are produced at the junction on the N-side and a large number of negatively charged ions are produced at the junction on P-side.

This situation soon prevents the further diffusion due to positive charge on N-side repels the holes to cross the junction and negative charge on P-side repels the electrons to cross the junction.

Thus a barrier is set up against the further movement of charge carriers i.e., holes and electrons. This is called as potential barrier or depletion region.

OPERATION OF P-N JUNCTION DIODE

Forward Bias:



When the P-type is connected to the positive terminal and N- type is connected to the negative terminal of the supply then that is said to be forward bias. Holes are repelled by the positive terminal of the supply and electrons are repelled by the negative terminal of the supply. Hence, the width of the depletion region decreases. At certain forward voltage, the width of the depletion region becomes zero, then diode starts conducting. This voltage is called as cut-in voltage. After cut-in voltage ,the current through the diode increases non-linearly. Cut-in voltage is

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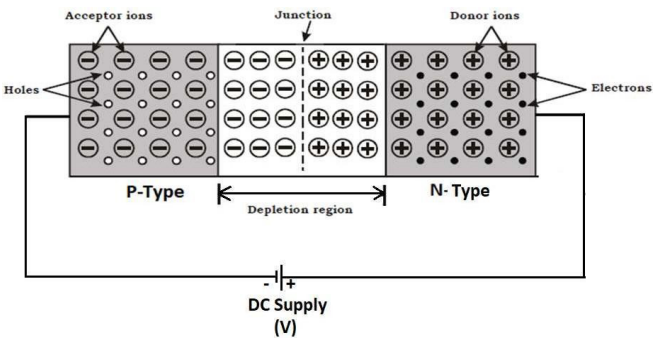
0.7V for silicon and 0.3V for germanium.

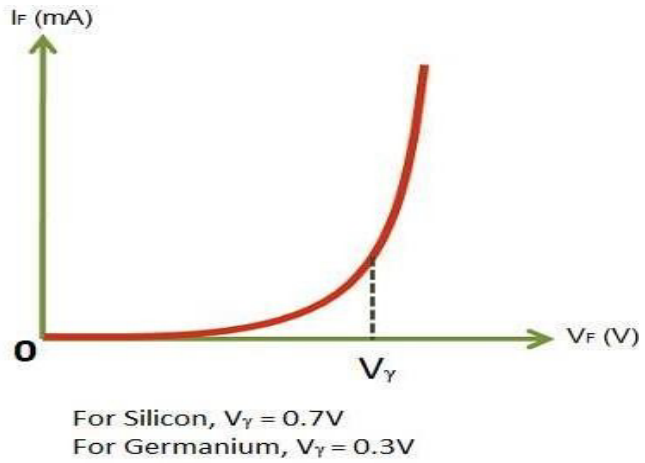
Reverse Bias:



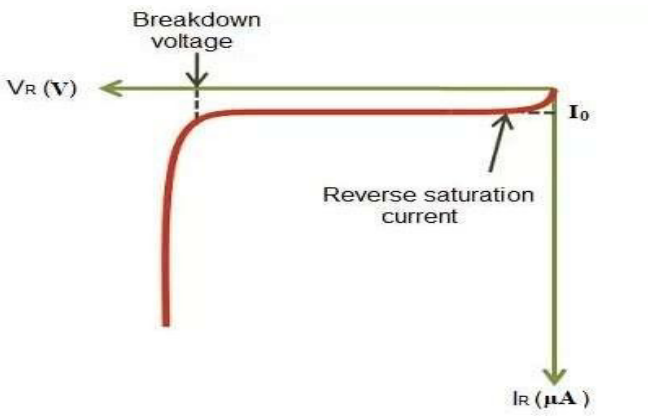
When the P-type is connected to the negative terminal and N- type is connected to the positive terminal of the supply then that is said to be reverse bias. Holes are attracted by the negative terminal of the supply and electrons are attracted by the positive terminal of the supply. Hence, the width of the depletion region increases. A small amount of current i.e., reverse saturation current flows through the diode due to flow of minority charge carriers. At certain reverse voltage, the reverse breakdown occurs(Avalanche breakdown), the current through the diode increases rapidly. This voltage is called as reverse breakdown voltage.

v-I characteristics

forward bias :

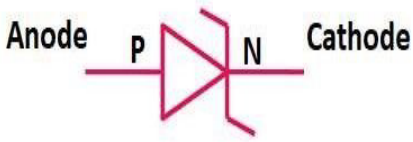


Reverse bias:



b) Explain the construction, operation and V-I characteristics of Zener diode.

Ans: ZENER DIODE: A Zener diode is a heavily doped silicon P-N junction semiconductor device that is designed to operate in the reverse bias condition . Heavily doped means the high level impurities are added to the material for making it more conductive.



In other words, the diode which is specially designed for optimizing the breakdown region is known as the Zener diode. Zener diode acts like normal P-N junction diode under forward biased condition.

The depletion region of the Zener diode is very thin as it is heavily doped. As it is heavily doped the intensity of the electric field across the depletion region is high even for the small reverse voltage.

Construction:

The operation of a Zener diodes depends up on the doping level of the PN junction. The depletion region is

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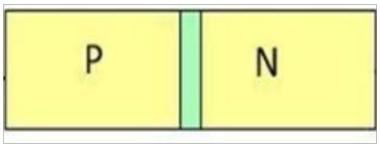
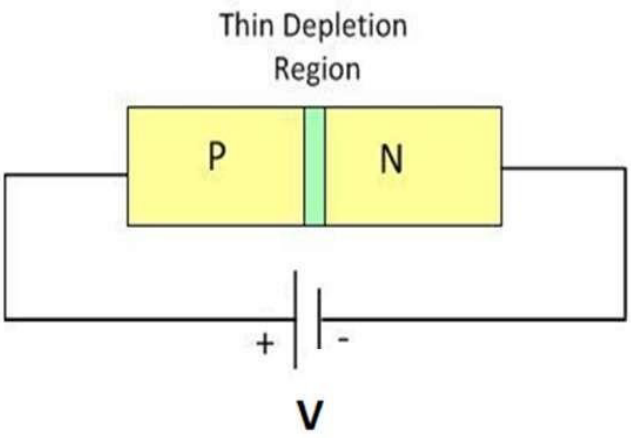
very thin and the electric field is very high even for a small reverse bias voltage. And it allows the electron to move from the valence band of p-type material to the conduction band of the N-type material.

The break down voltage of a diode can be accurately control at the time of the doping level. The breakdown voltage of a commonly available Zener diode.



