Basics Electrical
&
Electronics Engineering

(For Diploma II Yrs. I Part)

3rd Semester

(DCOM/IT)

By

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S.No Exam Year, Month

1. 2080 Bhadra Regular
2. Some Additional Question

BE&EE ----(DCOM/IT) 3rd Sem

(2080) Question Paper Solution.

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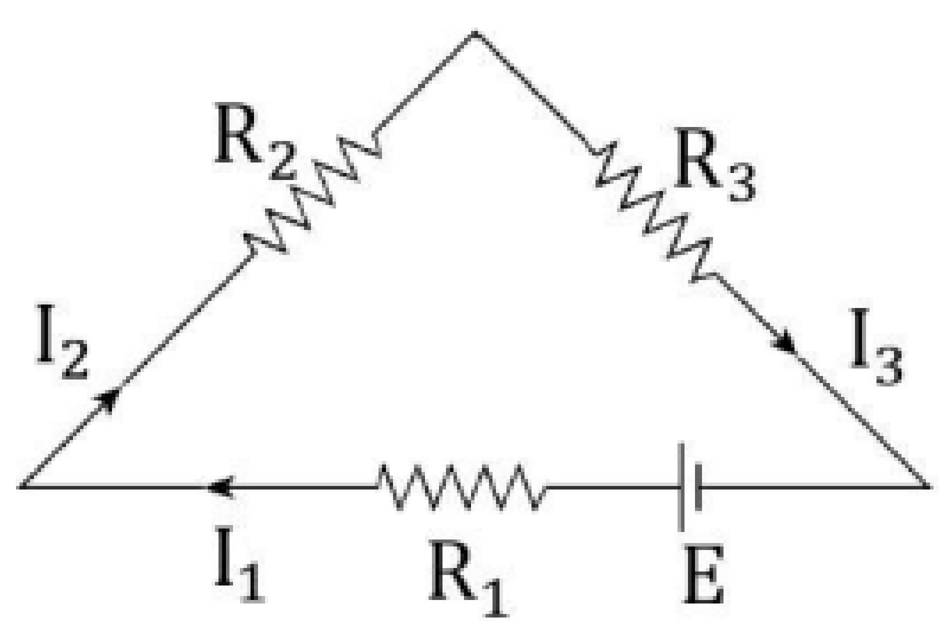
1. a) Define electromotive Force and potential difference.

- **Electromotive force** is defined as the electric potential produced by either an electrochemical cell or by changing the magnetic field. e.m.f is the commonly used acronym for electromotive force.
- The difference in the potentials of two charged is called (p.d) **potential difference**. If two bodies have different electric potentials, a potential difference exists between the bodies. Potential difference is also known as voltage "V".

b) Explain Kirchhoff's voltage law with suitable example.

- *According to Kirchhoff's Voltage Law*, In any closed circuit the algebraic sum of the products of the currents and resistance of each part of the circuit is equal to the algebraic sum of e.m.f.'s in that circuit. *For example*; In the circuit given



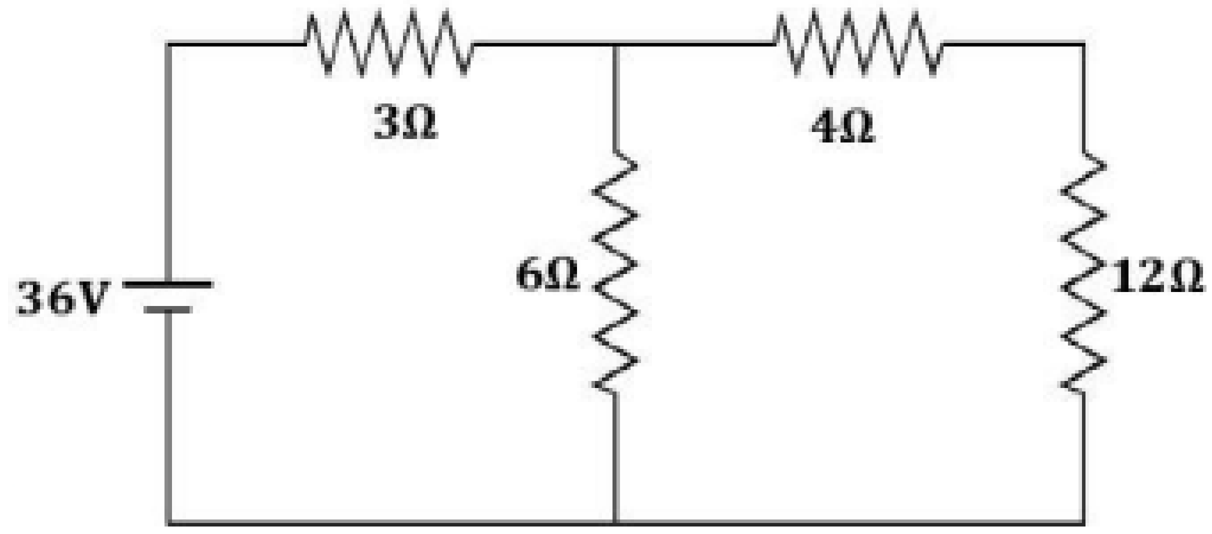
$$I_1R_1 + I_2R_2 + I_3R_3 = E$$

In general;

$$\sum IR = \sum E$$

The equation is true for any closed circuit.

c) Using Thevenin's theorem find the current through 12Ω resistor from below circuit.



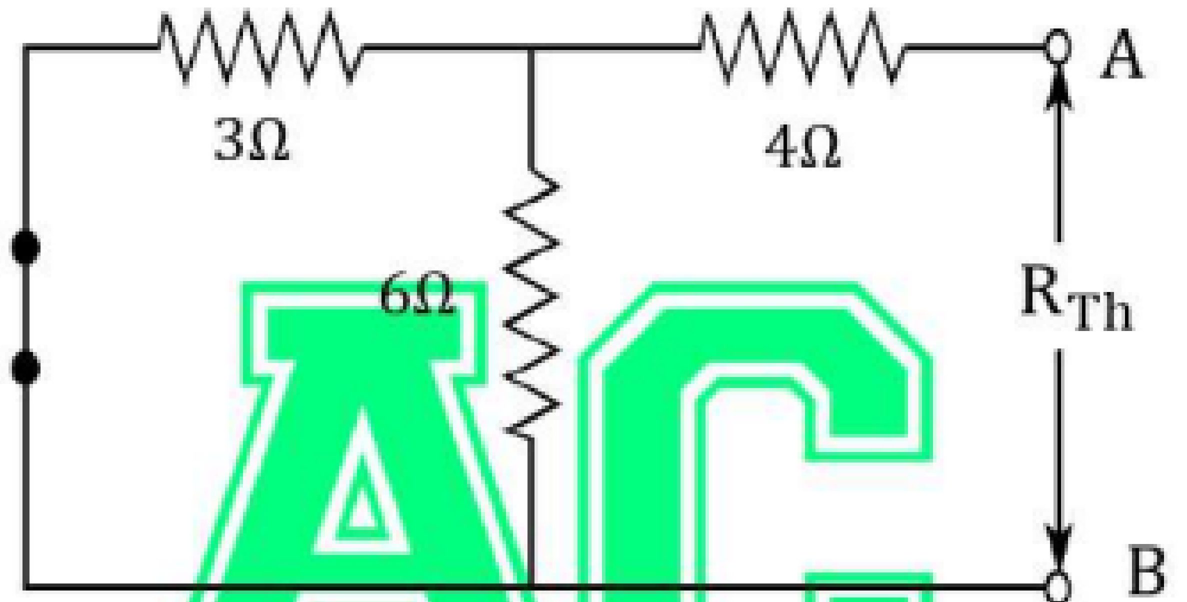
Solution:

Here, the circuit shown in the figure is converted into Thevenin's equivalent circuit.

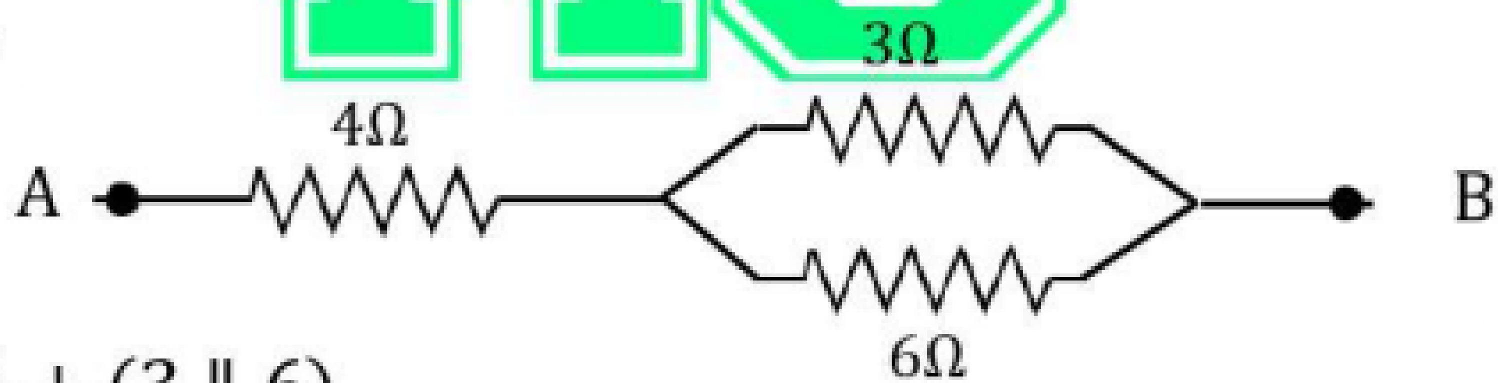
Now, applying Thevenin's theorem

$I_2 = ?$

To Find R_{Th},



Arranging,

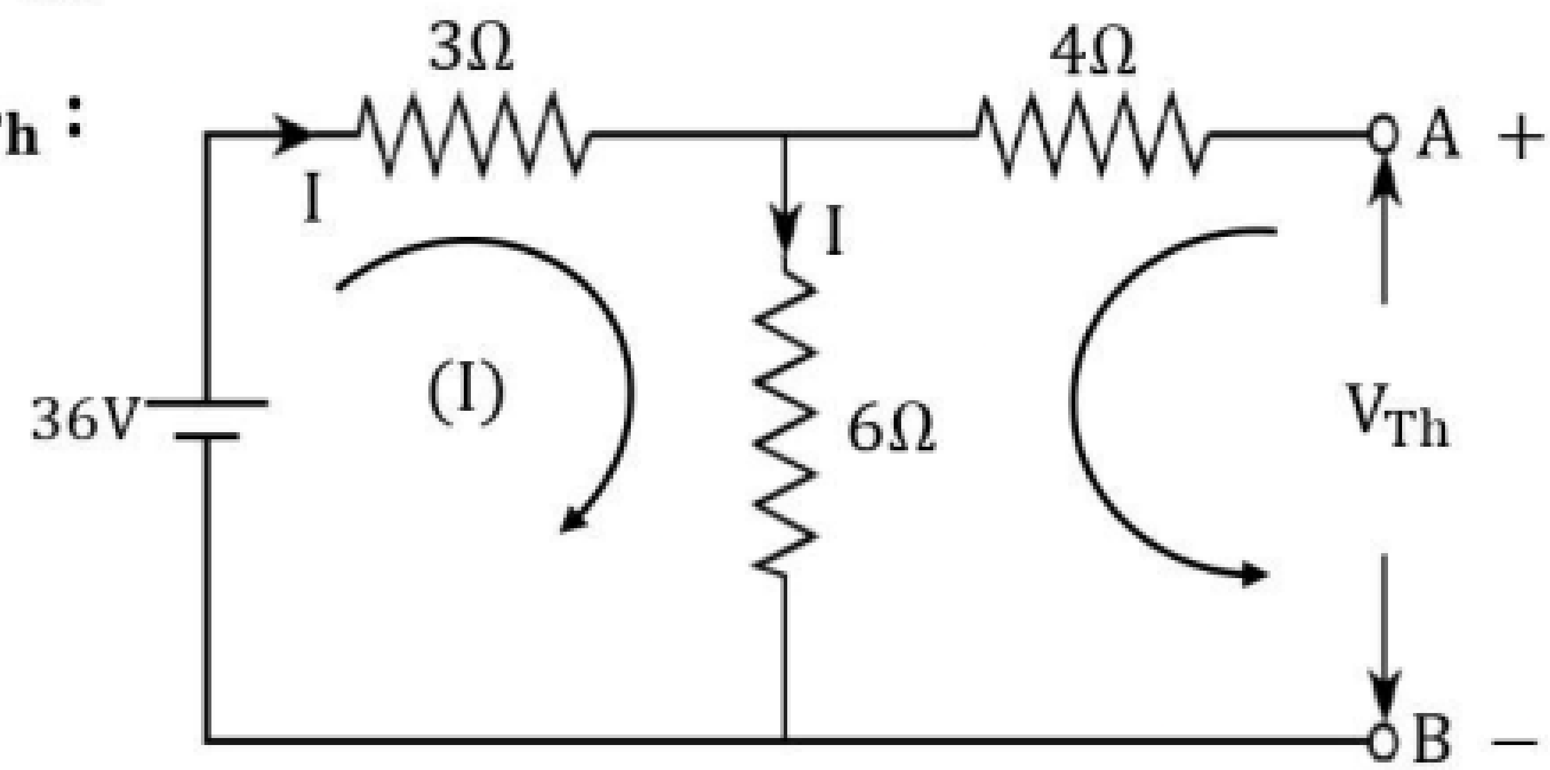


$$R_{Th} = R_{AB} = 4 + (3 \parallel 6)$$

$$= 4 + \frac{3 \times 6}{3 + 6}$$

$$= 6\Omega$$

To Find V_{Th} :

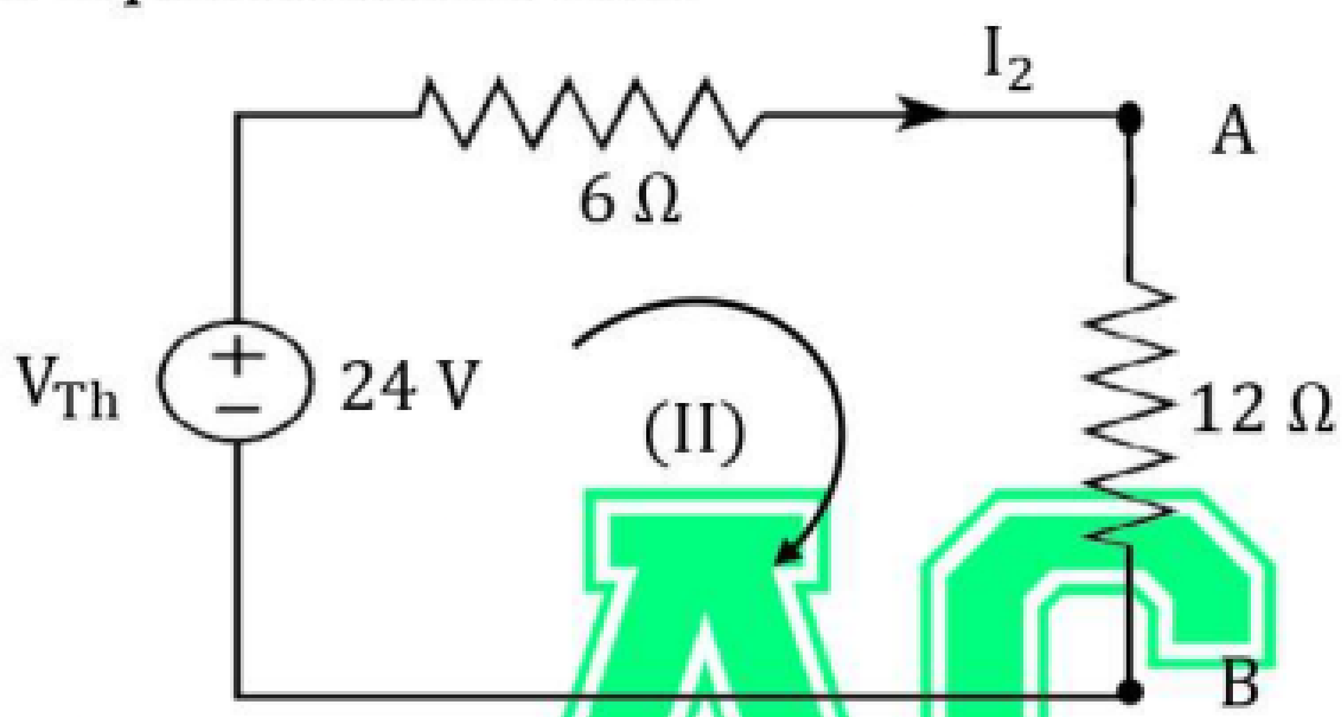


Using K.V.L in Loop (I)

$$36 - 3 \times I - 6 \times I = 0$$
$$9\,I = 36$$
$$I = 4\,A$$

$$\Rightarrow \left\{ \begin{aligned} V_{AB} = V_{Th} &= 4 \times 0 + 6 \times 4 \\ &= \mathbf{24\ Volts.} \end{aligned} \right\}$$

So, Thevenin's equivalent circuit



Let I_2 be current through 12 Ω

Then,

K.V.L in Loop (II)

$$24 - 6\,I_2 - 12\,I_2 = 0$$

$$I_2 = \frac{24}{6 + 12}$$

$$= \frac{24}{18}$$

$$I_2 = 1.33 \text{ Ampere.}$$

Hence,

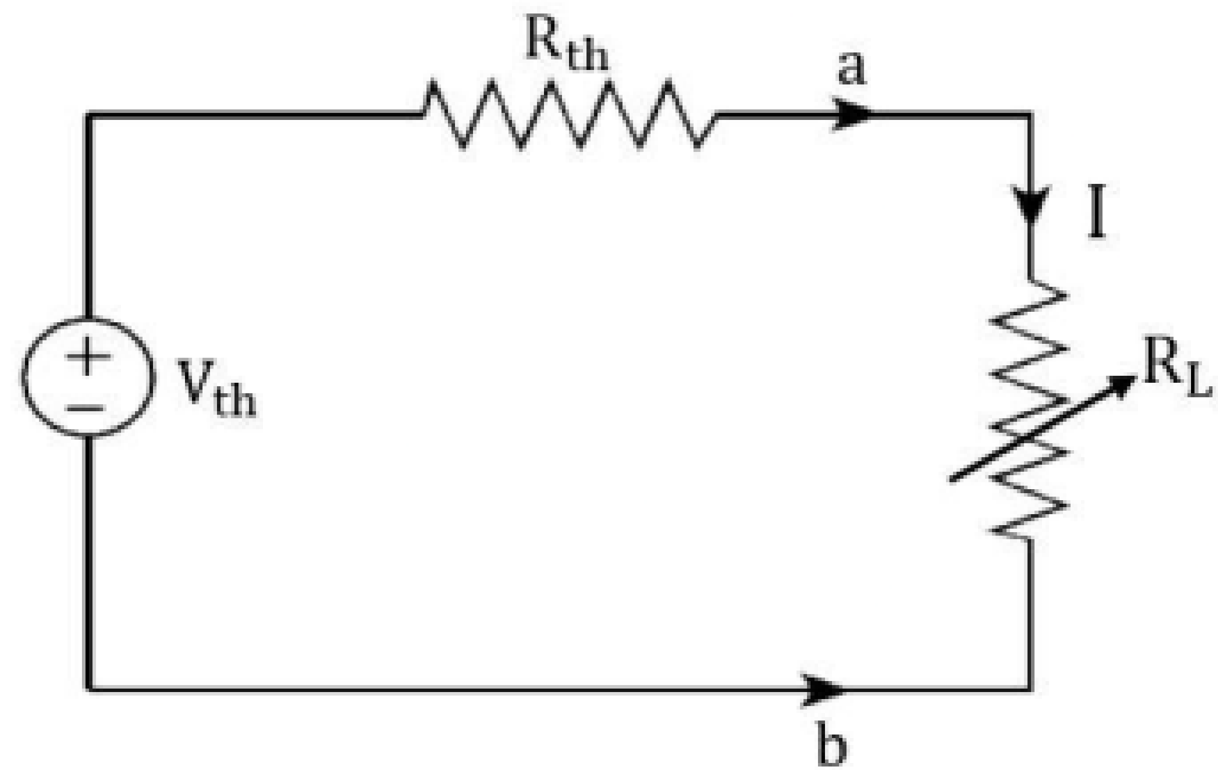
Current through 12 Ω = 1.33 Ampere

2. a) State and prove maximum power transfer theorem.