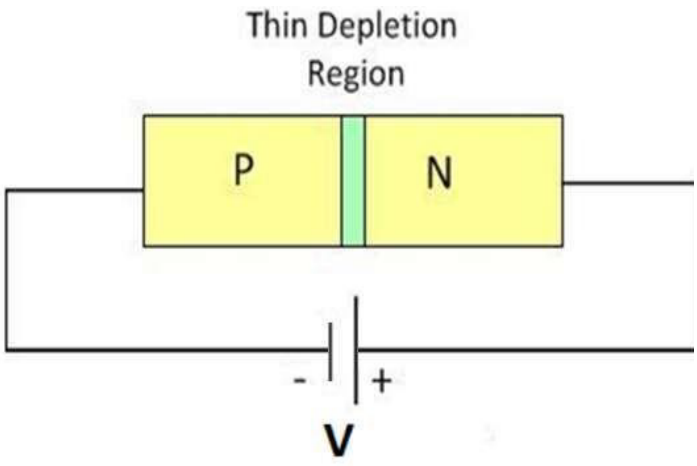
OPERATION OF ZENER DIODE

Forward bias:



When the P-type is connected to the positive terminal and N- type is connected to the negative terminal of the supply then that is said to be forward bias. Holes are repelled by the positive terminal of the supply and electrons are repelled by the negative terminal of the supply. Hence, the width of the depletion region decreases. At certain forward voltage, the width of the depletion region becomes zero, then diode starts conducting. This voltage is called as cut-in voltage which is less than P-N junction diode. After cut-in voltage ,the current through the Zener diode increases non-linearly.

Reverse bias:



When the P-type is connected to the negativeterminal and N- type is connected to the positive terminal of the supply then that is said to be reverse bias. When reverse biased voltage is applied to the Zener diode, it allows only a small amount of leakage current(reverse saturation current) until the voltage is less than Zener voltage. When reverse voltage reaches Zener voltage, Zener breakdown occurs, it starts allowing large amount of electric current. At this point, a small increase in reverse voltage will rapidly increase the electric current.

V- I Characteristics

Forward bias

Reverse bias:

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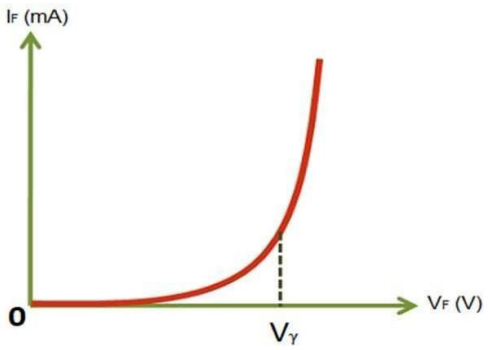
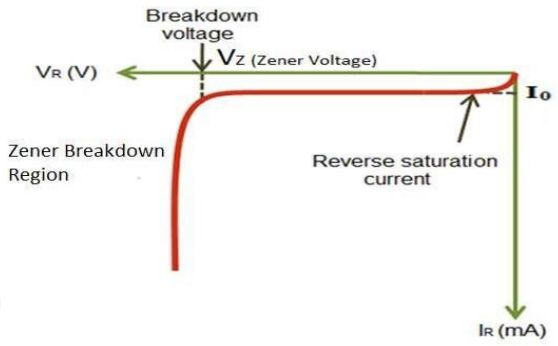
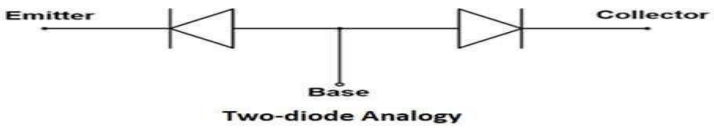


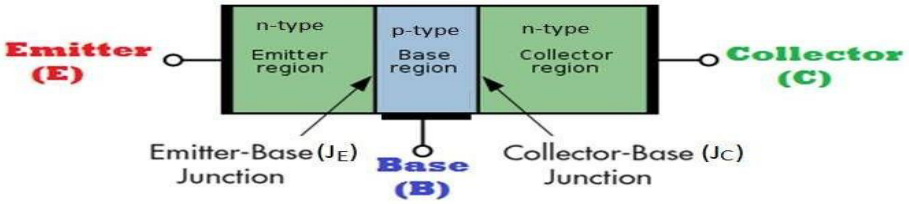


2. a) Explain the construction and operation of NPN transistor.

Ans: N P N T R A N S I S T O R



C O N S T R U C T I O N O F N P N T R A N S I S T O R :

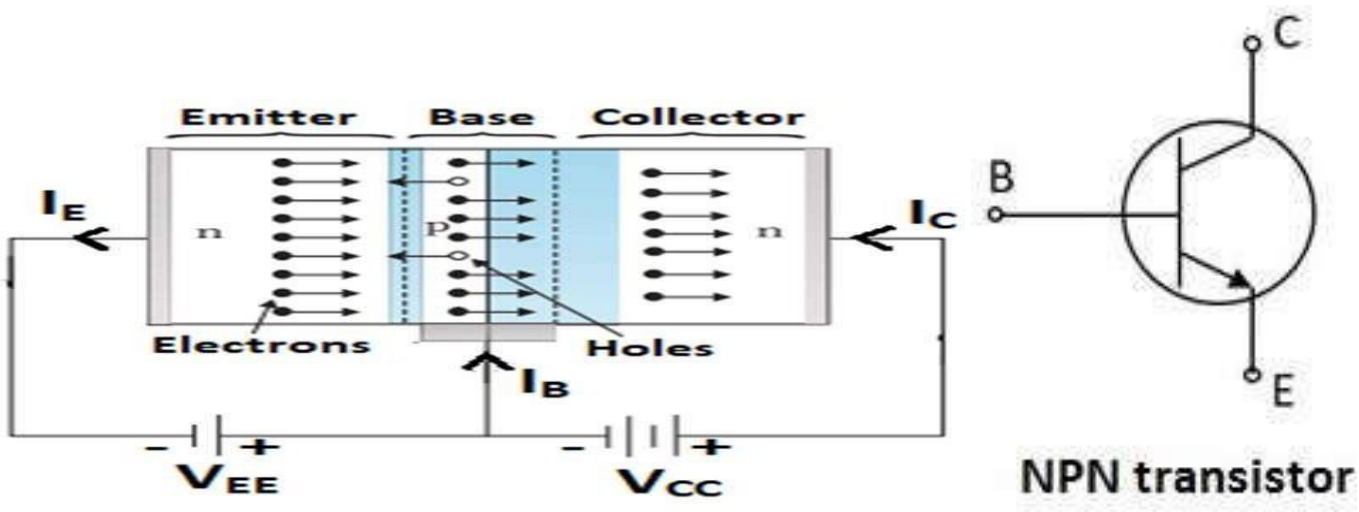


A NPN transistor is constructed by sandwiching a P-Typesemiconductor between two N-type semiconductors. The NPN transistor behaves like two P-N junctions diodes connected back to back.

These back to back P-N junction diodes are known as the emitter-base junction and collector-base junction.

The Emitter is heavily doped N-Type region, Base is lightly doped P-Type region and Collector is moderately doped N-type region. Therefore, the depletion region at both junctions penetrates more towards the Base region.

W O R K I N G O F N P N T R A N S I S T O R :



The Emitter-Base junction is connected in forward bias and the Collector- Base junction is

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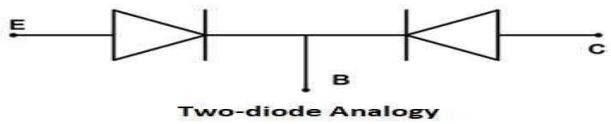
connected in reverse bias. Therefore,the depletion region at Emitter-Base junction is narrow and the depletion region at Collector-Base junction is wide. As the emitter-base junction is forward biased, a very large number of electrons from emitter region will cross the depletion region and enter into the base region. Simultaneously, a very few number of holes will enter into the emitter region from the base region and these holes will rec The loss of electrons in the emitter region is equal to the number of holes present in the base region. But the number of holes in the base region is very small as it is a lightly doped and thin region. Therefore, almost all electrons of emitter will cross the depletion region and enter into the base region. Because of the movement of electrons, the current will flow through the Emitter-Base junction. This current is known as emitter current (I_E). The electrons are majority charge carriers to flow the emitter current.The remaining electrons which do not recombine with holes in base region will further travel to the Collector. The collector current (I_C) flows through the Collector-Base region due to flow of electrons. combine with the electrons.

APPLYING KIRCHHOFF'S CURRENT LAW(KCL), THE EMITTER CURRENT ISGIVEN BY

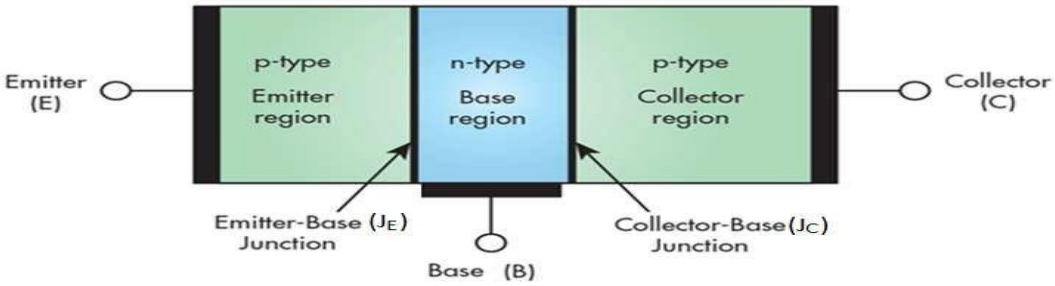
$$I_E = I_B + I_C$$

b) Explain the construction and operation of PNP transistor.

Ans: PNP TRANSISTOR



CONSTRUCTION OF PNP TRANSISTOR:



A PNP transistor is constructed by sandwiching an N-type semiconductor between two P-type semiconductors. The PNP transistor behaves like two PN junctions diodes connected back to back. These back to back PN junction diodes are known as the collector- base junction and base-emitter junction. The Emitter is heavily doped P-Type region, Base is lightly doped N-Type region and Collector is moderately doped P-type region. Therefore, the depletion region at both junctions penetrates more towards the Base region.

WORKING OF PNP TRANSISTOR:

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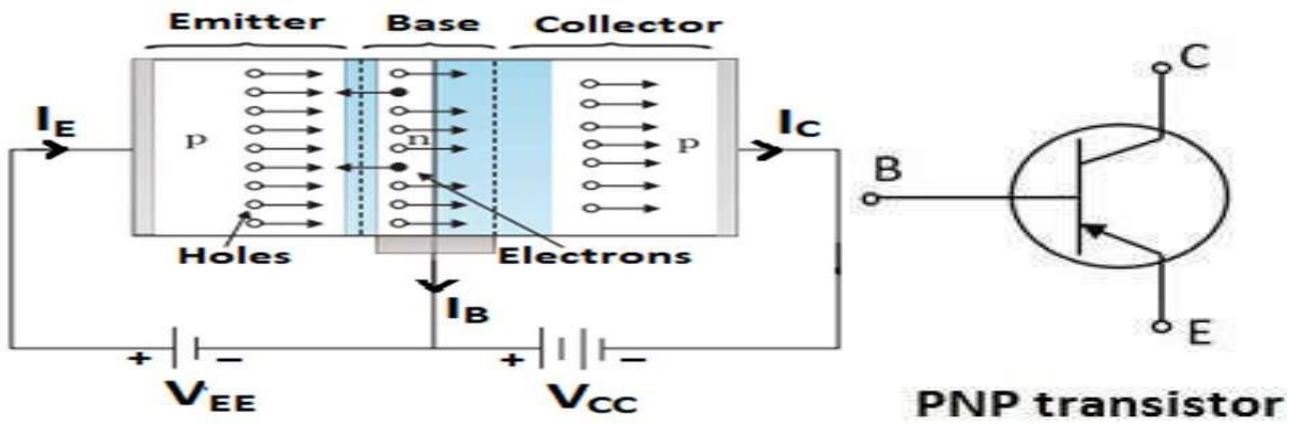

The Emitter-Base junction is connected in forward bias and the Collector-Base junction is connected in reverse bias. Therefore,the depletion region at Emitter-Base junction is and the depletion region at Collector-Base junction is wide. As the Emitter-Base junction is forward biased, a very large number of holes from emitter region will cross the depletion region and enter into the Base region. Simultaneously, a very few number of electrons will enter into the emitter region from the base region and these electrons will recombine with the holes.

The loss of holes in the emitter region is equal to the number of electrons present in the base region.

But the number of electrons in the base region is very small as it is a lightly doped and thin region.

Therefore, almost all holes of emitter will cross the depletion region and enter into the base region.

Because of the movement of holes, the current will flow through the Emitter-Base junction. This current is known as emitter current (I_E). The holes are majority charge carriers to flow the emitter current. The remaining holes which do not recombine with electrons in base region will further travel to the collector. The collector current (I_C) flows through the Collector-Base region due to flow of holes.

APPLYING KIRCHHOFF'S CURRENT LAW(KCL), THE EMITTER CURRENT IS GIVEN BY

$$I_E = I_B + I_C$$

3. Explain about Avalanche and Zener Breakdown Mechanisms.

Ans: Avalanche Breakdown :

When a high value of reverse voltage is applied to the P-N junction, the free electrons gain sufficient energy and accelerate at high velocities.

These free electrons moving at high velocity collides other atoms and knocks off more electrons.

Due to this continuous collision, a large number of free electrons are generated as a result of electric current in the diode rapidly increases.

This is called as avalanche breakdown.

Static Resistance (DC Resistance): It is the resistance offered by the diode in the forward bias to

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the flow of DC current. From the forward bias characteristics, the static resistance is given by

Static Resistance (Rs) = (Forward voltage diode/)Forward current through the diode

$$Rs = VF/IF$$

Dynamic resistance (AC Resistance): It is the resistance offered by the diode in the forward bias to the flow of AC current.From the forward bias characteristics the dynamic resistance is given by

Dynamic resistance (r_f) = Change in forward voltage/Change in forward current.

$$r_f = \Delta VF/\Delta IF$$

Reverse resistance: It is the resistance offered by the diode in the reverse bias to the flow of reverse saturation current. From the reverse characteristics it is given by

Reverse resistance (Rr) = Reverse voltage across the diode/Reverse saturation current.

$$Rr = V_R/I_0$$

Zener Breakdown:

The Zener breakdown occurs in heavily doped P-N junction diode because of its narrow depletion region.

When reverse biased voltage applied to the diode is increased, the narrow depletion region generates strong electric field.

When reverse biased voltage applied to the diode reaches the zener voltage, the electric field in the depletion region is strong enough to pull electrons from their valence band.

The valence electrons which gains sufficient energy from the strong electric field will break the bonding with the parent atom.

The valance electrons which breaks the bonding with parent atom will become free electrons. Hence, the current increases rapidly.