➢ Maximum power transfer theorem states that the DC voltage source will deliver maximum power to the variable load resistor only when the load resistance is equal to the source resistance. i.e $R_L = R_{th}$

Here,

$$I = \frac{V_{th}}{R_{th}+R_L}$$



Equivalent Thevenin Circuit

Now, power can be given as

$$P = I^2 R_L$$

or, $$P = \left(\frac{V_{th}}{R_{th}+R_L}\right)^2 \times R_L = V_{th}^2 \times \frac{R_L}{(R_{th}+R_L)^2} \quad \cdots\cdots\cdots\cdots\cdots \text{(i)}$$

To Proof,maximum power transfer theorem, differentiating equation (i), wrt R_L we get,

$$\frac{dP}{dR_L} = V_{th}^2 \times \frac{d}{dR_L}\left[\frac{R_L}{(R_{th}+R_L)^2}\right]$$

$$= V_{th}^2 \times \frac{[(R_{th}+R_L)^2 - 2R_L(R_{th}+R_L)]}{[(R_{th}+R_L)^2]^2}$$

$$= V_{th}^2 \times \frac{(R_{th}+R_L)[(R_{th}+R_L) - 2R_L]}{(R_{th}+R_L)^4}$$

$$\therefore \frac{dP}{dR_L} = (V_{th})^2 \times \frac{[(R_{th}-R_L)]}{(R_{th}+R_L)^3} \quad \cdots\cdots\cdots\cdots \text{(ii)}$$

Now, For maximum power, $\frac{dP}{dR_L} = 0$

So, $(V_{th})^2 \times \frac{[(R_{th} - R_L)]}{(R_{th} + R_L)^3} = 0 \quad [\because As, V_{th} \neq 0\ ]$

or, $\boxed{R_{th} = R_L} \cdots\cdots\cdots\cdots (iii)$

Hence, the maximum power takes place when the load resistance R_L equals to the Source resistance R_{th}

Now, From equation (i) and (iii) ,

$$\text{or,} \quad P_{max} = \frac{V_{th}^2}{(R_{th} + R_{th})^2} \times R_{th}$$

$\therefore$ *Hence*, maximum power is , $\boxed{P_{max} = \frac{V_{th}^2}{4R_{th}}}$

b) Define the following forms.

i) Instantaneous value

- The alternating quantity changes at every time. At any particular time, its value is called instantaneous value at time t, it is given as;

  $V(t) = V_m \sin \omega t.$

ii) Average value

➢ The arithmetic average of all the value of an alternating quantity over one cycle is called its average value.

$$\textbf{Average value} = \frac{\textbf{Area under one cycle}}{\textbf{Base}}$$

iii) Peak value

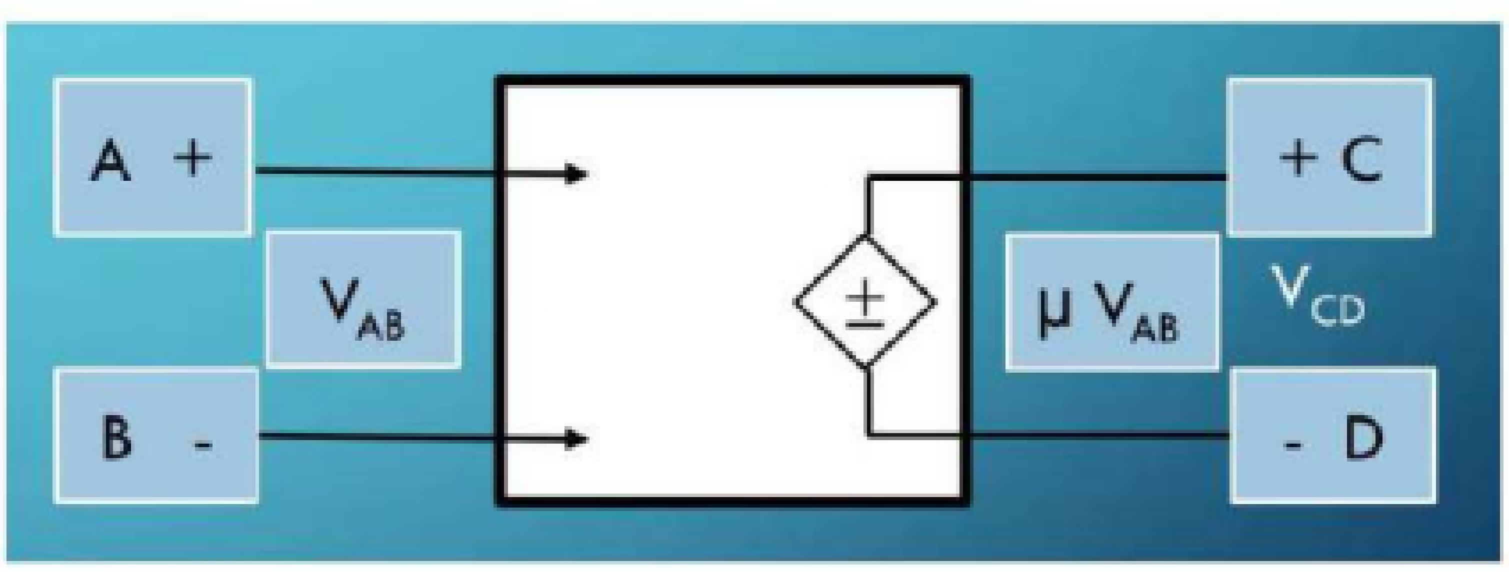
➢ The maximum value (positive or negative) of an AC quantities is known as its peak value. It is also known as amplitude of the wave form.

iv) RMS value

➢ The RMS value of an alternating quantity is that steady current (dc) which when flowing through a given resistance for a given time period, produces the same amount of heat, that produced by the alternating current flowing through the same resistance for the same time.

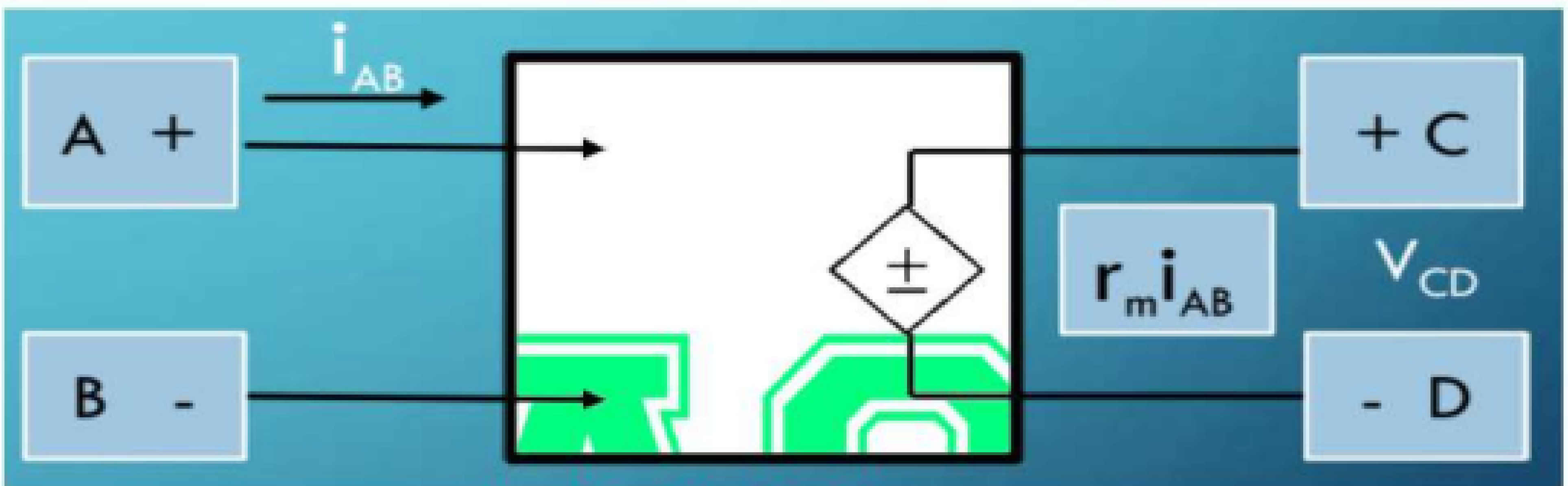
c) Explain VCVS and CCVS.

➢ VCVS stands for ***voltage controlled voltage source***. This is a four terminal network which provides an output voltage proportional to input voltage. The relationship between output voltage and input voltage of device is expressed as follows, $V_{CD} = \mu V_{AB}$. Where μ is called voltage amplification factor or voltage gain & unit less. Eg. Idealized amplifier, OP Amp, Transformer. The output voltage V_{CD} depends upon output current i_{CD} only if it depends on the input voltage V_{AB}.

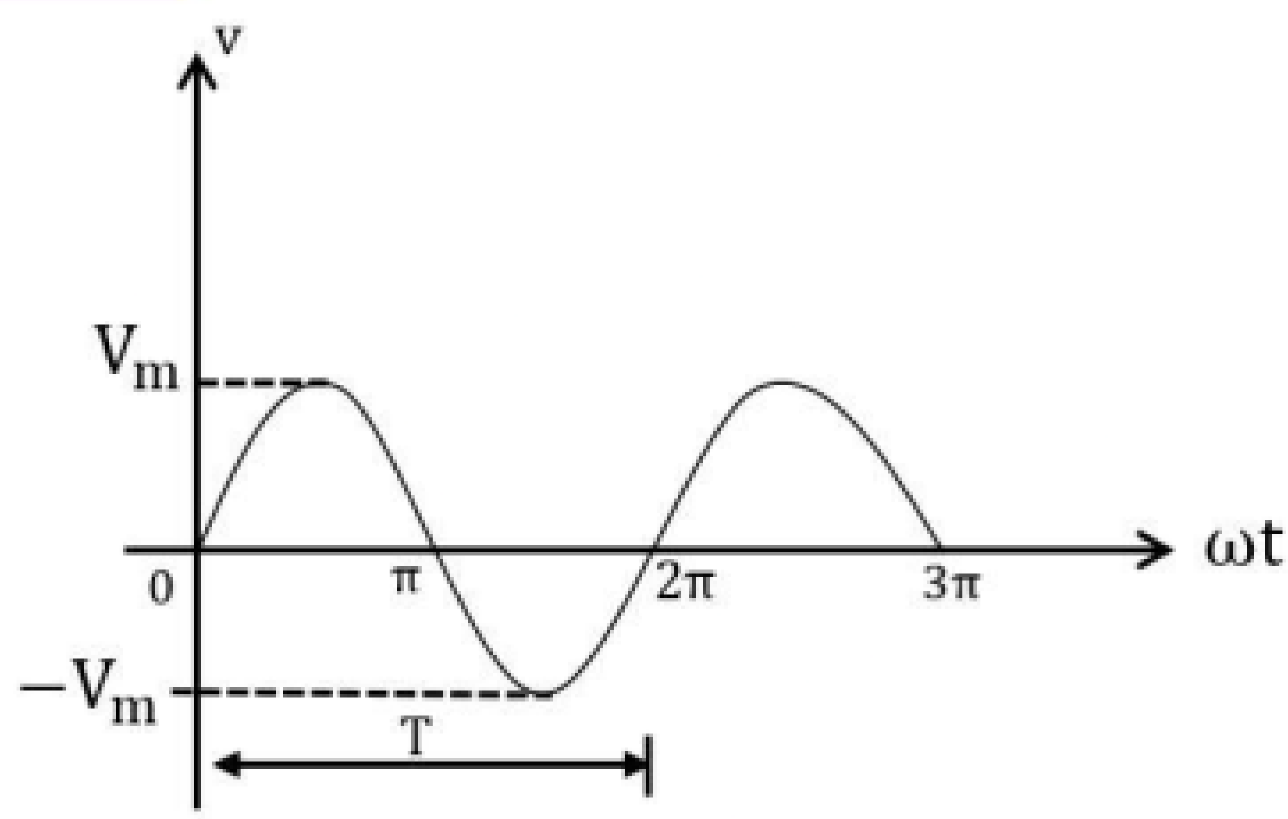


- CCVS stands for ***Current controlled voltage source***. This is a four terminal network which provides an output Voltage proportional to input current. The relationship between output voltage and input current of device is expressed as follows, $V_{CD} = r_m i_{AB}$. Where r_m is called Transresistance or transimpedance, mutual resistance and its unit is volt/amp. Electronic devices that produce output voltage proportional to the input current that can be constructed can be taken as an example of CCVS.

  Eg. Solar cell, Op- Amp summer circuit.



3. a) Derive the expression for the r.m.s. and average value of sinusoidal current and voltage.



The waveform Completes one cycle from 0 to 2π.

Hence,

Time period of the waveform is 2π as Denoted in figure.

Required Equations:

$$v = V_m \sin \omega t \quad \text{for } [0 \le \omega t \le 2\pi]$$

$$\therefore V_{rms} = \sqrt{\frac{1}{T}\int_0^1 v^2 d\omega t} \quad \text{for } [0 \le \omega t \le 2\pi]$$

$$\text{or,} \quad V_{rms}^2 = \frac{1}{2\pi}\int_0^{2\pi} (V_m \sin\omega t)^2 \, d\omega t$$

$$\text{or,} \quad V_{rms}^2 = \frac{1}{2\pi}\int_0^{2\pi} V_m^2 \sin^2\omega t \, d\omega t$$

$$\text{or,} \quad V_{rms}^2 = \frac{1}{2\pi} V_m^2 \int_0^{2\pi} \frac{1-\cos 2\omega t}{2} \, d\omega t$$

$$\text{or,} \quad V_{rms}^2 = \frac{V_m^2}{2\pi} \times \frac{1}{2}\left[\omega t \,\Big|_2^{2\pi} - \frac{\sin 2\omega t}{2}\Big|_2^{2\pi}\right]$$

$$\text{or,} \quad V_{rms}^2 = \frac{V_m^2}{4\pi} \times \left[2\pi - 0 - \frac{\sin 4\pi - \sin 0}{2}\right]$$

$$\text{or,} \quad V_{rms}^2 = \frac{V_m^2}{4\pi} \times 2\pi$$

$$= \frac{V_m^2}{2}$$

$$\therefore \quad \boxed{\mathbf{V_{rms} = \frac{V_m}{\sqrt{2}}}}$$

Similary,

$\boxed{\mathbf{I_{rms} = \frac{I_m}{\sqrt{2}}}}$ for sinusoidal wave form

OR, RMS Value current given by

$$I_{rms} = \frac{V_{rms}}{R_L}$$

$$= \frac{\frac{V_m}{\sqrt{2}}}{R_L}$$

$$I_{rms} = \frac{1}{\sqrt{2}} \frac{V_m}{R_L}$$

$$I_{rms} = \frac{1}{\sqrt{2}} I_m \qquad \left[\because \; I_m = \frac{V_m}{R_L}\right]$$

$$\boxed{\mathbf{I_{rms} = \frac{I_{rm}}{\sqrt{2}}}}$$

b) A 230V, 50Hz AC supply is applied a coil of 0.06H inductance and 50 resistance connected in series with a capacitor of 10µF. Calculate the following.

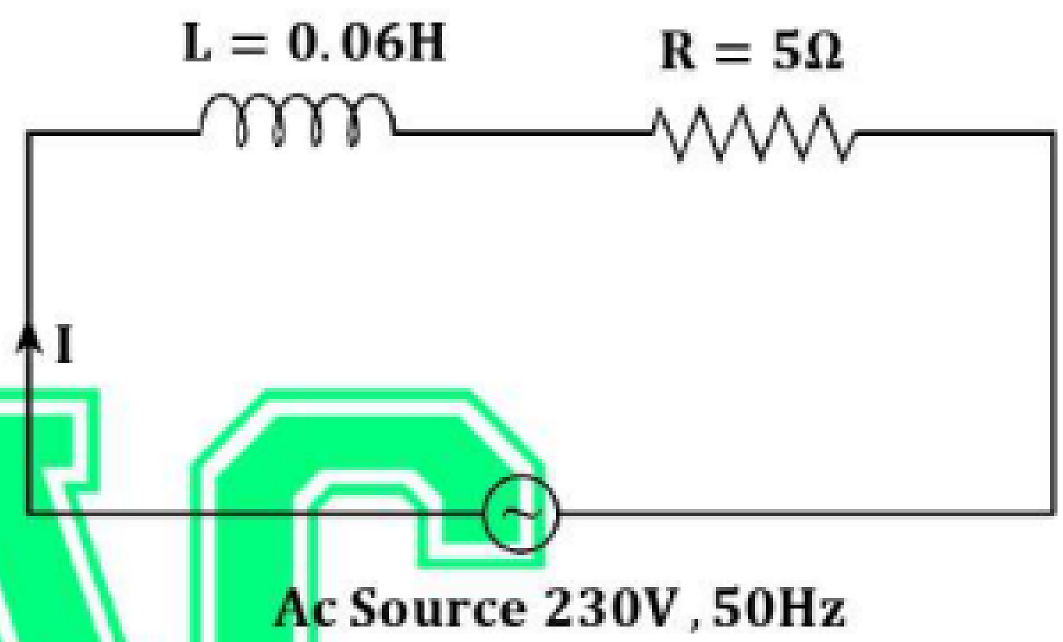
i) Impedance ii) Circuit current

iii) Power factor iv) Active power

Solution:-

To Find ,

Impedance (z) =?
Circuit Current (I) =?
Power factor, cos ϕ =?
Active power (p) =?



$V = 230$ Volt
$f = 50$ Hz
$W = 2\pi f = 2\pi \times 50 = 314.159$ rad/s

$X_L = W L$
$= 314.159 \times 0.06$
$\mathbf{X_L = 18.849\ \Omega}$

$R = 5\ \Omega$
From Impedance diagram,

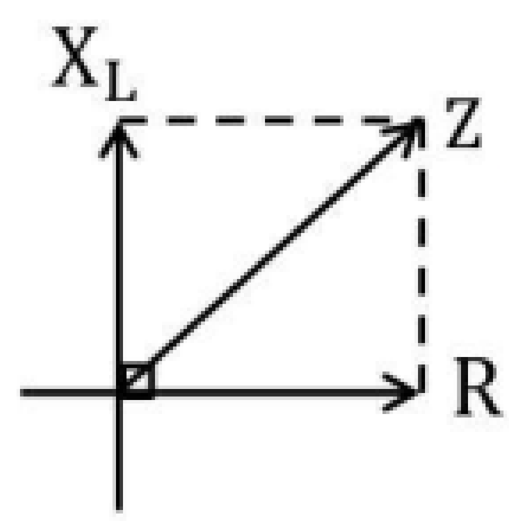


Fig : – Impedance diagram

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

$$z = \sqrt{18.849^2 + 5^2}$$

$$\boxed{\mathbf{z = 19.50\ \Omega}}$$

Now,

From diagram

$$V^2 = {V_L}^2 + {V_R}^2$$

$$V^2 = (I\,V_L)^2 + (I\,V_R)^2$$

$$V^2 = I^2\,(X_L + R^2)^2$$

$$I = \frac{V}{\sqrt{{X_L}^2 + R^2}}$$

$$I = \frac{V}{Z}$$

$$I = \frac{230}{19.50}$$

$$\boxed{\mathbf{I = 11.794\ Ampere}}$$

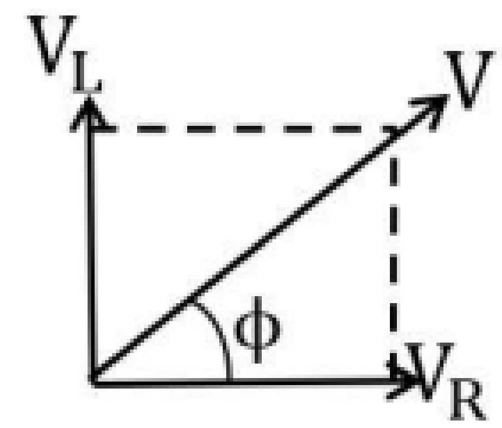


Fig : − Voltage diagram

Again,

From diagram

$$\tan\phi = \frac{V_L}{V_R} = \frac{I\,X_L}{I\,R}$$

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$$

$$= \tan^{-1}\left(\frac{18.849}{5}\right)$$

$$\phi = 75.14°$$

Phase angle, $\boldsymbol{\phi = 75.14°}$

Power factor, $p.f = \cos\phi$

$= \cos(75.14°)$

$\boxed{= 0.256}$

Now,

Active power $(p) = VI\cos\phi$

$= 230 \times 11.794 \times 6.256$

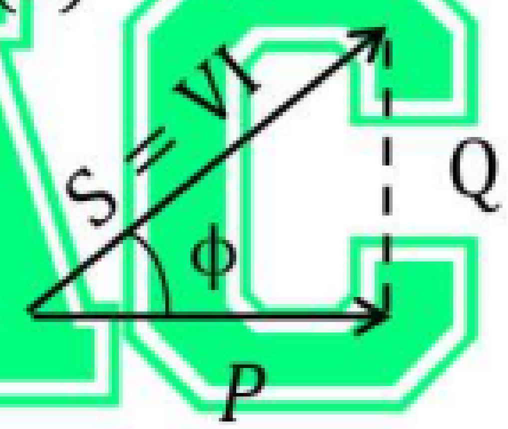
$\boxed{= \mathbf{694.430\ Watts}.}$

****Note,**

Similary if ask :

Reactive Power $(Q) = VI \sin\phi$

Apparent Power $(S) = VI$

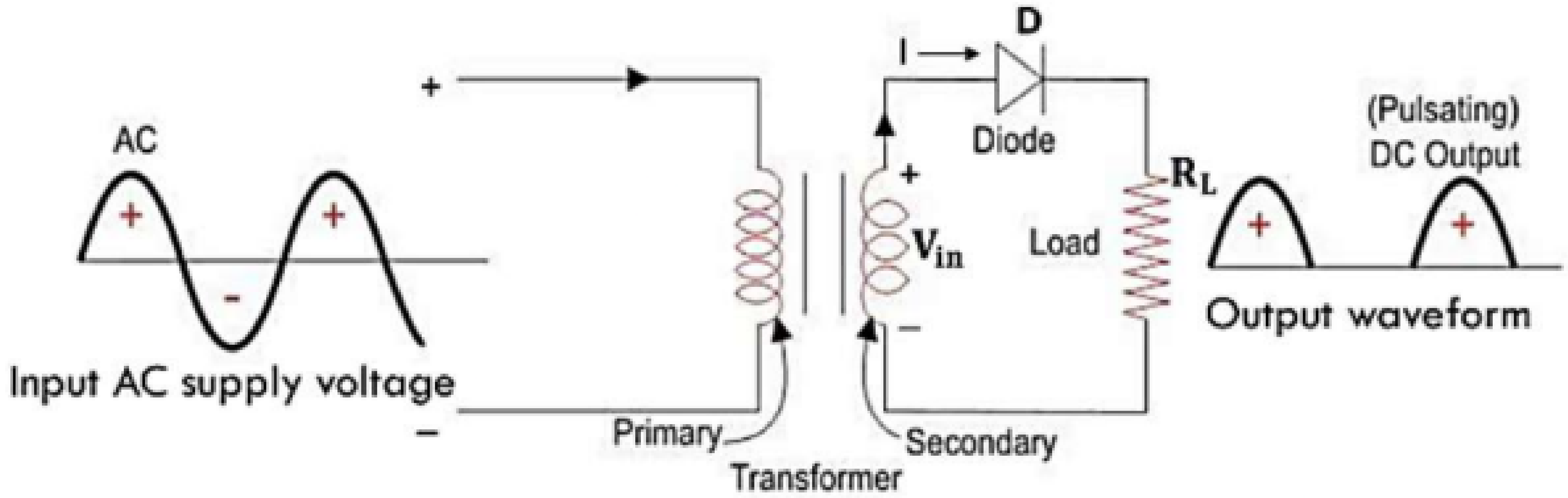


4. a) What do you mean by rectifier? Explain the working principle of half-wave rectifier with waveform.

- The circuit which converts the ac current/voltage to dc current/voltage is known as **rectifier**. The unidirectional current conduction property of diode has found its application in rectifier circuit. So diode can be used to implement a rectifier circuit so as to perform rectification. There are **two types** of rectifier are, **half wave rectifier** & **full wave rectifier**.

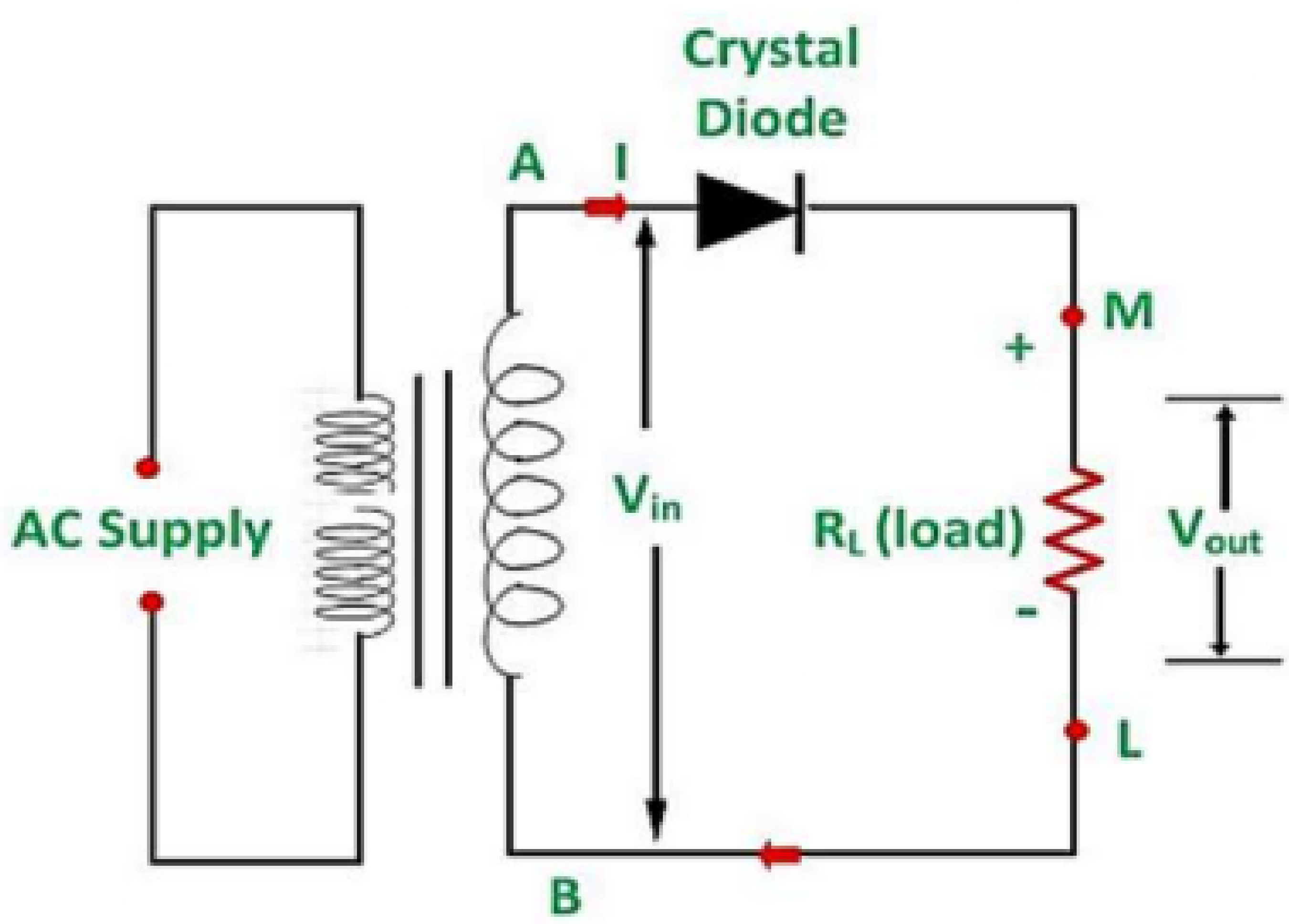
❖Half wave Rectifier

- In Half wave Rectification, the rectifier conducts current only during positive half cycles of inputs. The negative half cycles of AC supply are suppressed i.e. during negative half cycles, no current is conducted and hence, no voltage appears across the load. Therefore current always flows in one direction (i.e. DC) through the load through after every half cycle.



❖Working :-

- During the positive half cycle of input AC voltage, the V_{in} is positive and thus diode D is forward biased.
- The current is conducted through diode D and hence through R_L.
- The output is taken from load resistance R_L.
- During the negative half cycle of the input, voltage V_{in} is negative and hence diode D is reverse biased.
- No output is taken from R_L since no current flows through Diode and hence through load Resistor R_L.



b) What do you mean by transistor? Explain BJT as a switch with neat diagram.

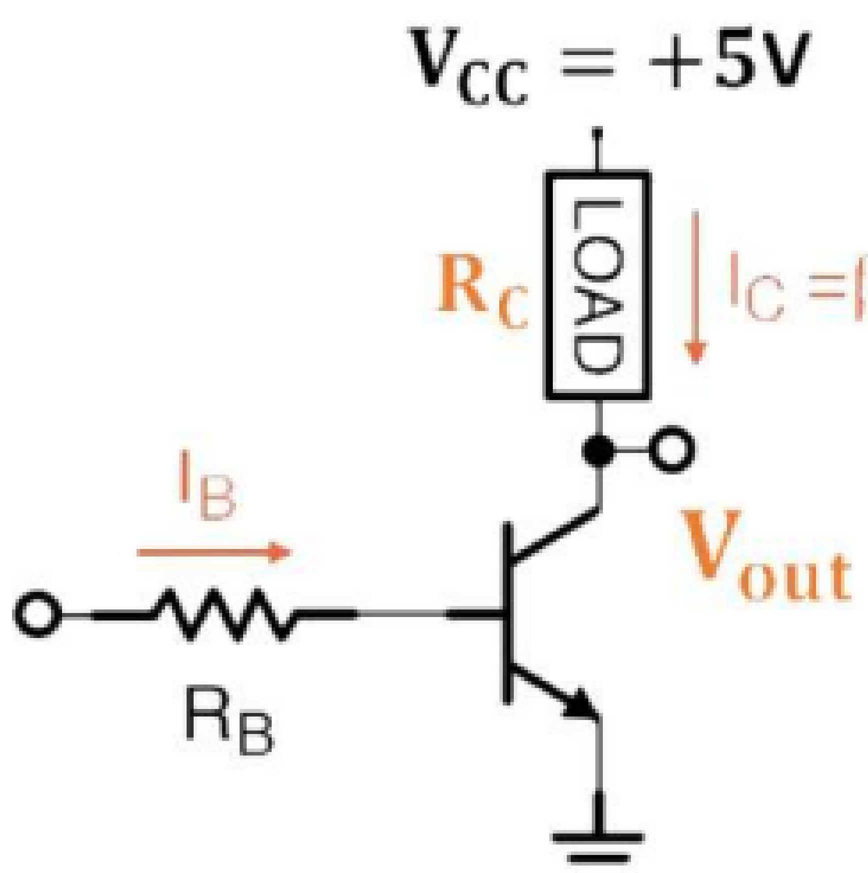
- A **transistor** is a semiconductor device that can amplify or switch electrical signals and power. It's made of materials like silicon or germanium that allow electrical current to flow through them in a controlled manner.
- **Or,** Transistors are the basic building blocks of modern electronics and are considered one of the most important inventions in the history of science.

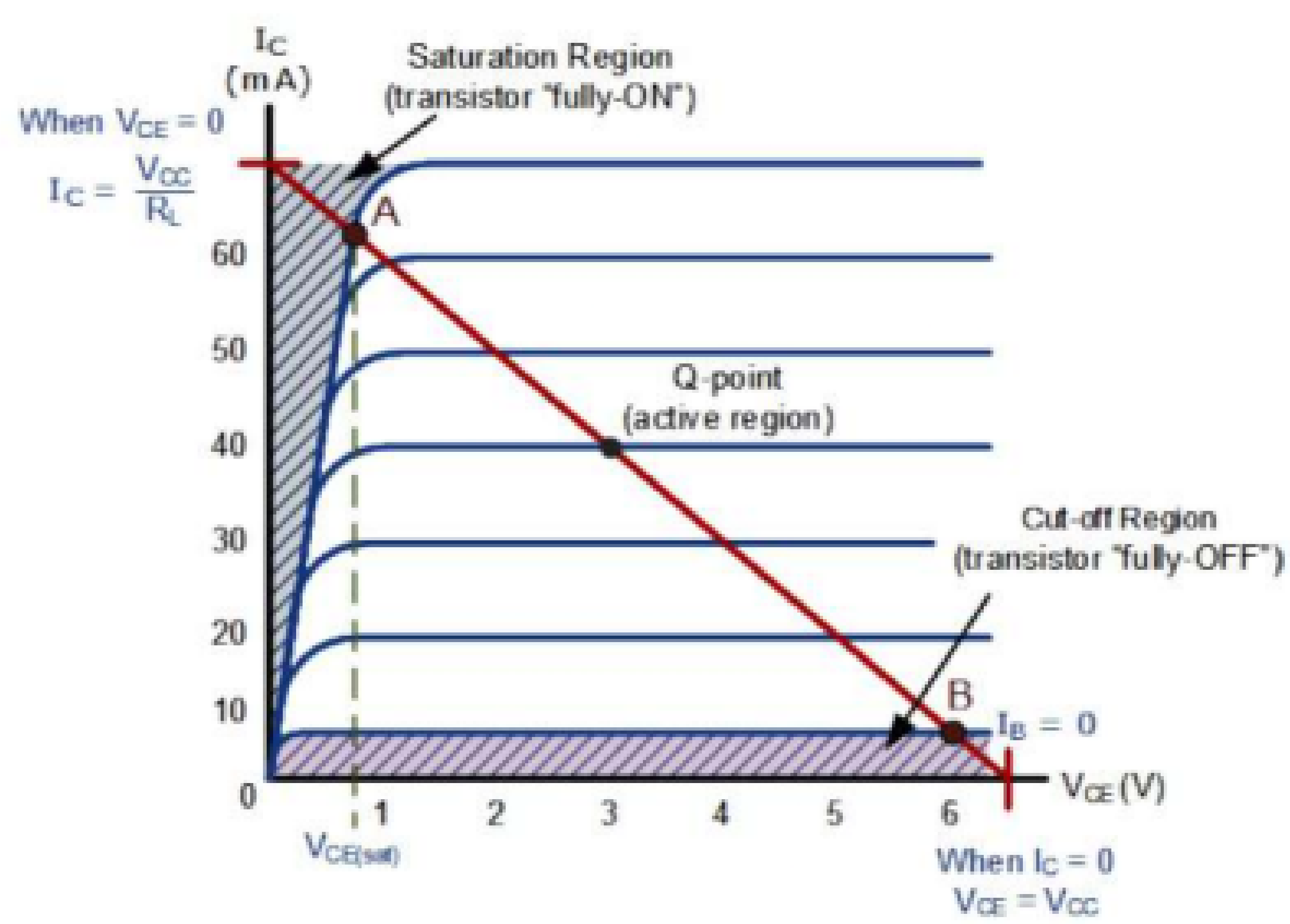
❖ BJT as a Switch/inverter

- The application of Transistor is not limited only to amplification of signal, it can also be used as switch. The areas of operation for a transistor switch are known as the **Saturation Region** and the **Cut-off Region**.

Operating regions:

The pink shaded area at the bottom of the curves represents the "Cut-off" region while the blue area to the left represents the "Saturation" region of the transistor.



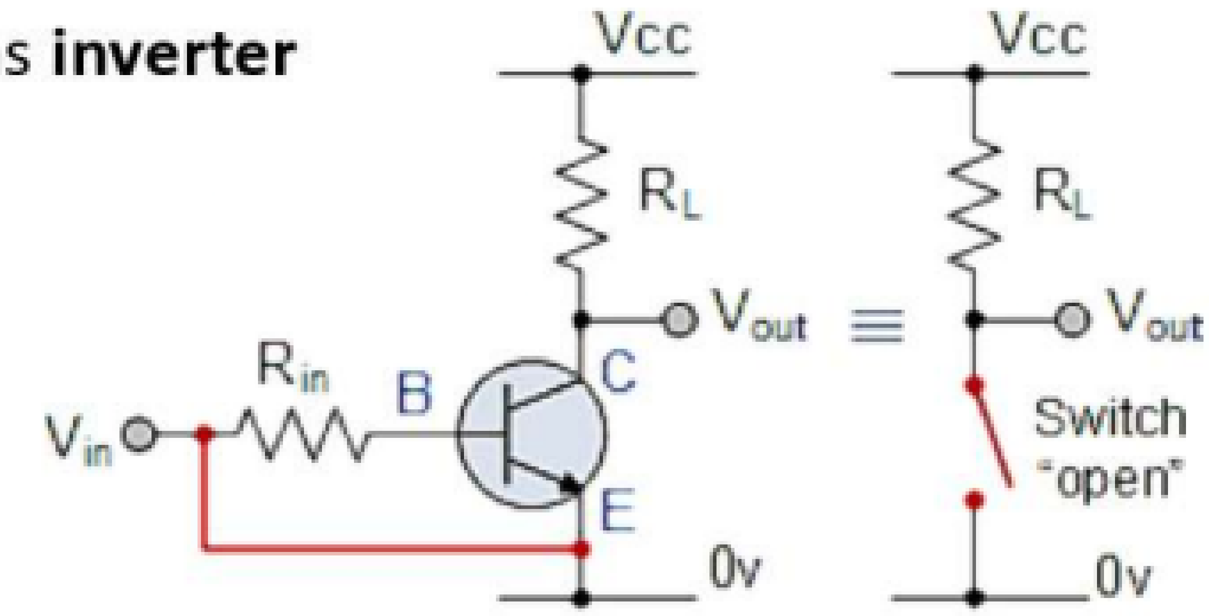


BJT as a switch-Operating regions:

1. Cut-off Region

- When Input voltage(V_{in}) is low i.e 0 ,no any current flowing through base ($I_B = 0$)
- output collector current , I_C *is zero*(0) *i.e* $I_C = \beta.I_B = \beta.0 = 0$
- Transistor is fully OFF , it is replaced by open circuit
- maximum collector voltage (V_{CE})=V_{cc} and no current flowing through the device.
- $V_{out} = V_{cc}$,i.e High output is obtained .
- i.e for low input, it produces high output act as **inverter**