This is called as zener breakdown.

Zener breakdown occurs in Zener diode with Zener voltage (V_z) less than 6V.

4. Explain the operation and Input and Output characteristics of BJTin CB configuration.

Ans: COMMON BASE CONFIGURATION (C.B):

- The base is at ground potential. So this is known as Common Base Configuration or Grounded Base Configuration.
- Emitter and Collector Voltages are measured with respect to the base.

The convention is currents, entering the transistor are taken as positive and those leaving the transistor as negative.

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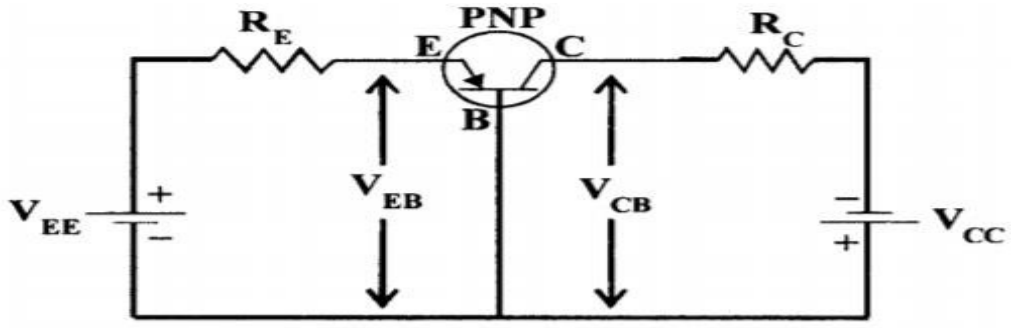


Common base amplifier circuit.

- For a PNP transistor, holes are the majority carriers. Emitter Base Junction is Forward Biased. Since holes are entering the base or I_E is positive.
- Holes through the base reach collector. I_C is flowing out of transistor. Hence Ic is negative; similarly I_B is negative.

Transistor Characteristics in Common Base Configuration:

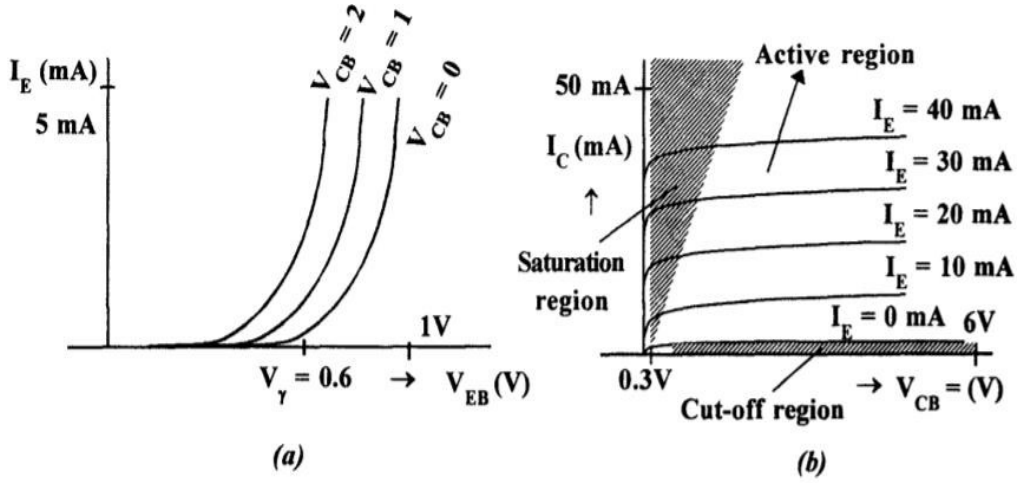
- The three regions in the output characteristics of a transistor are

1. Active region
2. Saturation region
3. Cut off region

1.The input and output characteristics for a transistor in C.B configuration are as shown in Fig. (a) and (b). When $I_E = 0$, the emitter is open circuited. So the transistor is not conducting and the I_{CBO} not considered.

2.Generally the transistor is not used in this mode and it is regarded as cut off region.; Even though I_{CBO} is present it is very small for operation.

3.During the region OA, for a small variation of V_{BC} there is very large, change in current Ic with I_E. So current is independent of voltage. There is no control over the current. Hence the transistor can not be operated in this region. So it is named as Saturation region.



(a) Input characteristics in C.B configuration

(b) Output characterisitics in C.B configuration.

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- The literal meaning of saturation should not be taken. The region to the right is called active region.
- For a given V_{CB}. with I_E increased, there is no appreciable change in I_C. It is in saturation.
- When transistor is being used as a switch, it is operated between cut off and saturation regions.
- The decrease in base width with increase in collector reverse bias voltage is known as Early Effect.

- *Active Region – the transistor operates as an amplifier and Ic = β*Ib*
- *Saturation – the transistor is "Fully-ON" operating as a switch and Ic = I(saturation)*
- *Cut-off – the transistor is "Fully-OFF" operating as a switch and Ic = 0* Current Application Factor: It is the ratio of output current to the input current.

α = Output current /Input current. $\alpha = I_C / I_E$

In common base configuration, the collector current is given by

$I_C = \alpha I_E + I_{CBO}$

Where,

I_C = Collector current.

I_E = Emitter current.

I_{CBO}= Reverse saturation current flowing between collector and base when emitter is open.

α= Current amplification factor.

- ✔ *Common Base Configuration – has Voltage Gain but no Current Gain*

b) In a common base connection, the emitter current is 1mA. If the emitter circuit is open, the collector current is 50uA.Find the total collector current. Given that ὰ=0.92

4) b) In a common base connecting the emitter current is 1mA. if the emitter circuit is open, the collector current is 50μA. Find the total collector current. Given that $\alpha = 0.92$.

Sol: Given that,

$I_E = 1mA$

$\alpha = 0.92$

$I_{CBO} = 50\mu A$.

$\therefore I_C = \alpha I_E + I_{CBO}$

$= 0.92 \times 1 + 50 \times 10^{-3}$

$I_C = 0.97mA$

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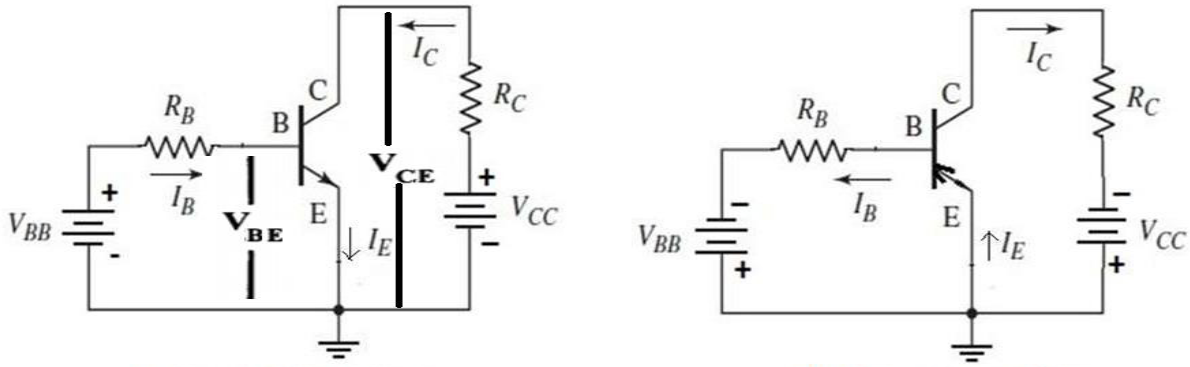
5. Explain the operation and Input and Output characteristics of BJT in CE configuration.