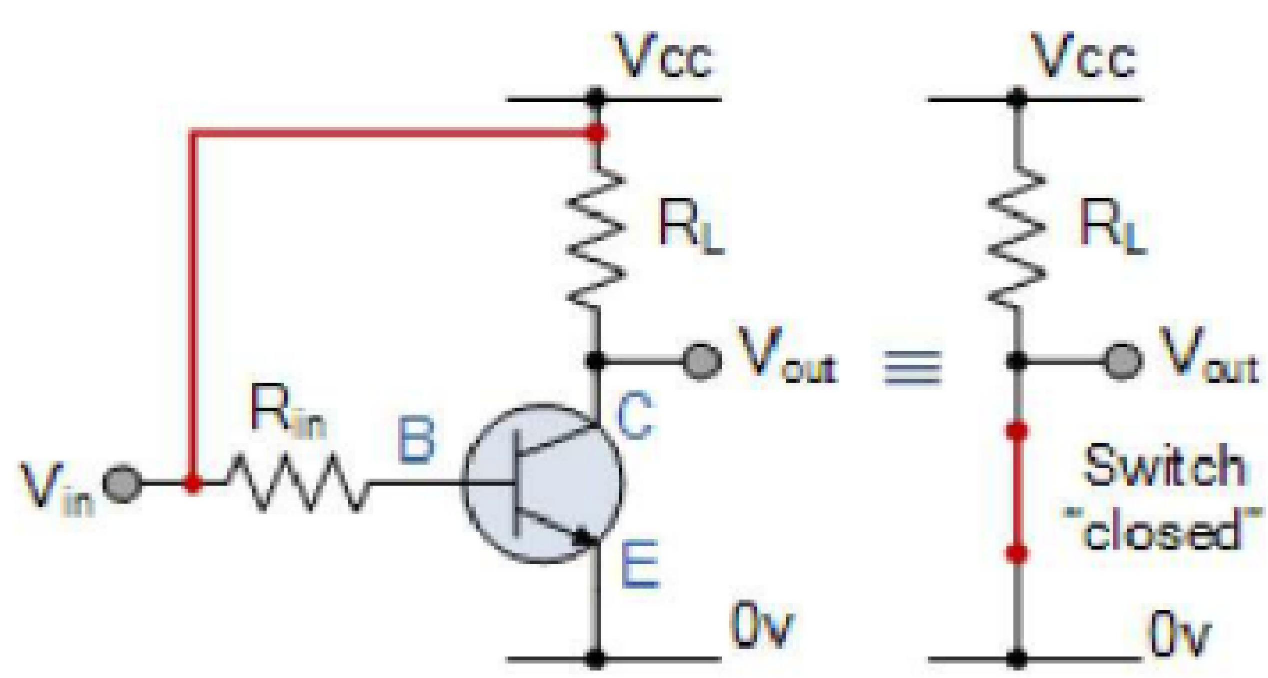
Transistor operates as an "open switch"



2. Saturation Region

- When Input voltage(V_{in}) is high i.e 1 , max. Current flowing through base (I_B)
- Output collector current , $I_C = \beta.I_B$ = maximum
- Transistor is fully **ON** , it is replaced by Closed circuit.
- VCE = 0, as it short-circuit to ground
- $V_{OUT} = V_{CE}$ = "0" ,i.e low output is obtained .
- i.e for High input (V_B >0.7V), it produces low output act as **inverter**

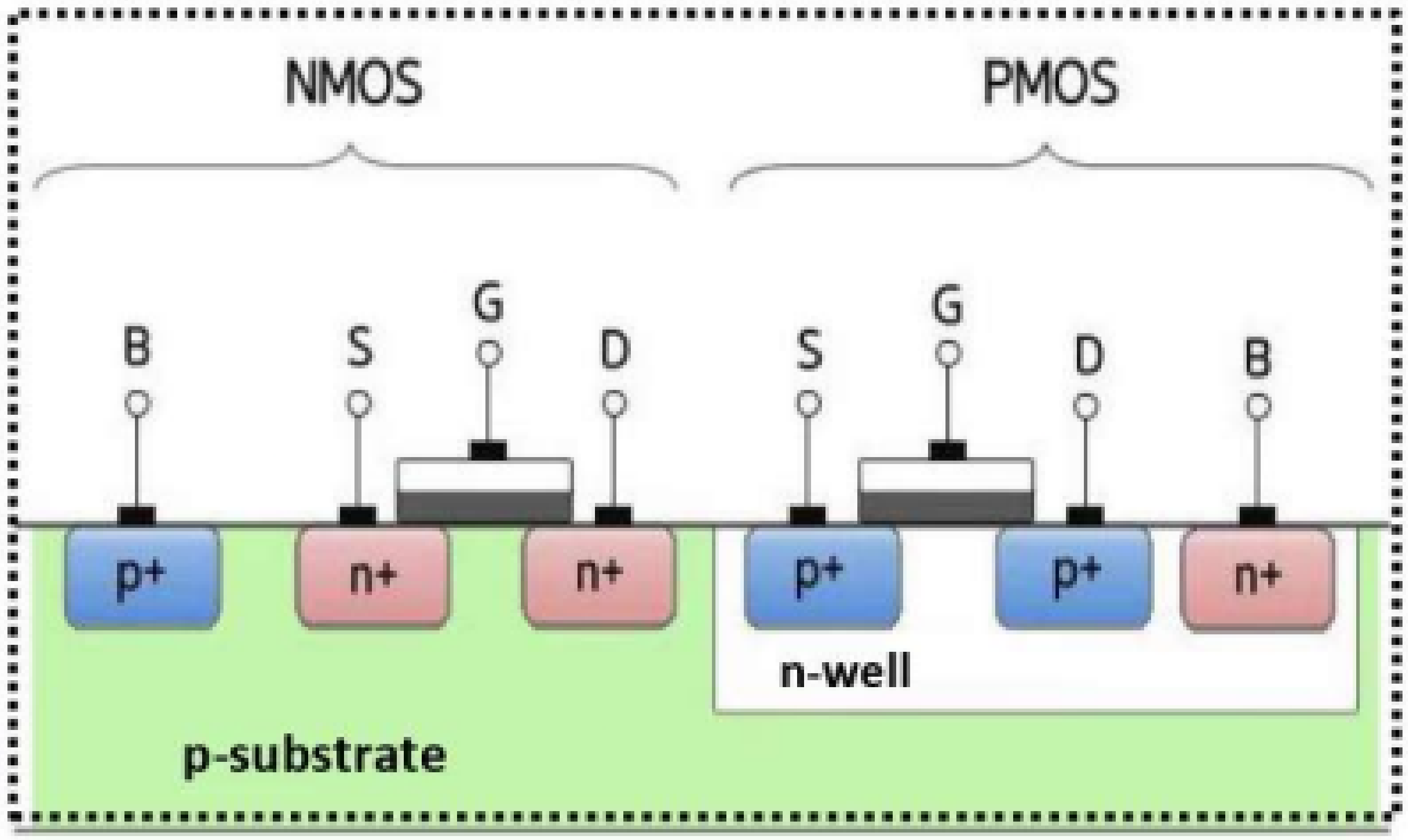
Transistor operates as a "closed switch"



5. a) Explain the construction and working of CMOS.

➢ Construction of CMOS :

- Consists of NMOS & PMOS transistors in same base.
- Widely used in digital circuits, difficult to fabricate as compare to PMOS or NMOS.
- Two MOS are insulated from each other by oxide layer.

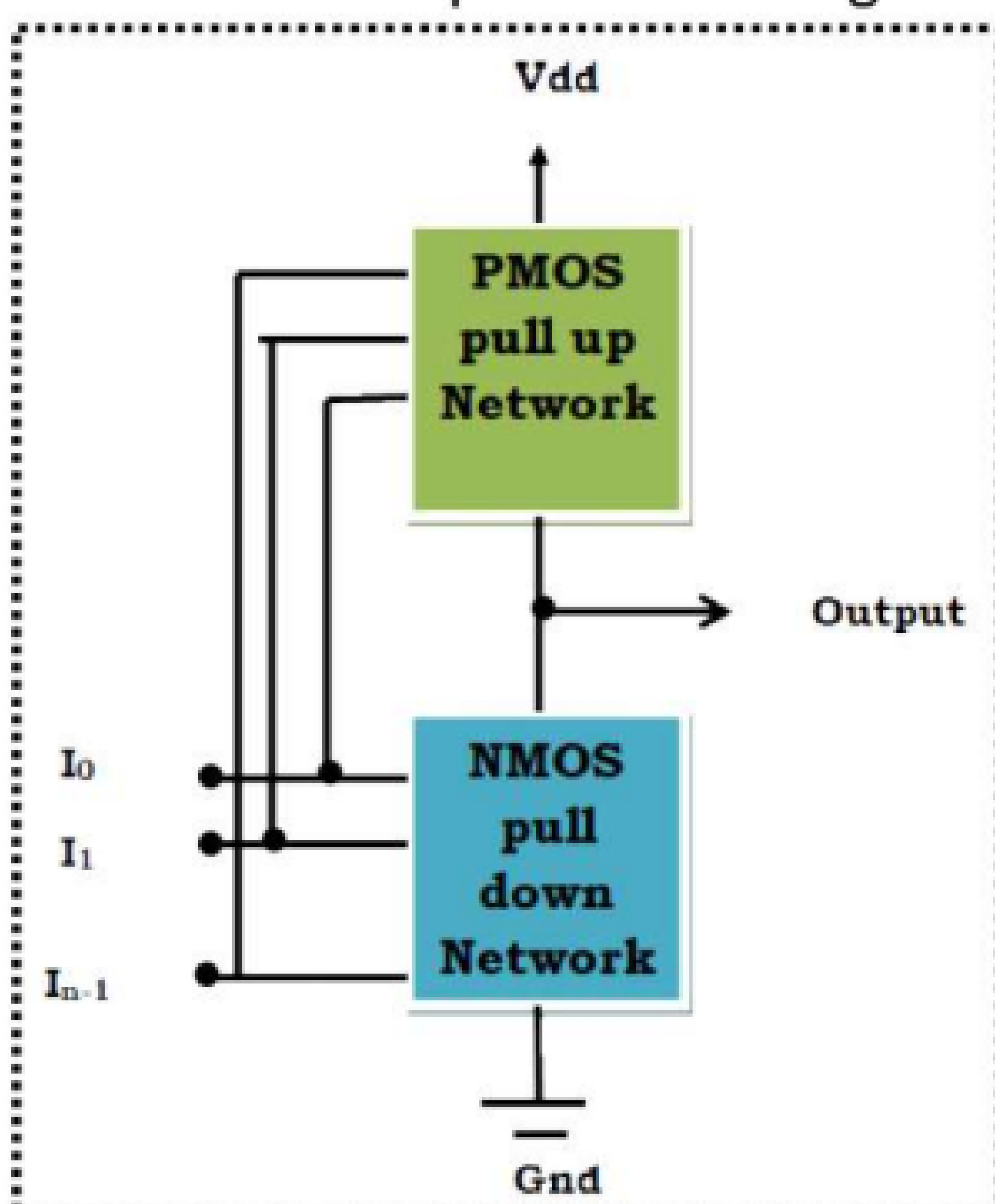


CMOS Working Principle :

➢ In CMOS technology, both N-type and P-type transistors are used to design logic functions. The same signal which turns ON a transistor of one type is used to turn OFF a transistor of the other type. This characteristic allows the design of logic devices using only simple switches, without the need for a pull-up resistor.

In CMOS logic gates a collection of n-type MOSFETs is arranged in a pull-down network between the output and the low voltage power supply rail (Vss). or quite often ground). Instead of the load resistor of NMOS logic gates, CMOS logic gates have a collection of p-type MOSFETs in a pull-up network between the output and the higher-voltage rail (often named Vdd).

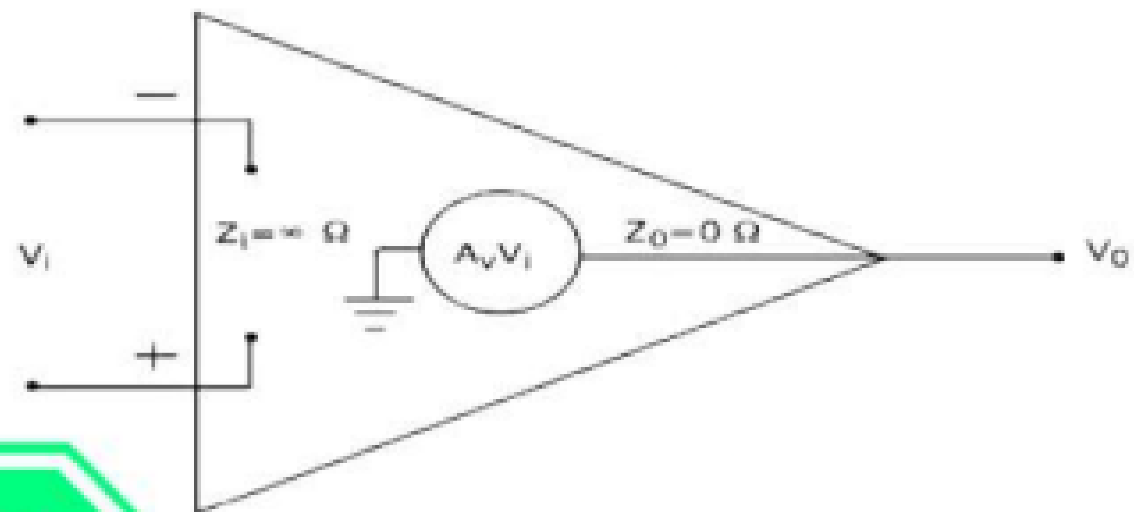
Thus, if both a p-type and n-type transistor have their gates connected to the same input, the p-type MOSFET will be ON when the n-type MOSFET is OFF, and vice-versa. The networks are arranged such that one is ON and the other OFF for any input pattern as shown in the figure.



b) What do you mean by operational amplifier? Explain the ideal and real characteristics of operational amplifier.

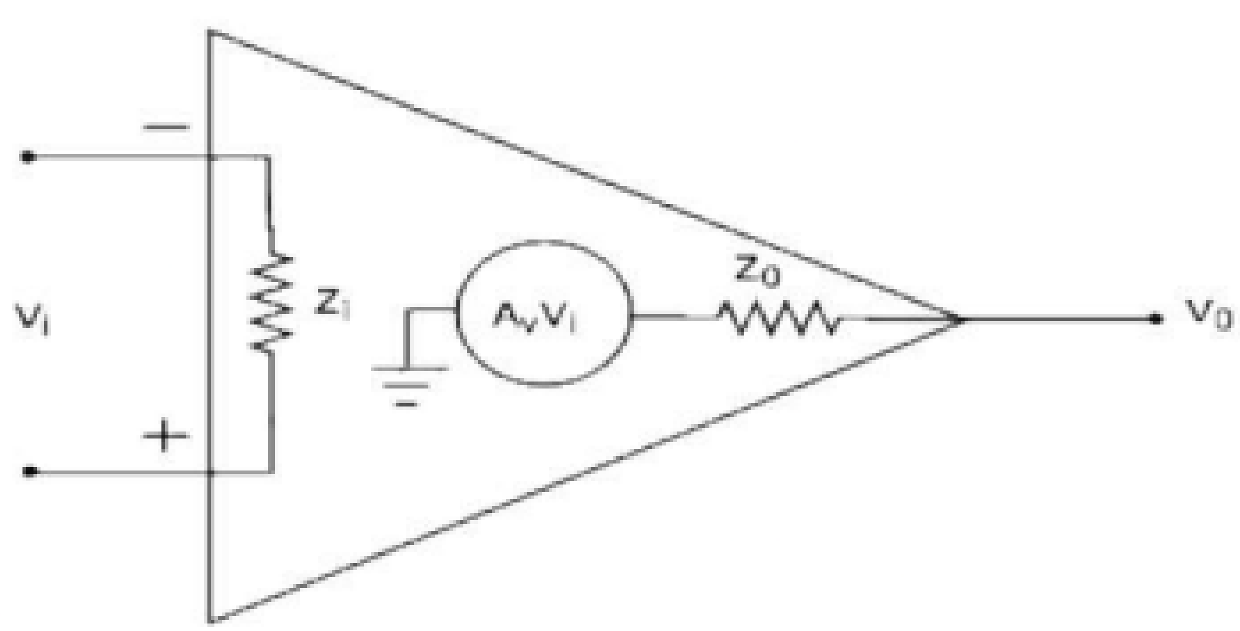
- An **operational amplifier** (op-amp) is an integrated circuit (IC) that amplifies the difference in voltage between two inputs. It has two input pins and one output pin, and its basic role is to amplify and output the voltage difference between the two input pins. Op-amps usually have three terminals: two high-impedance inputs and a low-impedance output port.

- **Ideal Op-Amp Characteristics :-**



  - Input impedance is Infinite. $(i.e., Z_{IN} = \infty)$
  - Output impedance is Zero. $(i.e., Z_{OUT} = 0)$
  - Open Loop Voltage Gain (A) is Infinite.
  - Bandwidth is Infinite.
  - Virtual ground are short between the input terminals.
  - Common mode rejection Ratio (CMMR) is infinite.
  - Slew rate is Infinite. slew rate is a measure of how fast the output voltage can change & is Measured in (V/ms).

- **An Real Op-Amp Characteristics :-**
  - Input impedance is finite. $(i.e., Z_{IN} = some\ value)$
  - Output impedance is low but not Zero. $(i.e., Z_{OUT} \neq 0)$
  - Open Loop Voltage Gain (A) is finite.
  - Bandwidth is limited.
  - Common mode rejection Ratio (CMMR) is finite.
  - Slew rate is finite.



6. Write short notes on: (Any Four)

a) Norton's theorem

- **Statement:-** It may be stated as any linear electric network or complex circuit with current and voltage sources can be replaced by an equivalent circuit containing of a single independent current source I_N and parallel resistance R_N.

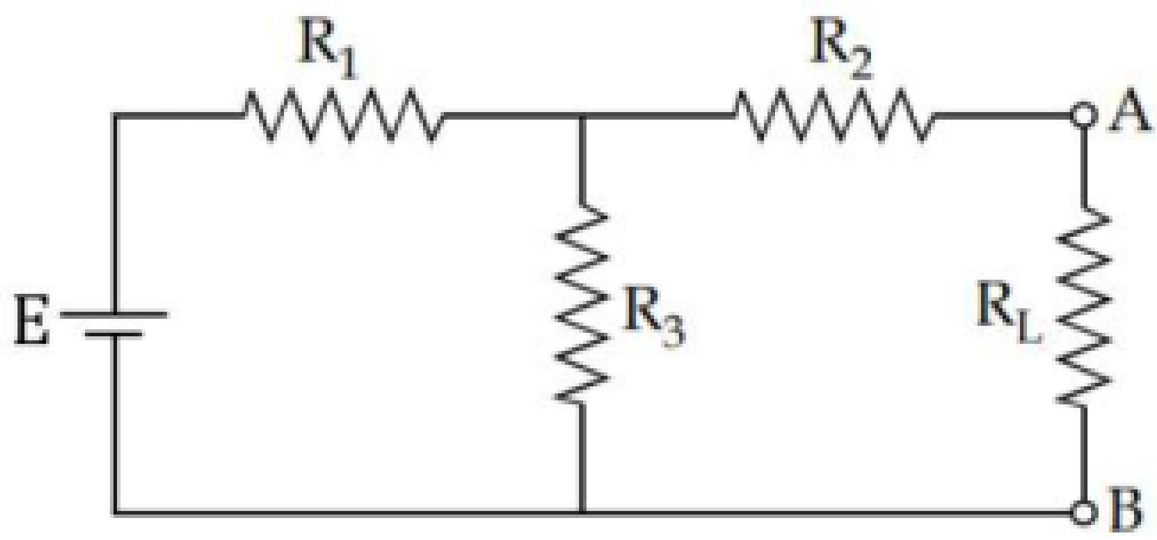


Figure:- *Any electric circuit*

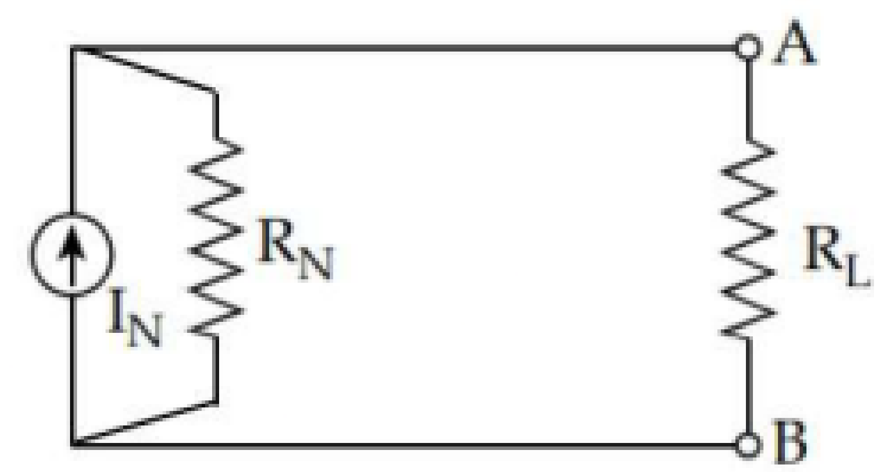


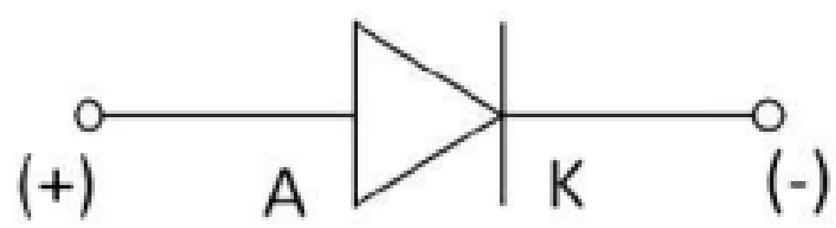
Figure:- *Norton's equivalent circuit*

- **Steps used to analyses electric circuit using Norton theorem :-**
  - Short the terminals at which Norton equivalent is required.
  - Calculate the short circuited current. This is the Norton current I_N.
  - Then, to get R_N, open current sources, short the voltage sources and remove load resistance. Then measure open circuit resistance, which is Norton's resistance (R_N).
  - Now, redraw the circuit with Norton's current and resistance in parallel and add load resistance at terminals.
  - Then use any rules to get current/voltage at load.

b) Semiconductor diode

- A **semiconductor diode** is fundamental electronic device which is basic concept for all the electronic device. Semiconductor diode is also known as p-n junction diode. It is a two-terminal device that conducts current only in one direction.