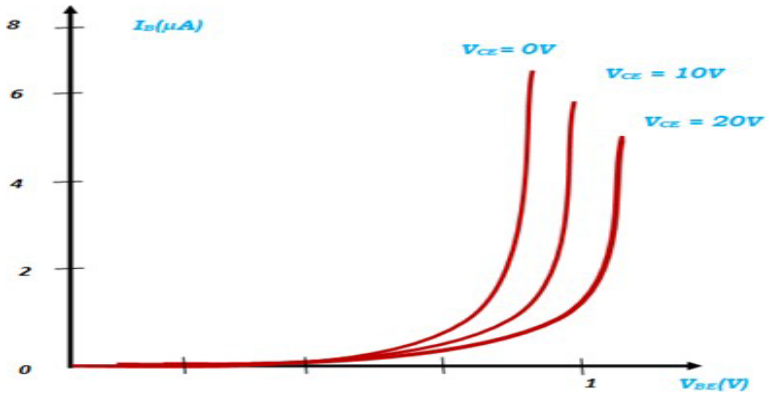
Ans: Common Emitter Configuration:

- Two terminals are needed for input and two terminals for output.
- Transistors have three terminals, so one terminal have to be taken as common terminal for both input and output.
- In Common Emitter configuration, emitter terminal is taken as common for both input and output.
- So input is given between base and the emitter terminals and output is taken between collector and emitter terminals. This is the most commonly used configuration.



(a) NPN TRANSISTOR (b) PNP TRANSISTOR

- **Common emitter configuration of NPN transistor**
- **Common emitter configuration of PNP transistor**
- Input voltage V_{BE} is applied between base and emitter terminals and output voltage V_{CE} is applied across emitter and collector. The output current I_C is taken at the collector terminal.
- The input side is forward biased and the output side is reverse biased.
- Emitter-base region acts like forward biased diode and so the depletion region is very small.
- Emitter-collector region acts like reverse biased diode and the depletion region is large.
- The input current I_B is measured in μA because the base region is very lightly doped.



- Input characteristics are the relationship between the input current (I_B) and the input voltage(V_{BE}) keeping output voltage(V_{CE}) constant

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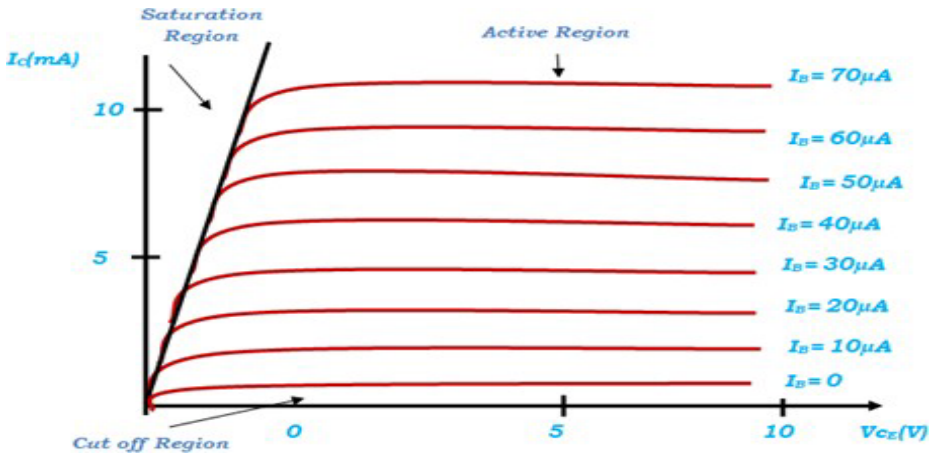

- Output characteristics is the relationship between the output current(I_C) and the output voltage(V_{CE}) keeping input current(I_B) constant
- Current Application Factor: It is the ratio of output current to the input current.
- β = Output Current /Input current.

  $\beta = I_C / I_B$
- In common emitter configuraiton,the collector current is given by

  $I_C = \beta I_B + I_{CEO}$

  Where,

  I_C = Collector current.

  I_B = Base current.

  I_{CEO}= Reverse saturation current flowing between collector and emitter when base is open.

  β = Current amplification factor.
- Relationship between α and β:

  The emitter current of transistor is given by $I_E = I_C + I_B$.....(1)

  From commonbase configuraton,we know that

  $I_C = \alpha I_E$ .....(2) Substituting equation (1) in (2) ,we get

  $I_C = \alpha (I_C + I_B)$

  $I_C = \alpha I_C + \alpha I_B$

  $I_C - \alpha I_C = \alpha I_B$

  $I_C (1-\alpha) = \alpha I_B$

  $I_C / I_B = \alpha /(1-\alpha)$
- From common emitter configuraton,we know that

  $\beta = I_C / I_B$

  Therefore, $I_C / I_B = \alpha /(1-\alpha)$

  $\beta = \alpha /(1-\alpha)$

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$\alpha = \beta / (\beta + 1)$

b) The collector leakage current for a transistor in CE arrangement is 300uA.If the transistor in now connected in CB arrangement, what will be the leakage current? Given that β = 120.

5 b) The collector leakage current for a transistor in CE arrangement is 300μA. If the transistor is now connected in CB arrangement, what will be the leakage current? Given $\beta = 120$.

Sol :- $I_{CEO} = 300\,\mu A$

$\beta = 120$

$$\alpha = \frac{\beta}{\beta + 1} = \frac{120}{120 + 1} = 0.992$$

$I_{CEO} = I_{CBO}/(1-\alpha)$

$I_{CBO} = (1-\alpha) I_{CEO}$

$= (1 - 0.992)\, 300$

$= 2.4\,\mu A$

$I_{CBO} = 2.4\,\mu A$

6. Explain the operation and Input and Output characteristics of BJT in CC configuration.

Ans: Common collector configuration:

Two terminals are needed for input and two terminals for output. Transistors have three terminals, so one terminal have to be taken as common terminal for both input and output. In common collector configuration collector terminal is taken as common. So input is applied between base and the collector terminals and output is taken from emitter and collector terminals.

The common collector configuration is also called emitter follower or voltage follower because the output emitter voltage always follows the base input voltage

- ✔ This configuration is widely used as a buffer and it is also called as voltage buffer.