The Symbol of the PN-junction diode is given below:-



Symbol of a Diode

Here the arrow indicates the major direction of flow of Current & the dash denotes the potential barrier.

The semiconductor diode is of two types :-

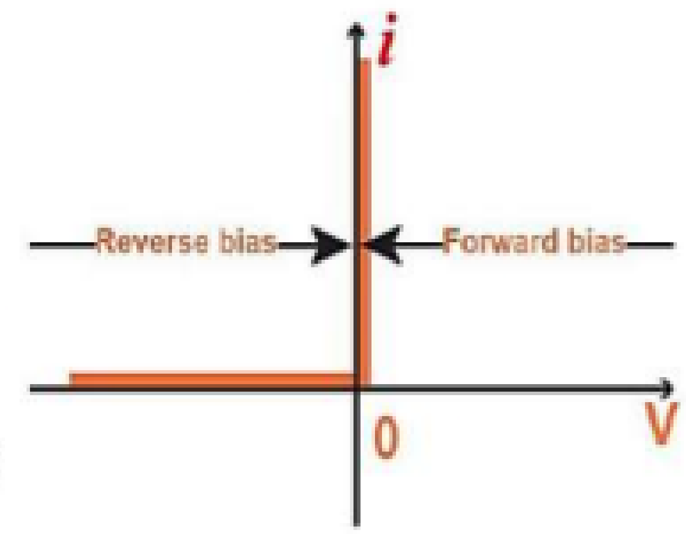


Fig: i-v characteristics

a) **Ideal semiconductor diode :-** An ideal semiconductor diode conducts current only when it is forward biased. When it is forward biased it has **zero resistance** and has **infinite resistance** in reverse biased condition.

b) **Practical semiconductor diode :-** The practical diode also conducts when it is forward biased and practically does not conducts (or conducts a very small reverse current) when it is reversed biased.

The reverse biased condition is analyzed from two characteristics:-

- ✓ Forward characteristics
- ✓ Reverse characteristics

c) BJT as a logic gate

➢ BJT as Logic Gate are :-

BJT as OR gate:

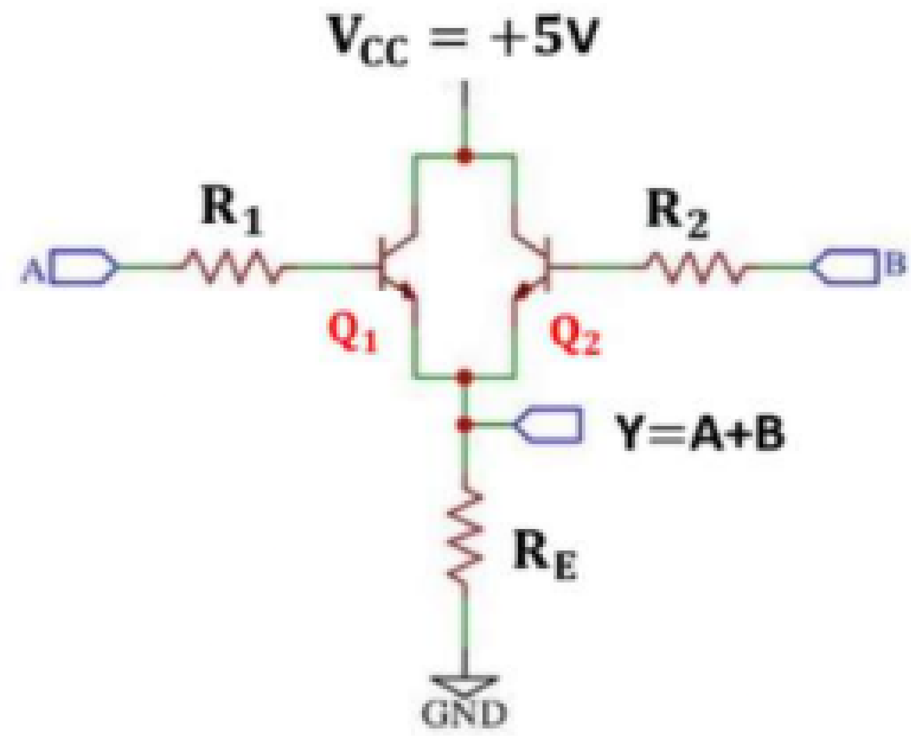
For low input the circuit can be replaced by open circuit
For High input the circuit can be replaced by closed circuit

❖ If both transistors A and B have a low (0V) input,
- ➢ Transistor Q_1 →OFF state; no current flows ;
- ➢ Transistor Q_2 →OFF state; no current flows ;
- ➢ Output is low (0V) due to both transistors Q_1 and Q_2

❖ If input A is low and B is high
- ➢ Transistor Q_1 →OFF state; no current flows;
- ➢ Transistor Q_2 →ON state; current flows through R_E;
- ➢ Output is High (5V) due to Q_2

❖ If input A is high and B is low
- ➢ Transistor Q_1 →ON state; current flows through R_E;
- ➢ Transistor Q_2 →OFF state; no current flows ;
- ➢ Output is High (5V) due to Q_1

❖ If both transistors A and B have a high (5V) input
- ➢ Transistor Q_1 →ON state; current flows through R_E;
- ➢ Transistor Q_2 →ON state; current flows through R_E;
- ➢ Output is High (5V) due to both transistors Q_1 and Q_2



A	B	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	1

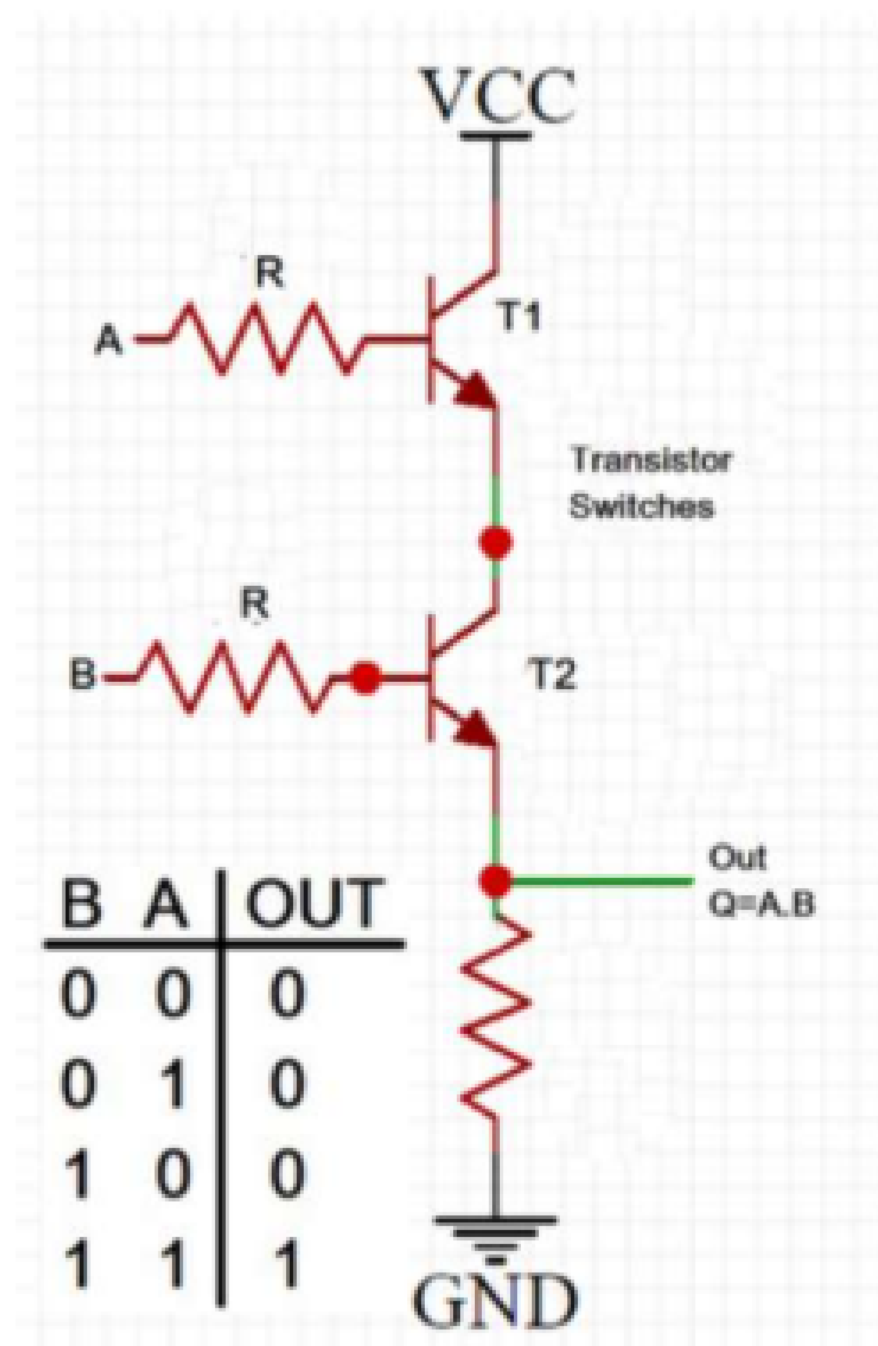
BJT as AND gate:

❖ If both transistors A and B have a low (0V) input,
- ➢ Transistor Q_1 →OFF state; no current flows ;
- ➢ Transistor Q_2 →OFF state; no current flows ;
- ➢ Output is low (0V) due to both transistors Q_1 and Q_2

❖ If input A is low and B is high
- ➢ Transistor Q_1 →OFF state; no current flows;
- ➢ Transistor Q_2 →ON state; Q_2 active;
- ➢ Output is low (0V)

❖ If input A is high and B is low
- ➢ Transistor Q_1 →ON state; Q_2 active;
- ➢ Transistor Q_2 →OFF state; no current flows ;
- ➢ Output is low (0V)

❖ If both transistors A and B have a high (5V) input
- ➢ Transistor Q_1 →ON state; Q_1 active
- ➢ Transistor Q_2 →ON state; current flows through R_E;
- ➢ Output is High (5V) due to both transistors Q_1 and Q_2



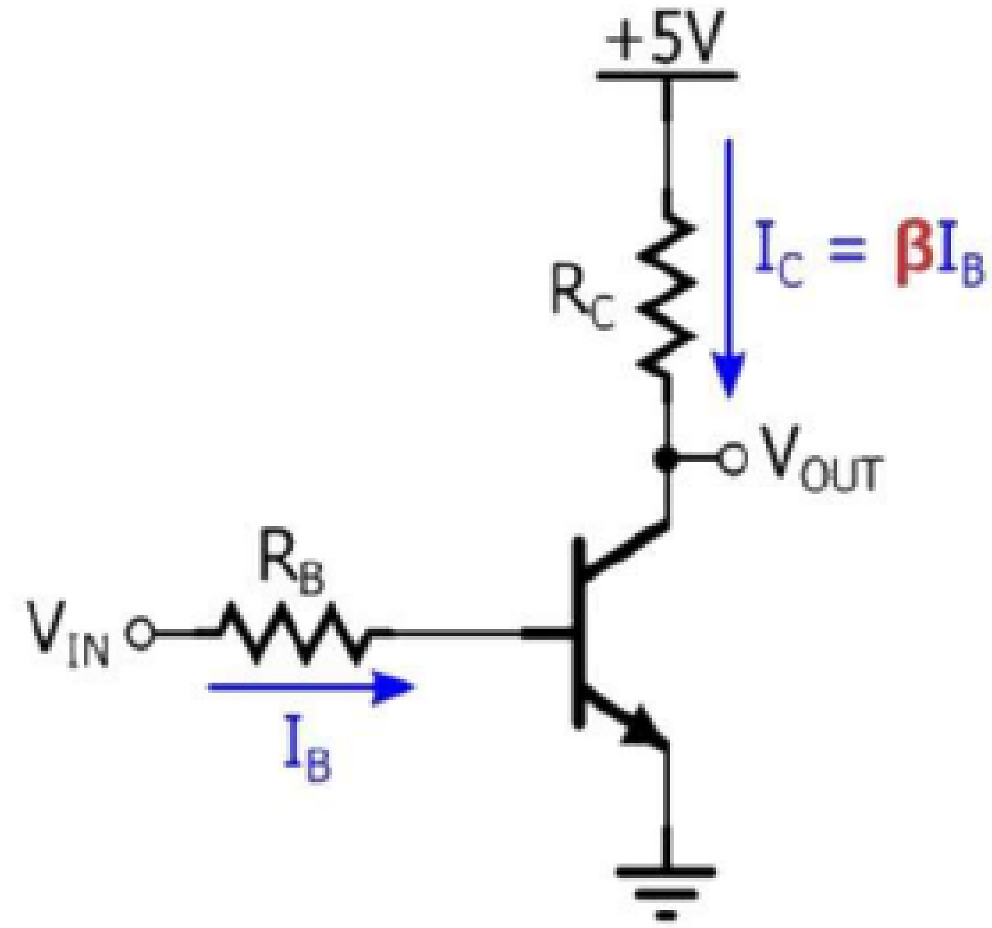
B	A	OUT
0	0	0
0	1	0
1	0	0
1	1	1

BJT as NOT gate:

BJT as switch

- When Input is high (+5V)
  - Transistor is ON state, Output is low (0 V)
- When Input is low (0 V)
  - Transistor is OFF state, Output is high(+5 V)

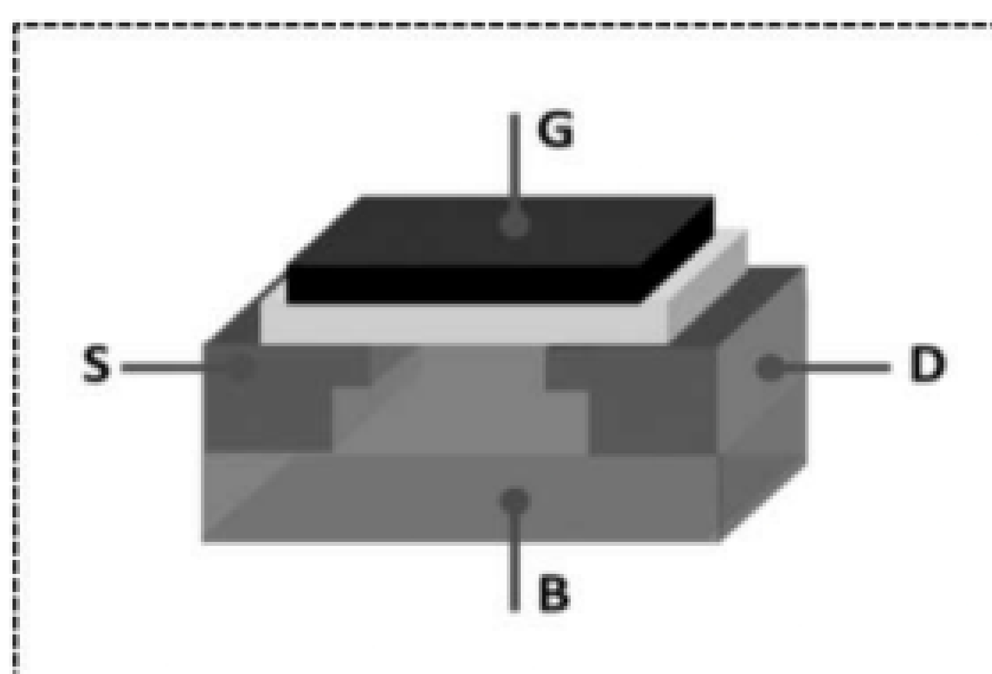
Inputs	Output	Remarks
V_{IN}	V_{OUT}	
Low (0)	High (1)	Transistor → OFF mode
High (1)	Low (0)	Transistor → ON mode



d) MOSFET

- The MOSFET (**Metal Oxide Semiconductor Field Effect Transistor**) transistor is a semiconductor device that is widely used for switching purposes and for the amplification of electronic signals in electronic devices. A MOSFET is either a core or integrated circuit where it is designed and fabricated in a single chip because the device is available in very small sizes.

  A MOSFET is a four-terminal device having source(S), gate (G), drain (D) and body (B) terminals. In general, The body of the MOSFET is in connection with the source terminal thus forming a three-terminal device such as a field-effect transistor. MOSFET is generally considered as a transistor and employed in both the analog and digital circuits. This is the basic introduction to MOSFET. And the general structure of this device is as below :-



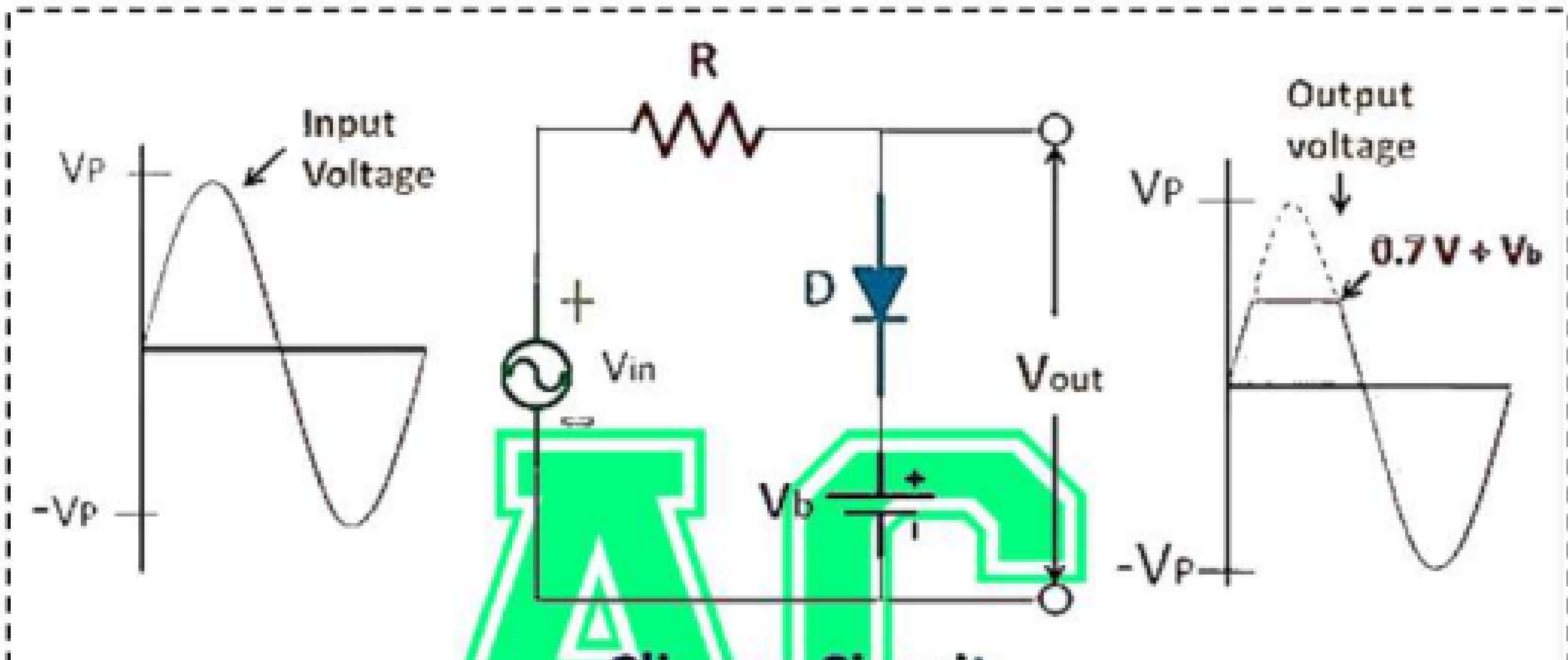
A MOSFET can function in two ways :-

a) Depletion Mode.

b) Enhancement Mode.

e) Clipper circuit

➢ A **clipper circuit** is also known as a clipping circuit, amplitude selector, or limiter, is an electronic circuit that prevents a signal from exceeding a predetermined voltage level. The circuit removes a portion of the applied wave to shape the waveform. Clippers can remove unwanted noise from an AC signal's amplitude and are widely used in digital, radar, and other electronic systems.