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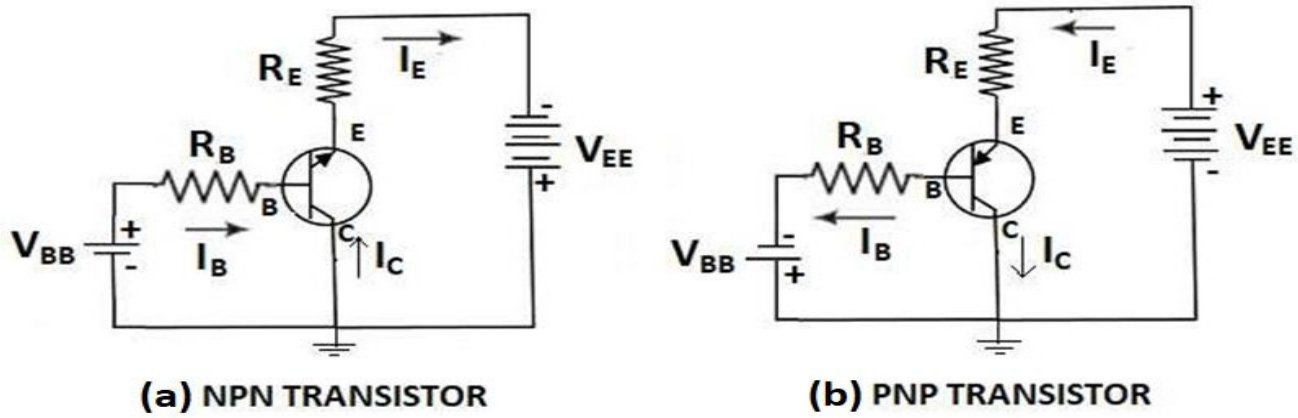
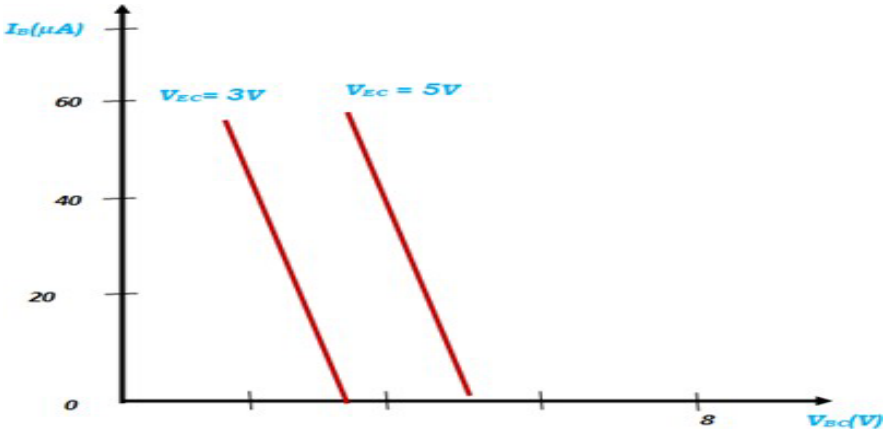


(a) Common collector configuration of NPN transistor

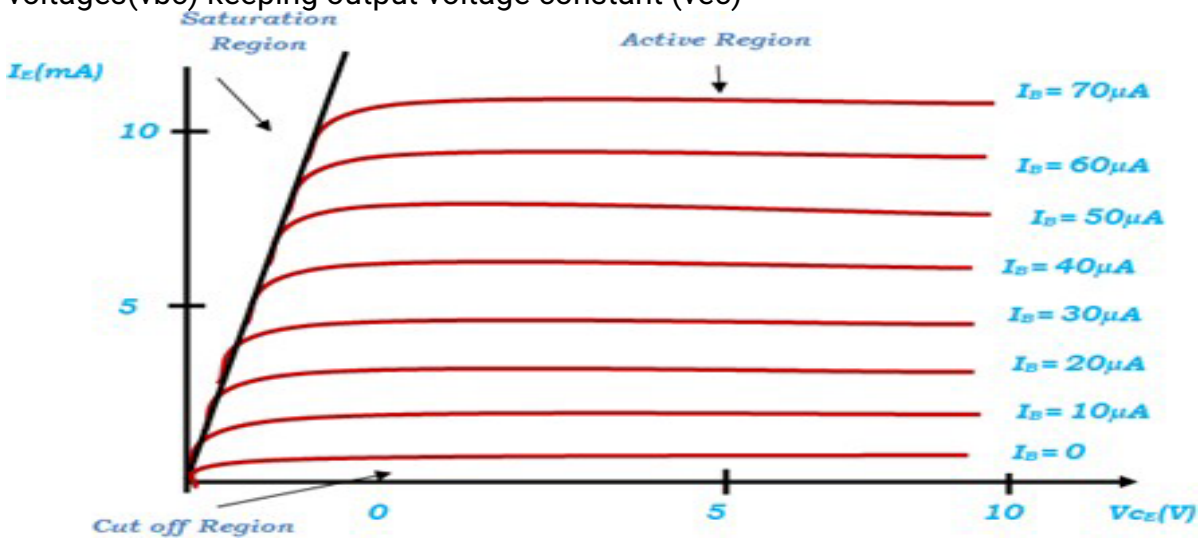
(b) Common collector configuration of PNP transistor

1) Input is applied between the base and the collector terminals. Input current that is the base current is denoted as I_B and the input voltage that is the base collector voltage is denoted as V_{BC}. Collector terminal which is taken as common is grounded.

2) The output current is the emitter current, it is denoted as I_E and the output voltage is emitter collector voltage and it is denoted as V_{EC}. The output emitter current is the summation of the base and collector current. Emitter junction is forward biased and collector junction is reverse biased.



- Input characteristics are the relationship between the input current (Ib) and input voltages(vbc) keeping output voltage constant (vec)



Output characteristics are the relationship between the output Current (I_E) and output voltage (V_{CE}) keeping input current (I_B) constant.

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Common Collector Configuration–has Current Gain but no Voltage Gain.

- **Current Application Factor:** It is the ratio of output current to the input current.
  γ = Output Current /Input current.
  $\gamma = I_E / I_B$

Where,

I_E = Emitter current. I_B = Base current.
γ = Current amplification factor.

- RELATIONSHIP BETWEEN A, B AND Γ:
  The current amplification factor of CC configuration is given by
  $\gamma = I_E / I_B$ …… (1)
  The emitter current of transistor is given by
  $I_E = I_C + I_B$…… (2)
  Substituting equation (2) in (1), we get
  $\gamma = (I_C + I_B)/ I_B$
  $\gamma = I_C / I_B + 1$
  $\gamma = \beta + 1$
  $\gamma = \alpha /(1-\alpha) + 1$
  $\gamma = (\alpha + 1-\alpha) /(1-\alpha)$
  $\gamma = 1 /(1-\alpha)$
  $\gamma = 1 /(1-\alpha) = \beta+1$

b) Find the values of β and γ, if (i) α=0.9 (ii) α=0.98.

6 b) Find the values of β and γ, if (i) α = 0.9 (ii) α = 0.98?

Sol: (i) $\alpha = 0.9$

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.9}{1-0.9} = 9$$

$$\gamma = \frac{1}{1-\alpha} = \frac{1}{1-0.9} = 10$$

(ii) $\alpha = 0.98$

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = 49$$

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$$Y = \frac{1}{1-x} = \frac{1}{1-0.98} = 50.$$

unit-5

1. Explain various number systems and codes and their conversion with examples for each.

Decimal number system: The decimal number system uses the following ten digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

- Hence, the numbers in this system have a base of 10.

Examples: 18_{10}, 222_{10}, 7877_{10}

Binary number system: Binary number system uses just two digits: 0 and 1.

- Hence, the numbers in this system have a base 2.
- 0 and 1 are called bits.
- 8 bits together make a byte.

Examples: 1011_2, 111_2, etc

Octal number system: The octal number system uses the following eight digits: 0, 1, 2, 3, 4, 5, 6, and 7.

- Hence, the numbers in this system have a base 8.
- The advantage of this system is that it has less number of digits and therefore, there would not be many computational errors.

Examples: 245_8, 51_8 etc.

Hexadecimal number system: The hexadecimal number system uses the following sixteen digits/alphabets: The digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and following are the alphabets A, B, C, D, E, and F.

- Therefore, the numbers in this system have a base of 16.

Examples: $A7B_{16}$, BC_{16} etc.

Conversions

Decimal to binary: Divide the given decimal number by "2" where it gives the result along

with the remainder.

Ex: $(160)_{10}$

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Divide by 2	Result	Remainder	Binary Value
160 ÷ 2	80	0	0 (LSB)
80 ÷ 2	40	0	0
40 ÷ 2	20	0	0
20 ÷ 2	10	0	0
10 ÷ 2	5	0	0
5 ÷ 2	2	1	1
2 ÷ 2	1	0	0
1 ÷ 2	0	1	1 (MSB)

$(160)_{10} = (10100000)_2$

Decimal to octal: Divide the number by 8.Get the remainder for the octal digit.

Ex: $(7562)_{10}$

Division by 8	Quotient (integer)	Remainder (decimal)
7562/8	945	2
945/8	118	1
118/8	14	6
14/8	1	6
1/8	0	1

$(7562)_{10} = (16612)_8$

Decimal to hexadecimal : Divide the number by 16. Get the remainder for the hex digit.

Ex: $(7562)_{10}$

Division by 16	Quotient (integer)	Remainder (decimal)	Remainder (hex)
7562/16	472	10	A
472/16	29	8	8
29/16	1	13	D
1/16	0	1	1

$(7562)_{10} = (1D8A)_{16}$

Binary to decimal: To convert the binary number to a decimal number, we use the multiplication method.

Solution: MSB LSB

Given binary number = $(1\ 1\ 0\ 1\ )_2$

Now, multiplying each digit from MSB to LSB with reducing the power of the base number 2.

$(1101)_2 = 1 \times 23 + 1 \times 22 + 0 \times 21 + 1 \times 20 = 8 + 4 + 0 + 1 = 13$

$(1101)_2 = (13)_{10}$

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Binary to octal: Converting from binary to octal is very easy since octal numbers are only simplified versions of binary strings. You just need to remember that each octal digit represents three binary digits.

Binary	Octal
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

the binary number 110110100 would break down to

110 110 100.

6 6 4

$(110110100)_2 = (664)_8$

Binary to hexadecimal:

Binary	Hex
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7

Binary	Hex
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Convert $(01001110)_2$ to hex:

$(0100)_2 = (4)_{16}$ $(1110)_2 = (E)_{16}$

Therefore, $(01001110)_2 = (4E)_{16}$

Octal to decimal: 37 in base 8 is equal to each digit multiplied with its corresponding 8^n:

$37_8 = 3\times8^1+7\times8^0 = 24+7 = (31)_{10}$

Octal to binary: To Convert an octal number we write 3-bit binary equivalent of each octal digit in the same order. 3-bit binary equivalent of octal digits are shown below:

Convert $(162.05)_8 = (\ \ )_2$

$(162.05)_8 = (001110010.000101)_2$

Octal to hexadecimal:

STEP1: Convert the **octal number to binary**

STEP2: Convert the obtained binary (from step1) to hexadecimal by taking **4 bits as one group.**

Convert $(\mathbf{46.1})_8 = (\quad)_2$

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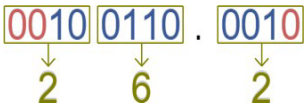
$(46.1)_8 = (100110.001)_2$



$(100110.001)_2 = (26.2)_{16}$

COMBINING RESULTS: $(46.1)_8 = (26.2)_{16}$

Hexadecimal to decimal: 3B in base 16 is equal to each digit multiplied with its corresponding power of 16:

$3B_{16} = 3\times16^1+11\times16^0 = 48+11 = 59$

Hexadecimal to binary:

Convert hex $6C_{16}$ to binary: $6C_{16}$ = 6 C

= 110 1100

= 1101100_2

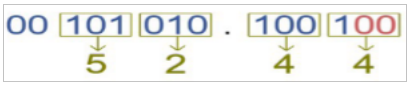
Hexadecimal to octal:

STEP 1:we convert the hexadecimal number to binary.

STEP 2 :we convert the binary to octal.

$(2A.9)_{16}=()_8$

$(2A.9)_{16} = (00101010.1001)_2$

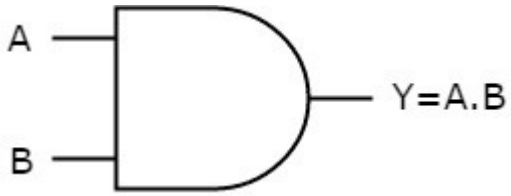


$(00101010.1001)_2 = (52.44)_8$

$(2A.9)_{16}=(52.44)_8$

2. Write the truth table and symbols of AND, OR and NOT gates.

Ans: AND GATE: An AND gate is a digital circuit that has two or more inputs and produces an output, which is the logical AND of all those inputs. It is optional to represent the Logical AND with the symbol '.'.



Symbol of AND gate

A	B	Y = A.B
0	0	0
0	1	0
1	0	0
1	1	1

Truth table of AND gate

Similarly, if there are 'n' inputs, then the AND gate produces an output, which is the logical AND of all those inputs. That means, the output of AND gate will be '1', when all the inputs are '1'.

OR GATE: An OR gate is a digital circuit that has two or more inputs and produces an output, which is the

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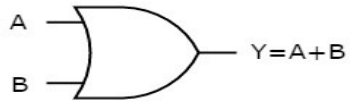
logical OR of all those inputs. This logical OR is represented with the symbol '+'.

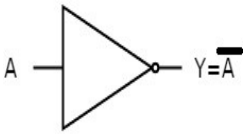


A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Symbol of OR gate **Truth table of OR gate**

Similarly, if there are 'n' inputs, then the OR gate produces an output, which is the logical OR of all those inputs. That means, the output of an OR gate will be '1', when at least one of those inputs is '1'.

NOT gate: A NOT gate is a digital circuit that has single input and single output. The output of NOT gate is the logical inversion of input. Hence, the NOT gate is also called as inverter.



A	Y = $\overline{A}$
0	1
1	0

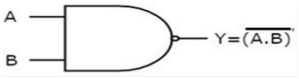
Symbol of NOT gate **Truth table of NOT gate**

This NOT gate produces an output Y, which is the **complement** of input, A.

3. Explain about NAND and NOR gates (Universal gates).

Universal gates: NAND & NOR gates are called as universal gates. Because we can implement any Boolean function, which is in sum of products form by using NAND gates alone. Similarly, we can implement any Boolean function, which is in product of sums form by using NOR gates alone.

NAND gate: NAND gate is a digital circuit that has two or more inputs and produces an output, which is the inversion of logical AND of all those inputs.