Clipper Circuit

Clippers work by selecting the part of a signal waveform that is above or below the reference voltage level, while leaving the remaining part of the waveform intact. The main component of a clipper circuit is a diode, which can be used in series or parallel. There are three types of clippers based on the positioning of the diode:

- ✓ Series clippers: The diode is in series with the load resistance
- ✓ Shunt clippers: The diode is shunted across the load resistance
- ✓ Parallel clippers: A diode is connected to a load

-The End-

Some Additional Question Solution

1) Resistance of 2 Ω, 3 Ω and 6 Ω are connected in parallel and the combination is connected in series with a resistance of 1 Ω across a battery with an E.M.F. of 44V. find

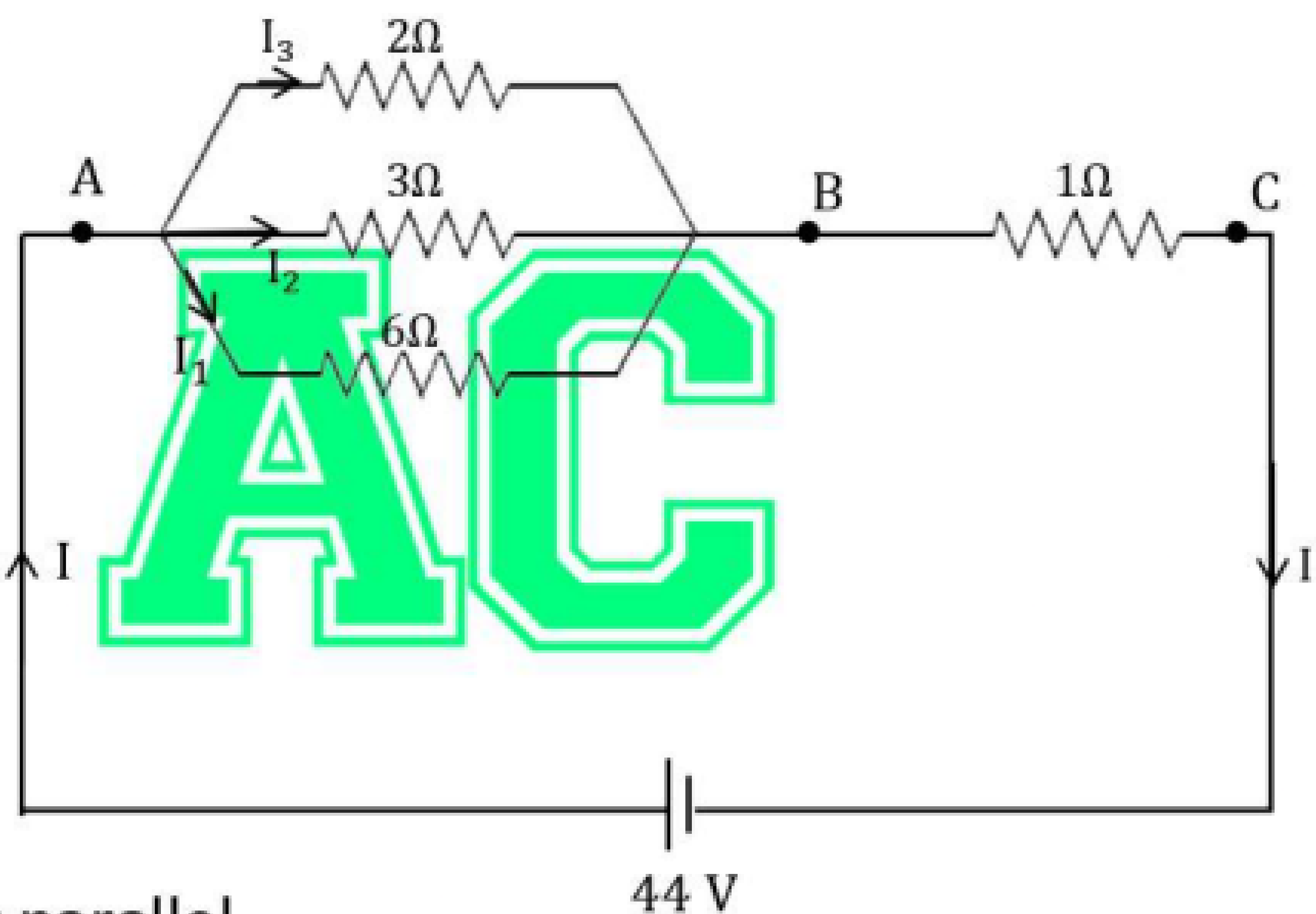
a. Potential difference across 1 Ω resistance.

b. Potential difference across parallel circuit.

c. Current in each resistor.

Solution:

By Question,



Equivalent (A,B) for parallel,

$$\frac{1}{R_{AB}} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6}$$

$$\frac{1}{R_{AB}} = \frac{5}{6} + \frac{5}{6}$$

$$\frac{1}{R_{AB}} = \frac{6}{6}$$

$$R_{AB} = \mathbf{1\Omega}$$

Req. $= R_{AB} + R_{BC}$

$$= 1 + 1 = \mathbf{2\Omega}$$

Current in Circuit $(I) = \frac{V}{Req.}$

$$= \frac{44}{2}$$

$$= \mathbf{22\ Ampere.}$$

a) Potential difference across 1 Ω resistance.

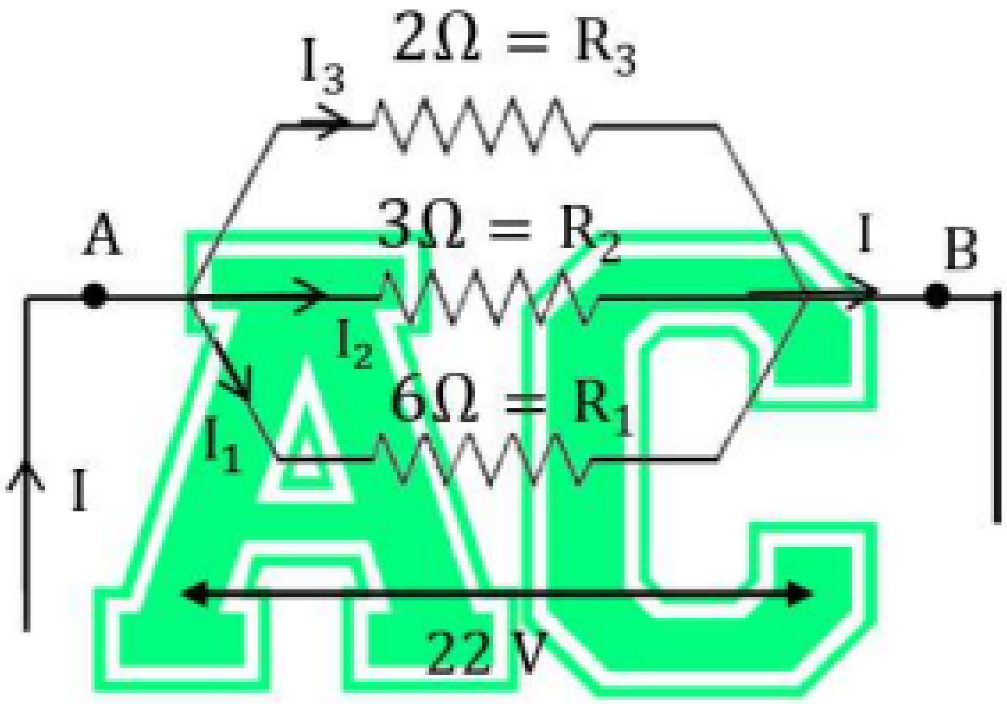
$$V_{BC} = I\,R_{BC} = 22 \times 1 = 22 \text{ volt.}$$

b) Potential difference across parallel circuit.

$$V_{AB} = I\,R_{AB(equivalent)} = 22 \times 1 = 22 \text{ volt.}$$

c) Current in each resistor.

In parallel circuit, Voltage remain same so,



So,

$$I_1 = \frac{V_{AB}}{R_1} = \frac{22}{6} = \frac{11}{3} \text{Ampere} = 3.67\text{A}$$

$$I_2 = \frac{V_{AB}}{R_2} = \frac{22}{3} = \frac{22}{3} \text{Ampere} = 7.33\text{A}$$

$$I_3 = \frac{V_{AB}}{R_3} = \frac{22}{2} = 11 \text{ Ampere}$$

For Series, Current is same,

Current through $1\Omega = I_{BC} = I = \mathbf{22\ A}$

2) A circuit consists of 10 W resistance in series with a inductance of 100 mH. It is connected across 1-f supply of 230 V, 50 Hz. Find impedance and current flowing through the circuit.

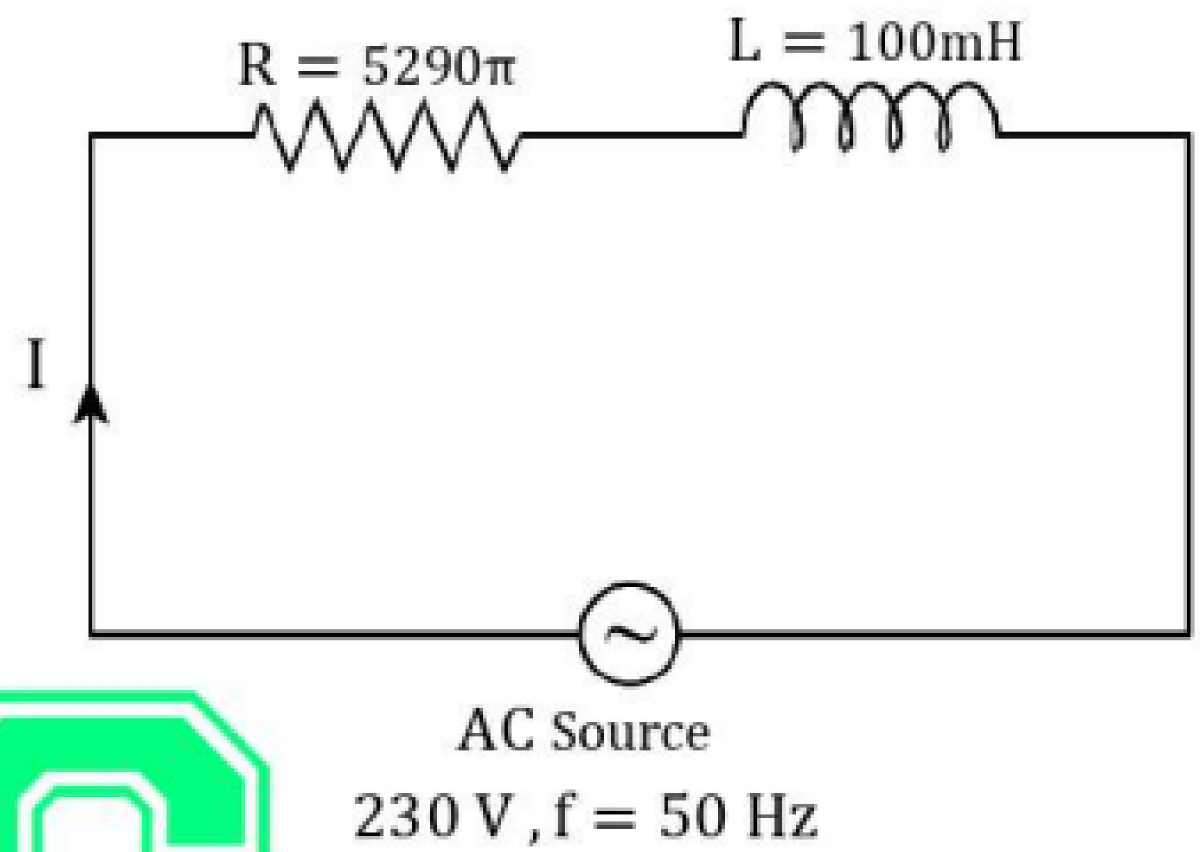
Solution:

$L = 100\text{mH} = 100 \times 10^{-3}\text{H} = 0.1\text{H}$

Power in resistance $= 10\text{W}$

$V = 230\text{V}, f = 50\text{Hz}$

$W = 2\pi f = 2\pi \times 50 = \mathbf{314.16\ radis}$



We have,

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{P} = \frac{230^2}{10} = \mathbf{5290\Omega}$$

Inductive reactance,

$$X_L = wL = 314.16 \times 0.1 = \mathbf{31.416\Omega}$$

Now,

From Impedance diagram

$$\text{Impedance } (Z) = \sqrt{{X_L}^2 + R^2}$$

$$Z = \sqrt{(31.416)^2 + (5290)^2}$$

$$\boxed{\mathbf{Z = 5290.093\ \Omega}}$$

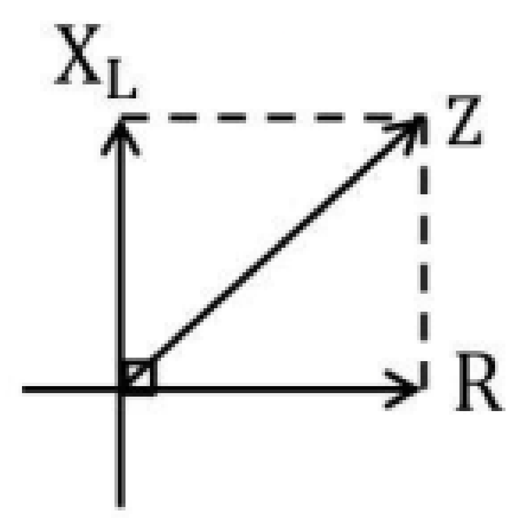


Fig :- Impedance diagram

$$\text{Current in Circuit } (I) = \frac{V}{Z}$$

$$= \frac{230}{5290.093} = \boxed{\mathbf{0.0434\ Ampere}.}$$

3. a) A series circuit having a resistance of 12 Ω is series with a capacitance of 100μF is connected across 230V, 50 Hz supply. Calculate
(i) Reactance (ii) Impedance (iii) Current (iv) Power factor (v) Power.

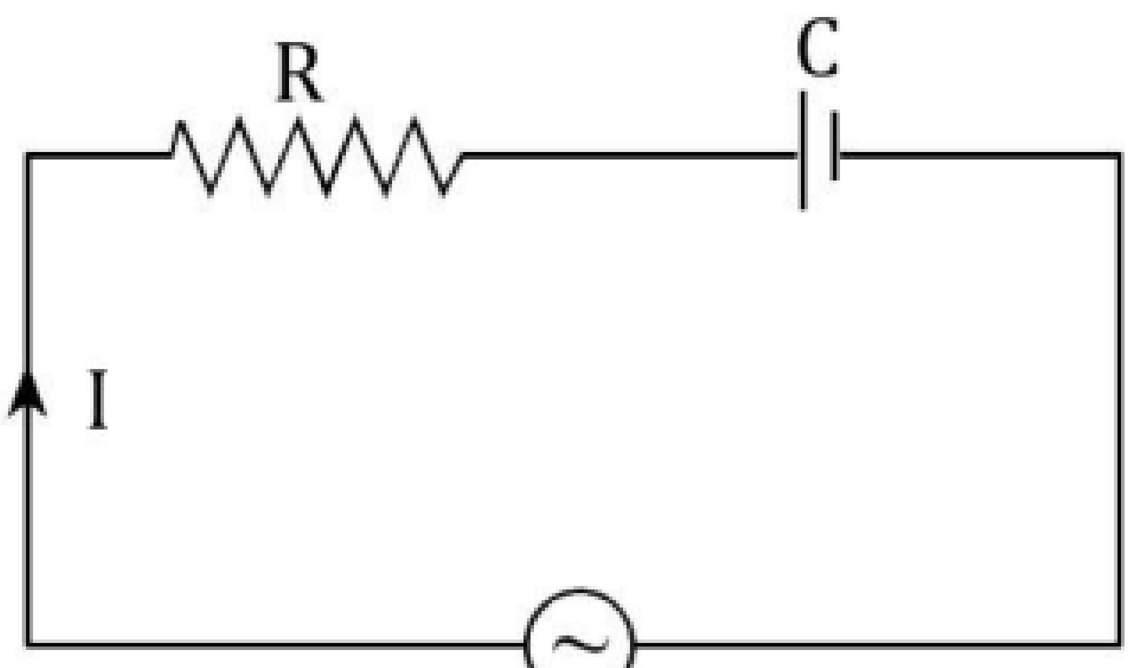
Solution:

$R = 12\Omega$

$C = 100\mu F$

$W = 2\pi f = 2\pi \times 50$

$= 314.16 \text{ rad/s}$



(i) Capacitive Reactance,

$$X_C = \frac{1}{WC} = \frac{1}{314.16 \times 100 \times 10^{-6}}$$

$$= \mathbf{31.83\ \Omega}$$

Let Z be impedance & ϕ be phase angle,

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

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

$$= \sqrt{1157.207}$$

$$\mathbf{Z = 34.0177\ \Omega}$$

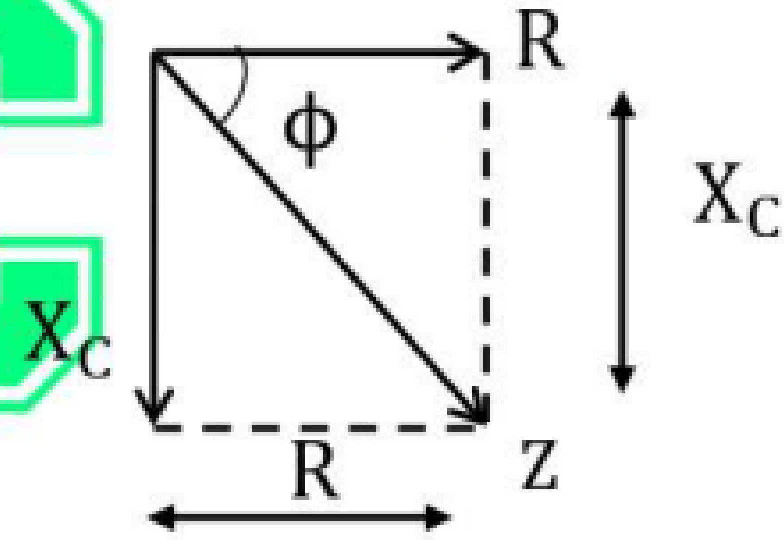


Fig :- Impedance diagram

(ii) Impedance , $Z = 34.0177\ \Omega$

From Impedance diagram,

$$\tan\phi = \frac{X_C}{R}$$

$$\phi = \tan^{-1}\left(\frac{31.83}{12}\right)$$

$$\mathbf{\phi = 69.34}$$

(iii) Current

Current in Circuit $(I) = \frac{V}{Z}$

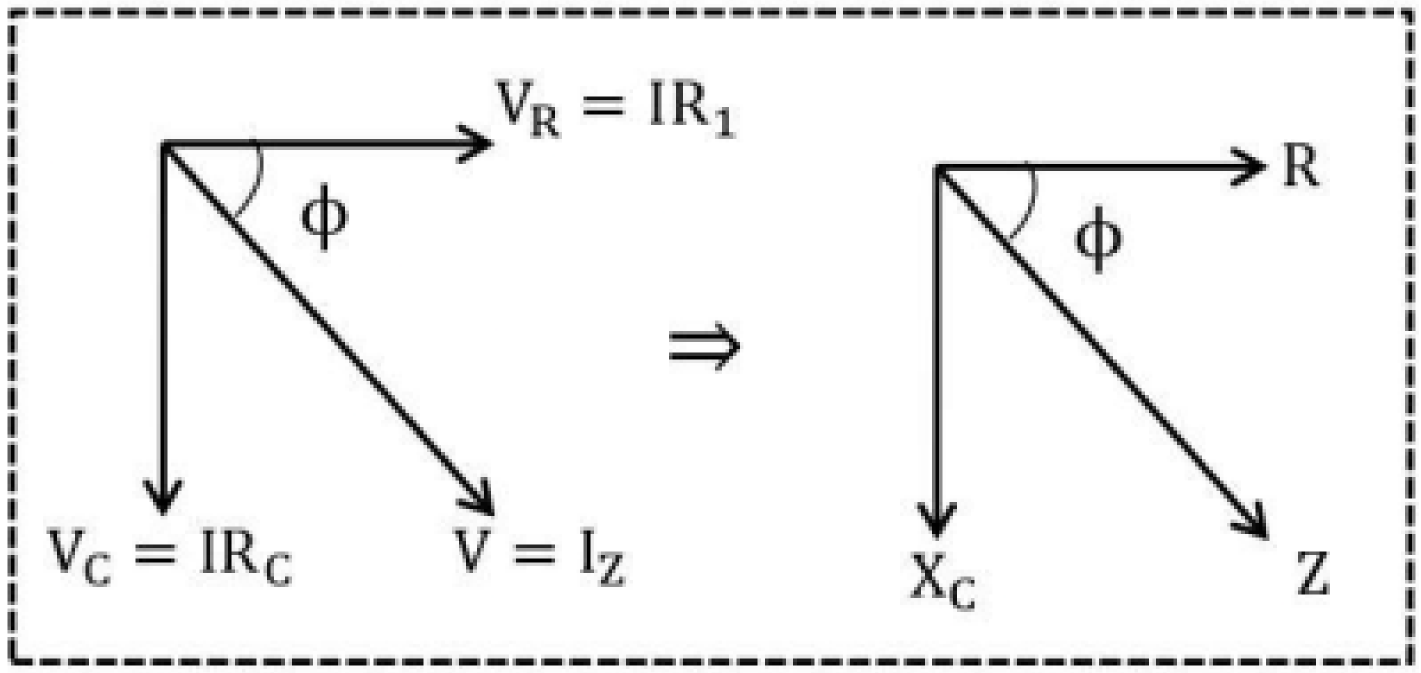
$$= \frac{230}{34.0177}$$

$$= \mathbf{6.761\ A}$$

(iv) Power factor

Power factor is the cosine of angle between Voltage and Current i.e. it is denote by **p.f**

$$p.f = \cos(\phi)$$
$$= \cos(69.94)$$
$$\boxed{\mathbf{p.f = 0.3528}}$$



(v) Power

$$P = VI\cos\phi$$
$$= 230 \times 6.761 \ \cos(69.34)$$
$$\boxed{= \mathbf{548.648\ Watt}.}$$

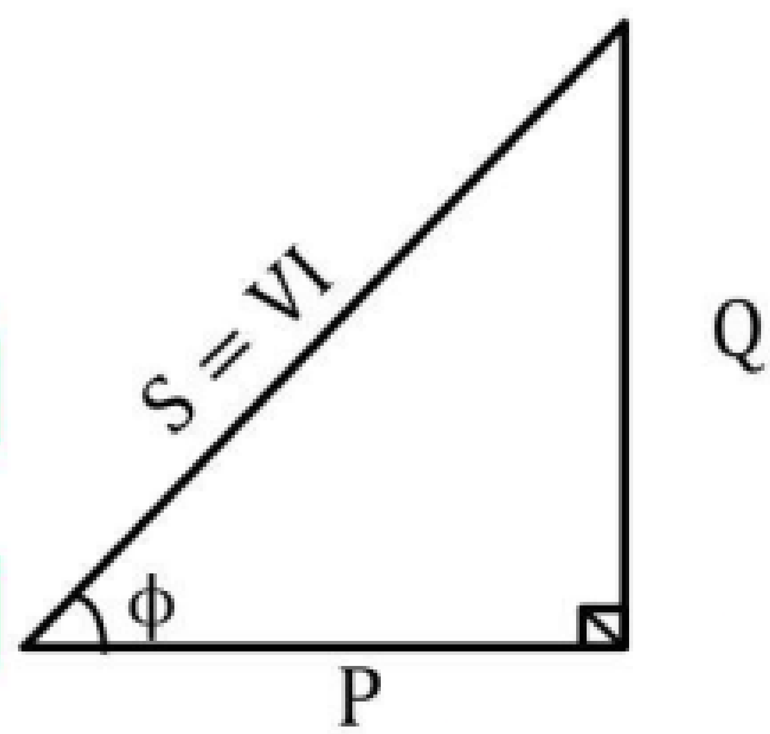


Fig :- **Power triangle**

If ask:

For Power,

There are three types ,

Reactive (Q) ⟶ VAR (Volt-Ampere-Reactive)

Active (P) ⟶ W (Watt)

Apparent (S) ⟶ VA (Volt-Ampere)

From Figure,

$$\mathbf{S = VI} \qquad \left\{or, \quad S = \sqrt{P^2 + Q^2}\right\}$$
$$= 230 \times 6.761$$
$$= \boxed{1555.03 \text{ Volt-Ampere.}}$$

$$\mathbf{Q = S\cos\phi}$$
$$Q = VI\cos\phi$$
$$= 230 \times 6.761 \times \sin(69.34)$$
$$= \boxed{1455.0269 \ \text{Volt-Ampere-Reactive.}}$$

3. b) Three resistances 2Ω , 3Ω and 6Ω are connected in (i) series and (ii) parallel. Calculate the effective resistance in each case.

Solution:

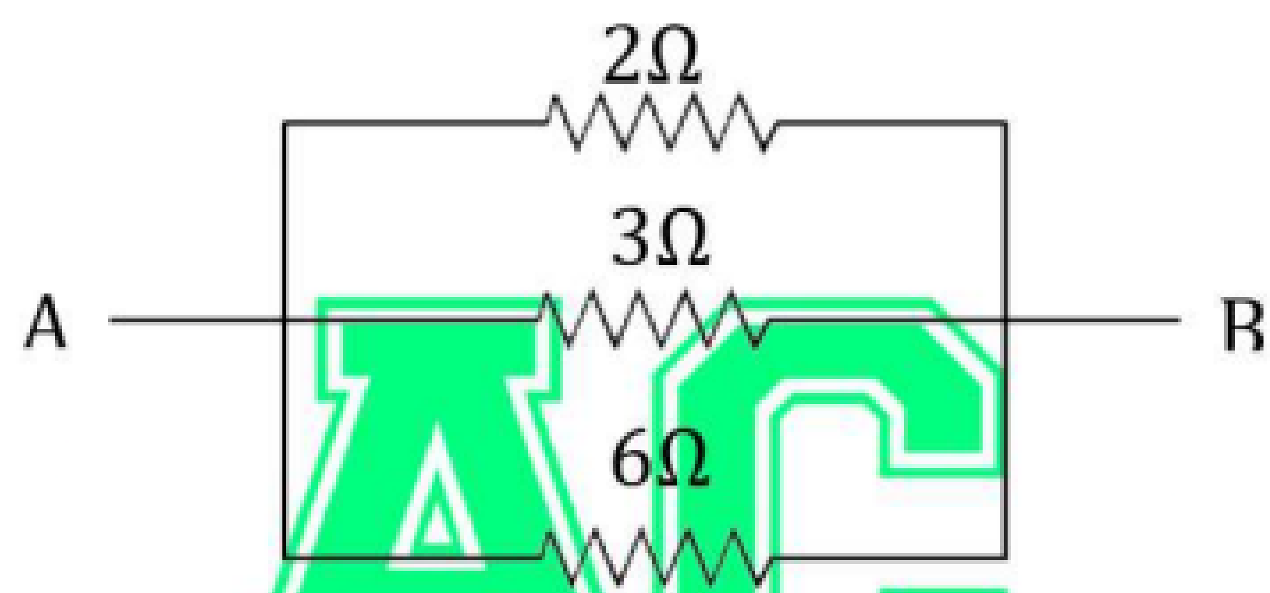
(i) series

In Series,

$$\text{Req.} = R_{AB} = R_1 + R_2 + R_3$$

$$R_{AB} = 2 + 3 + 6 = \boxed{\mathbf{11\Omega}}$$

(ii) parallel



In Parallel, $\frac{\mathbf{1}}{\mathbf{R}_{eq}} = \frac{1}{R_1} + \frac{2}{R_2} + \frac{3}{R_3}$

$$\frac{1}{R_{eq}} = \frac{1}{2} + \frac{2}{3} + \frac{3}{6}$$

$$\boxed{\boldsymbol{R_{eq} = 1\Omega}}$$

4) How much current will flow through a 20Ω electric heater when a voltage of 200 V is supplied?

Solution:

$R = 20\Omega$

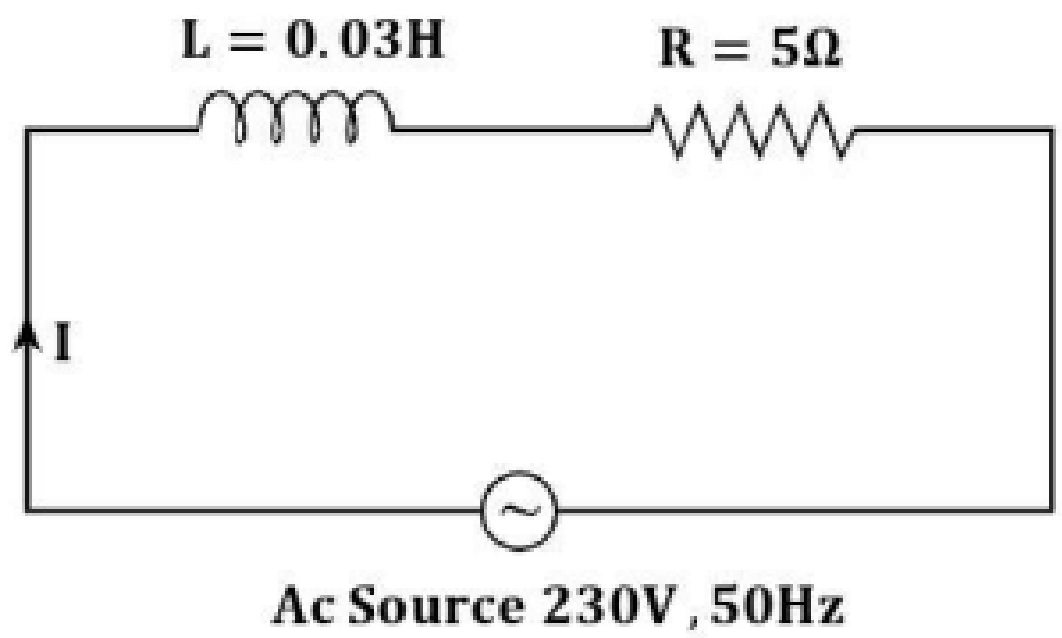
$V = 200V$

To Find I =?

From ohm law, $V = I\,R$

$$I = \frac{200}{20} = \boxed{\mathbf{10\ A.}}$$

5) An inductive circuit has a resistance of 5 W in series with an inductance of 0·03 H. Calculate the current and power factor, when connected across 230 V, 50 Hz supply.



Similar as **Q1**.

- Do yourself.

6) Define resistor and capacitor.

- A **resistor** has been defined as physical device that limits or regulates the flow of electric current in an electronic circuit. Resistor is denoted by R and unit of resistance is ohm or Ω.

- An electronic device which is used to store the energy in the form of charge is called **capacitor.** It is a passive electronic component with two terminals.

7) Define extrinsic semiconductor. Differences between P- types & N-types Semiconductor.

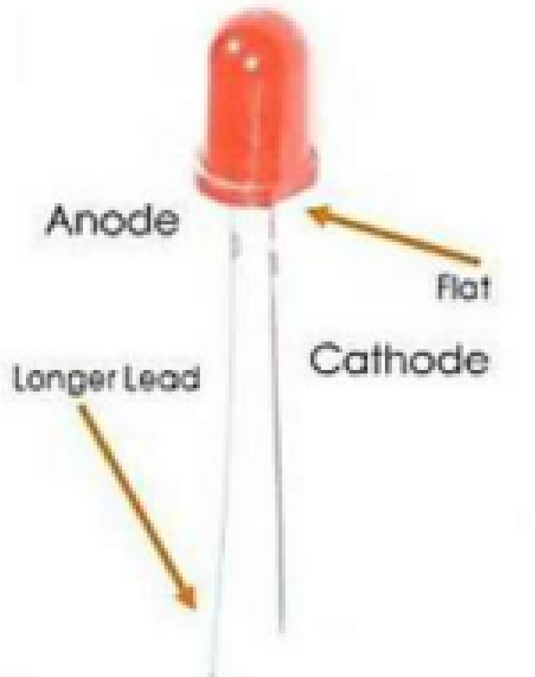
✓ Some impurities atoms are added to pure semi-conductor materials to improve conductivity. The process of adding impurities to the pure semiconductor is called Doping, and the resulting material is called as **extrinsic semiconductor**. Depending upon the type of impurity added, there are **two types of extrinsic semiconductor** :-

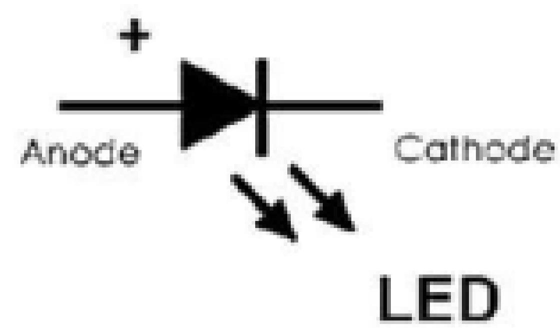
a) N-type Semiconductor
b) P-type semiconductor

Basis of Difference	P-Type Semiconductor	N-Type Semiconductor
Definition	When a trivalent impurity is added to an intrinsic semiconductor, the obtained semiconductor is known as P-type semiconductor.	When a pentavalent impurity is added to an intrinsic semiconductor, the obtained semiconductor is known as N-type semiconductor.
Type of impurity added	To obtain the P-type semiconductor, a trivalent impurity such as aluminum, gallium, indium, etc. is added to the pure semiconductor.	The pentavalent impurities such as P, Sb, As, Bi, etc. are added to pure semiconductor to obtain N-type semiconductor.
Group of doping element (or impurity)	The elements of group 13 are added as doping element to form a P-type semiconductor.	The elements of group 15 are added as doping element to form an N-type semiconductor.
Effect of impurity or doping element	In case of P-type semiconductor, the impurity added creates a vacancy of electron in the structure, known as hole.	In case of N-type semiconductor, the impurity added provides extra electrons in the structure.
Majority charge carriers	Holes are the majority charge carriers in a P-type semiconductor.	Electrons are the majority charge carriers in an N-type semiconductor.
Minority charge carriers	Electrons are the minority charge carries in a P-type semiconductor.	Holes are the minority charge carriers in an N-type semiconductor.
Charge density	In case of P-type semiconductor, the number of holes are much more than number of electrons, i.e. $N_h >> N_e$.	In an N-type semiconductor, the number of electrons are much more than the number of holes, i.e. $N_e >> N_h$.
Movement of majority charge carriers	In a P-type semiconductor, the majority charge carriers are holes (which are positive), thus moves from higher potential to lower potential.	The majority charge carries in an N-type semiconductor are electrons (which are negative), thus moves from lower potential to higher potential.
Energy levels	P-type semiconductor has acceptor energy levels very close to the valance band and away from the conduction band.	N-type semiconductor has donor energy levels very close to the conduction band and away from the valance band.
Conductivity	In P-type semiconductors, the conductivity is due to the presence of holes.	The conductivity in the N-type semiconductor is due to the presence of electrons.

8) Explain about LED and LDR in brief.

➢ An **LED** is a light emitting diode. The LED emits light when it is forward biased and it emits no light when it is reverse biased. The intensity of light is proportional to the square of the current flowing through the device. Light emitting diodes are not made from silicon or germanium but are made by using elements like gallium, phosphorus and arsenic.





Advantages of LED

- The Light emitting diode (LED) is a solid - state light source.
- LEDs have replaced incandescent lamps in many applications because they have following advantages:-
  - a) Low power consumption
  - b) Longer life (more than 20 years)
  - c) Fast ON-OFF switching

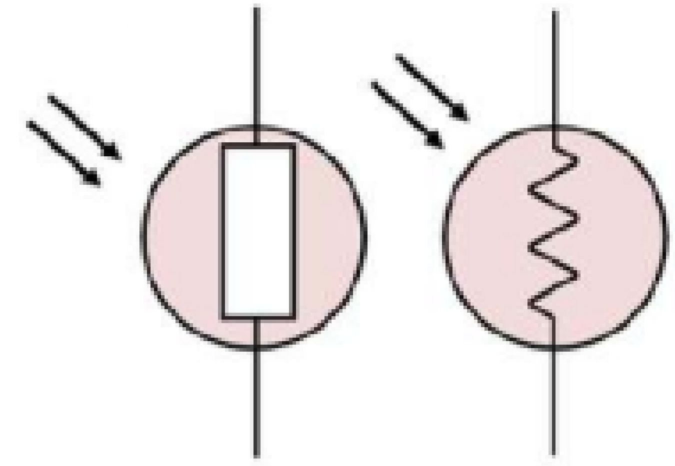
❖LDR

➢ **Light Dependent Resistor** is called by many names such as photoresistor, photocell, photoconductor, photoconductive cells. The resistivity of LDR depends on the light incident on it and the sensitivity of LDR depends on the wavelength of the incident light. Thus it is a light sensitive device. Mostly it is used in circuits to detect the presence of the level of the light.