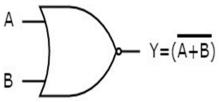
Symbol of NAND gate

A	B	Y = A.B
0	0	1
0	1	1
1	0	1
1	1	0

Truth table of NAND gate

NAND gate operation is same as that of AND gate followed by an inverter. That's why the NAND gate symbol is represented like that.

NOR gate: NOR gate is a digital circuit that has two or more inputs and produces an output, which is the inversion of logical OR of all those inputs.



A	B	Y = A+B
0	0	1
0	1	0
1	0	0
1	1	0

Symbol of NOR gate **Truth table of NOR gate**

NOR gate operation is same as that of OR gate followed by an inverter. That's why the NOR gate symbol is represented like that.

4. a) Find 1's complement of binary number 10001.001.

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4)

a) Find 1's complement of binary number 10001.001?

A: 1st 1's complement of binary no is 10001.001

$$
\begin{array}{r}
11111.111 \\
(-)\ 10001.001 \\
\hline
01110.110 \\
\hline
\end{array}
$$

$\Rightarrow$

b) Find 2's complement of binary number 10001.001.

2's complement of binary number is

$$
\begin{array}{r}
01110.110 \\
1 \\
\hline
01110.111 \\
\hline
\end{array}
$$

5. a) Find the 9's compliment of the numbers 12345678, 87654321.

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5) a) Find the 9's compliment of the numbers

12345678, 87654321

Sol:-

$$
\begin{array}{r}
99999999 \\
12345678 \\
(-)\ \hline
87654321 \\
\hline
\end{array}
$$

$$
\begin{array}{r}
99999999 \\
(-)\ 87654321 \\
\hline
12345678 \\
\hline
\end{array}
$$

b) Find the 10's compliment of the numbers 12345678, 87654321.

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5) b) Find the 10's complement of the numbers 12345678, 87654321?

Sol:-

9's complement of 12345678 is 87654321

87654321
(+) 1
87654322

9's complent of 87654321 is 12345678

12345678
(+) 1
12345679

6. a) Convert the given binary code number to equivalent gray code 001001011110010

6)
a) Convert the given binary code to equivalent gray code 001001011110010

Sol:- 001001011110010 to equivalent

Gray code => 001101111000101 1

b) Convert the given binary code number to equivalent Excess-3 code 1001

b) Convert the given binary code to equivalent Excess-3 code 1001

Sol:- 1001 = 1100

7. a) Express the following numbers in decimal: $(10110.0101)_2$, $(16.5)_{16}$, $(26.24)_8$.

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7) a) Express the following in decimal

$(10110.0101)_2$ $(16.5)_{16}$ $(26.24)_8$

Sol: $(10110.0101)_2 =$

$1\times2^4 + 0\times2^3 + 1\times2^2 + 1\times2^1 + 0\times2^0 + 0\times2^{-1} +$

$1\times2^{-2} + 0\times2^{-3} + 1\times2^{-4}$

$= 16 + 0 + 4 + 2 + 0 + 0 + 0.5 + 0 + 0.625$

$= (22.125)_{10}$

$(16.5)_{16} =$

$1\times16^1 + 6\times16^0 . 5\times16^{-1}$

$= 16 + 6 . 0.3125$

$= 22.3125$

$(26.24)_8 =$

$= 2\times8^1 + 6\times8^0 + 2\times8^{-1} + 4\times8^{-2}$

$= 16 + 6 + 0.25 + 0.0625$

$= 22.3125$

b) $(A0F9.0EB)_{16}$, $(A98.0DC)_{16}$ into decimal, binary and octal.

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7(b) $(A0F9.0EB)_{16}$ $(A98.0DC)_{16}$ in to decimal binary, octal?

Sol:- $(A0F9.0EB)_{16} = (\quad)_{10}$

$= A \times 16^3 + 0 \times 16^2 + F \times 16^1 + 9 \times 16^0 + 0 \times 16^{-1} + E \times 16^{-2} + B \times 16^{-3}$

$= 40960 + 0 + 240 + 9 + 0 + 0.0546875 + 2.6855$

$= (41211.7395)_{10}$

$(A0F9.0EB)_{16} = (\quad)_2$

A	0	F	9	.	0	E	B
1	1	1	1		1	1	1
1010	0000	1111	1001		0000	1110	1011

$(1010000011111001.0000111010111)_2$

$(A0F9.0EB)_{16} = (\quad)_8$

001 010 000 011 111 001 . 000 011 101 011

1 2 0 3 7 1 . 0 3 5 3

$(120371.0353)_8$.

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$(A98.0DC)_{16} = (\ )_{10} = (\ )_8 = (\ )_2$

$= A \times 16^2 + 9 \times 16^1 + 8 \times 16^0 + 0 \times 16^{-1} + D \times 16^{-2}$

$+ C \times 16^{-3}$

$= 10 \times 256 + 9 \times 16 + 8 \times 1 + 0 + 13 \times \frac{1}{256}$

$+ 12 \times \frac{1}{4096}$

$= 2560 + 144 + 8 + 0 + 0.05078125 +$

0.02968750

$= (2714.98046875)_{10}$.

$= (\ )_8$

A	9	8	.	0	D	C
↓	↓	↓		↓	↓	↓
1010	1001	1000		0000	1101	1100

Edit with WPS Office

101010011000.000011011100

↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

5 2 3 0 . 0 3 3 4

$(5230.0334)_8$

$(\ )_2$

= A 9 8 . 0 D C

1010 1001 1000 0000 1101 1100

$= (101010011000.000011011100)_2$

8. Perform the following conversions

a) $(476.64)_{10} = (\ )_2 = (\ )_8$ b) $(2564.603)_8 = (\ )_{16}$ c) $110001.1010010 = (\ )_{16}$

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(a) $(476.64)_{10} = (\quad)_2 = (\quad)_8$

$$
\begin{array}{r|l}
2 & 476 \\
2 & 238 \quad \text{—— } 0 \\
2 & 119 \quad \text{—— } 0 \\
2 & 59 \quad \text{—— } 1 \\
2 & 29 \quad \text{—— } 1 \\
2 & 14 \quad \text{—— } 1 \\
2 & 7 \quad \text{—— } 0 \\
2 & 3 \quad \text{—— } 1 \\
 & 1 \quad \text{—— } 1
\end{array}
$$

$= (111011100)_2$

$\Rightarrow 0.64 \times 2 = 1.28 = 1$

$\Rightarrow 0.28 \times 2 = 0.56 = 0$

Now,

$(111011100.10)_2$

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8 | 476.
8 | 59 — 4
7 — 3

(734)

$0.64 \times 8 = 5.12 = 5$

$0.12 \times 8 = 0.96 = 0$

$= (734.50)_8$.

(b) $(2564.603)_8 = (\quad)_{16}$

2	5	6	4	.	6	0	3
↓	↓	↓	↓		↓	↓	↓
010	101	110	100		110	000	011

010101110100 . 110000011000

↓ ↓ ↓ ↓ ↓ ↓

5 7 4 C 1 8

$= (574.C18)_{16}$.

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(c) $(110001.10100010)_2 = (\quad)_{16}$

$\underline{0011}\ \underline{0001} \cdot \underline{1010}\ \underline{0100}$

$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$

$3 \quad 1 \quad A \quad 4$

$= (31.A4)_{16}$

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