❖Advantages:

- Low cost
- Available in many shapes and sizes
- Low power operation
- High sensitivity

Symbol of LDR:-

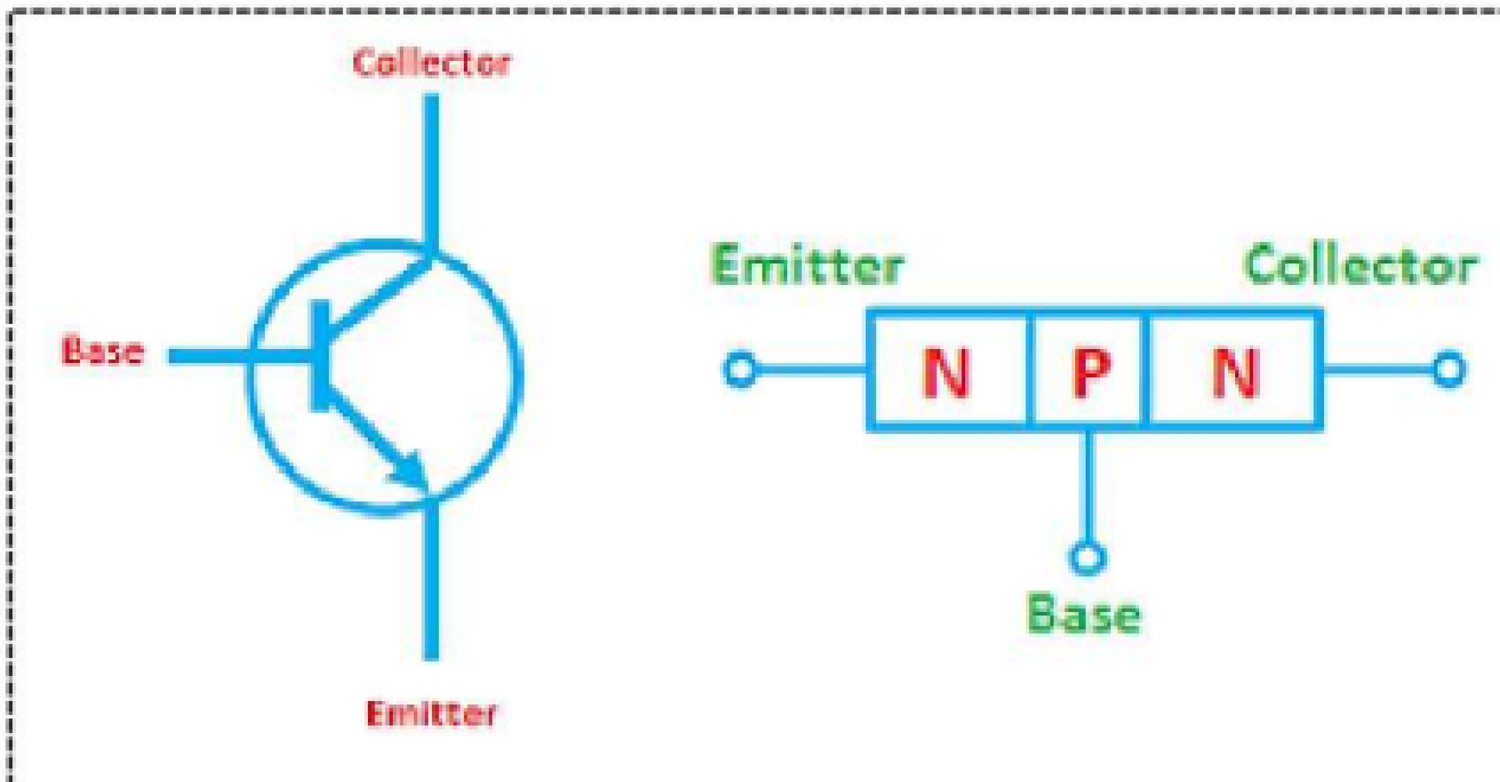


❖Disadvantages:

- Large response time- The variation in resistance value is slow to the light action.

9) NPN Transistor

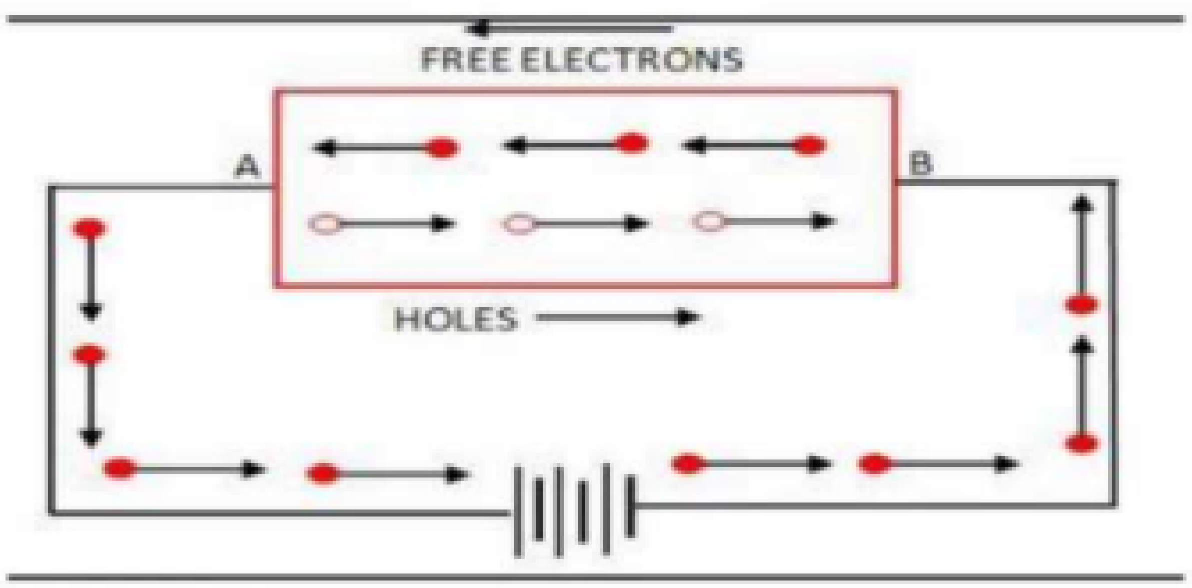
➢ **NPN transistor** is one type of Bipolar Junction Transistor (BJT). The NPN transistor has two n-type semiconductor materials, and a thin layer of p-type semiconductor separates them. In this type of transistor, the majority of charge carriers are electrons. The flowing of electrons in the direction of the emitter to the collector forms the current flow in the NPN transistor. Generally, the NPN transistor is the most popular type of bipolar transistors and used much more because electrons' mobility is higher than the mobility of holes. As discussed before, The NPN transistor has three terminals – emitter, base, and collector same as the other types. The NPN transistor is mainly used for amplifying and switching signals.

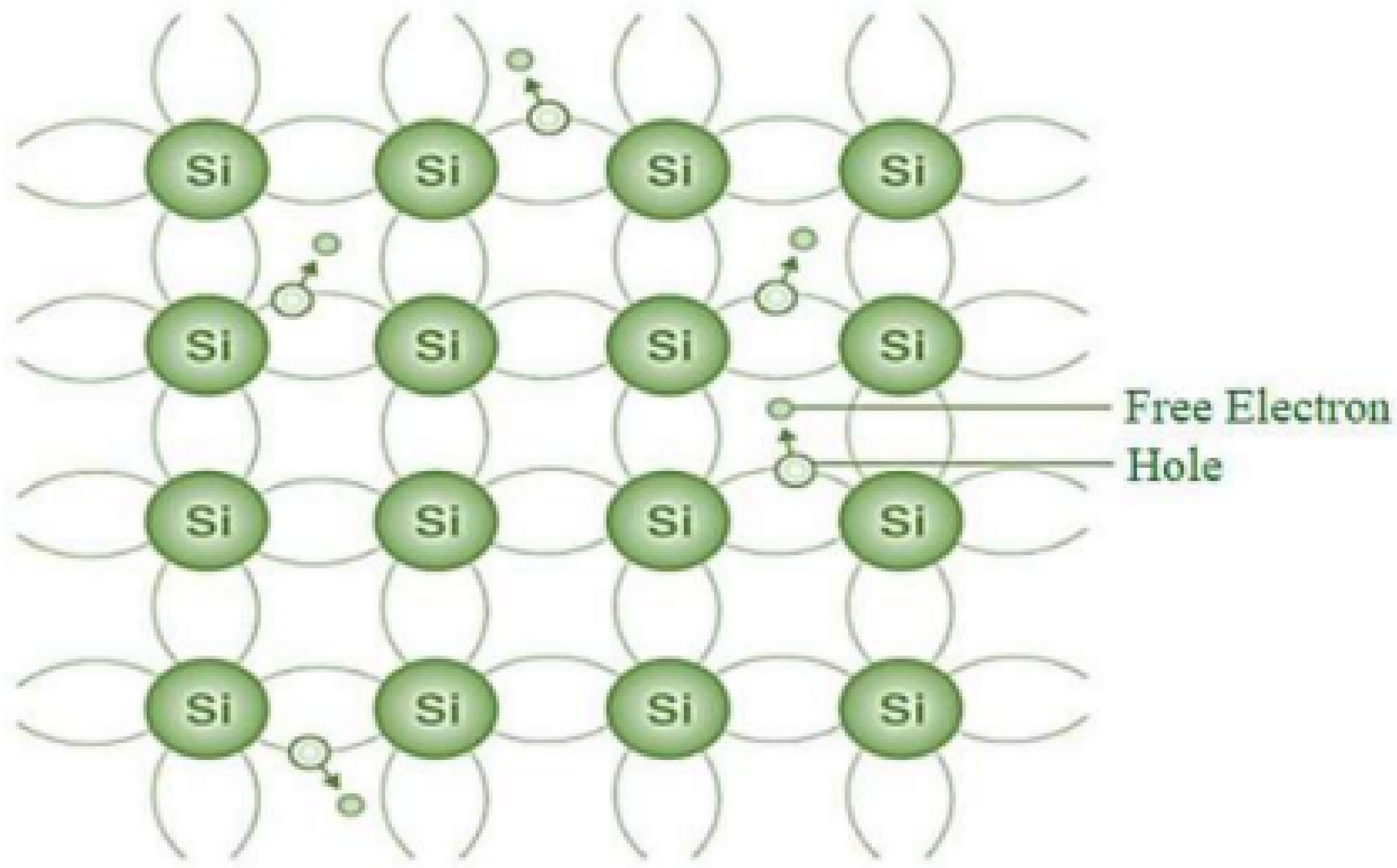


NPN transistor symbol

10) Explain in detail intrinsic and extrinsic semiconductors with all necessary diagrams.

➢

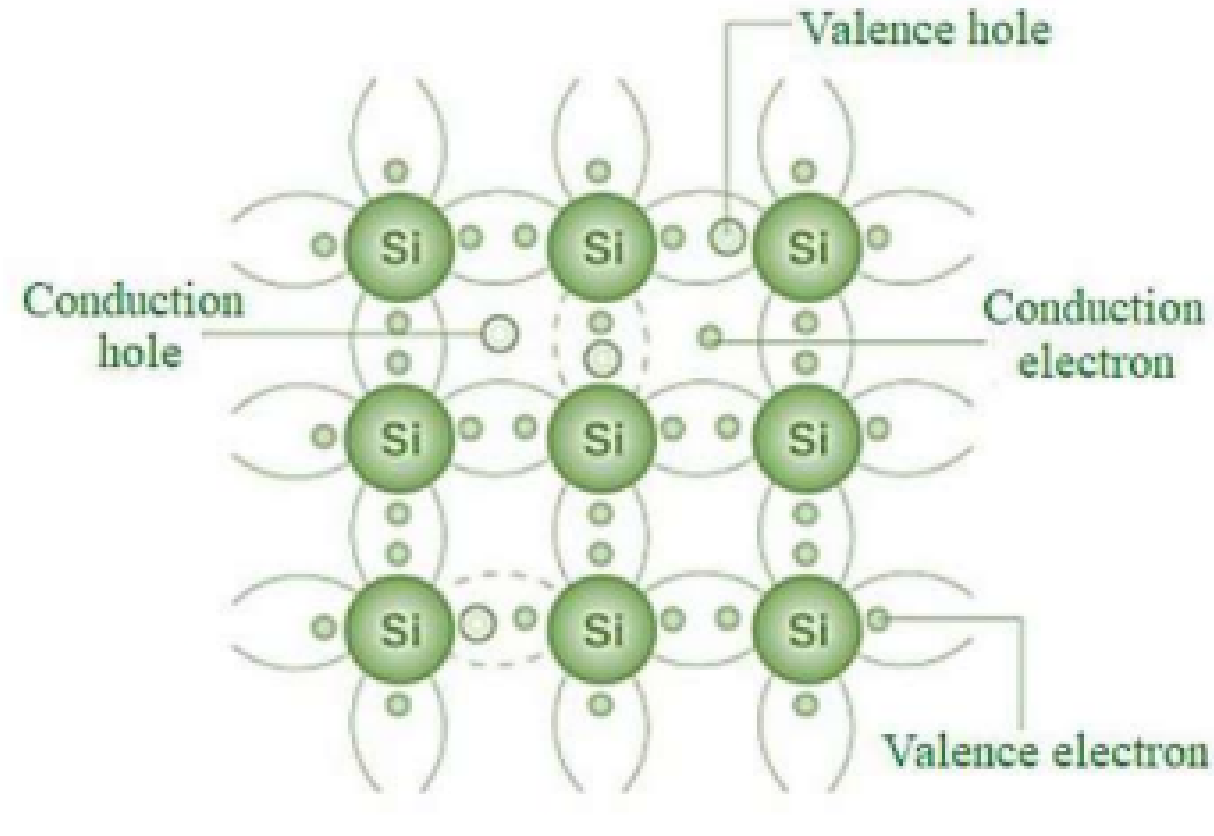




Intrinsic Semiconductors

- A semiconductor in its pure form is known as intrinsic semiconductor.
- In an intrinsic semiconductor, even at room temperature, hole -electronpairs are created.
- When electric field is applied across an intrinsic semiconductor, the current conduction takes place by two ways :-
  a) By free electrons
  b) By Holes
- The free electrons are produced due to the breaking up of some covalent bonds by Thermal energy, At the same time, holes are created in the covalent bonds.
- Under the influence of electric field, the conduction is due to both free electrons & holes.
  - ➢ In Intrinsic semiconductor, No. of electrons = No. of holes
  - ➢ Total current inside semiconductor = Current due to a free electrons + currents due to holes.

Extrinsic semiconductors :-

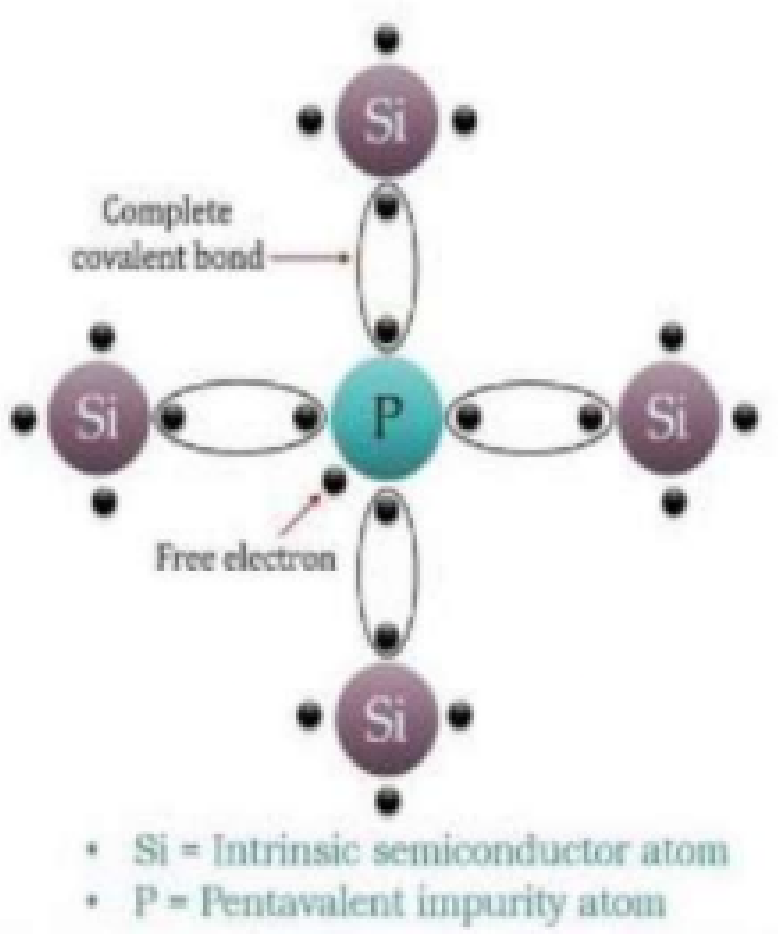


Extrinsic Semiconductor

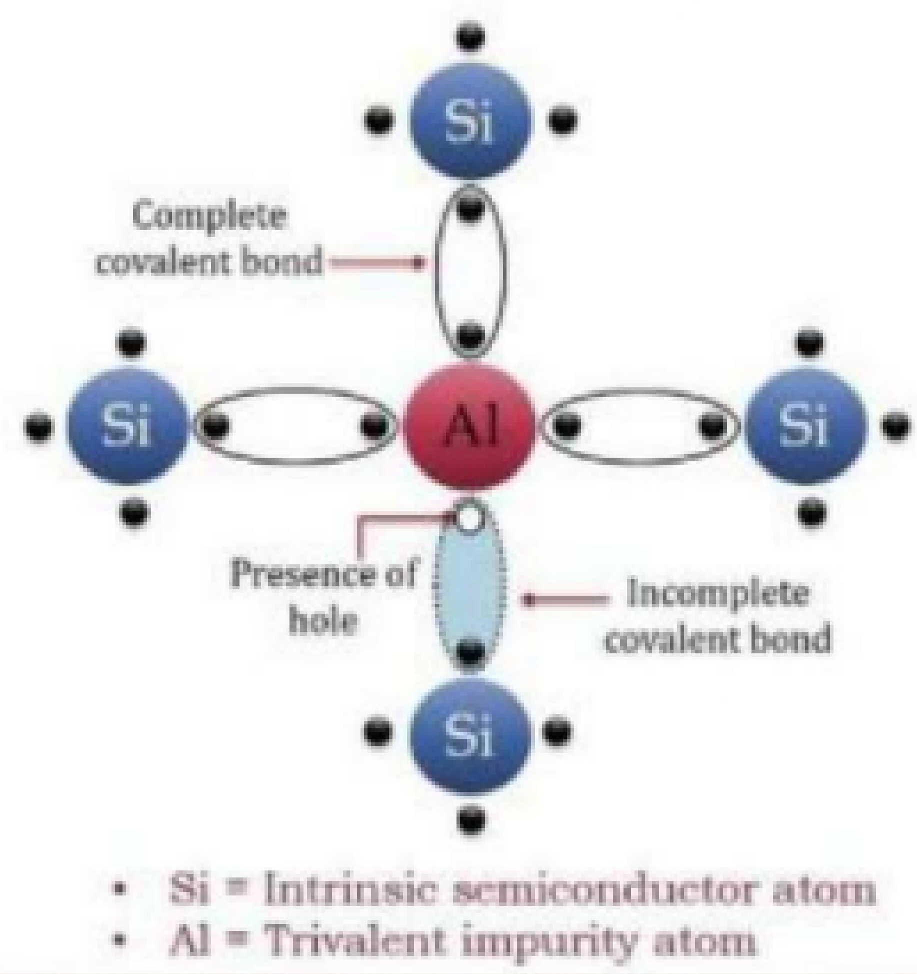
- Some impurities atoms are added to pure semi-conductor materials to improve conductivity. The process of adding impurities to the pure semiconductor is called Doping, and the resulting material is called as **extrinsic semiconductor**. Depending upon the type of impurity added, there are **two types of extrinsic semiconductor** :-

  a) **N-type Semiconductor:** N-type semiconductors are materials doped with elements like phosphorus, creating excess electrons. These extra electrons serve as negative charge carriers.

  b) **P-type Semiconductor:** P-type semiconductors are materials doped with elements like boron, creating electron deficiencies or "holes" in the crystal lattice, which act as positive charge carriers.



Formation of N type extrinsic semiconductor



Formation of P type extrinsic semiconductor

11) Explain Tunnel diode along with I-V curve.

➢ It is the types of semiconductor diode which has negative resistance due to quantum mechanical effect is called **Tunneling**.

- It has high conductivity and doping level is 1000th more than convential PN Junction diode.
- Due to heavily doping, The width of depletion layer is reduced is 10^{-5}mm. Due to extremely small barrier potential a small forward or reverse bias can give electron sufficient energy to cross the barrier potential.

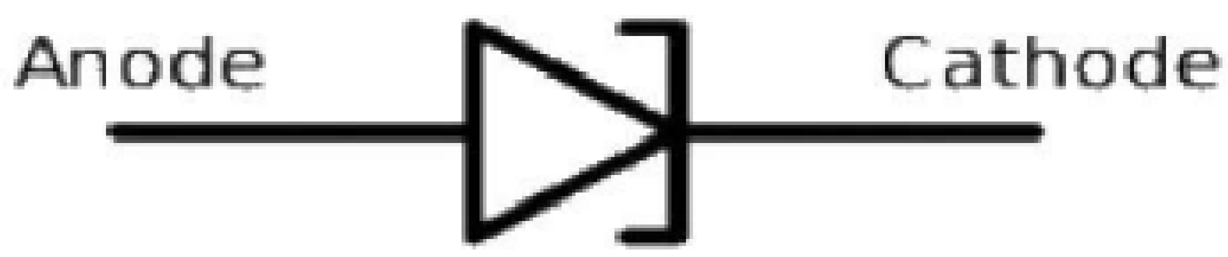
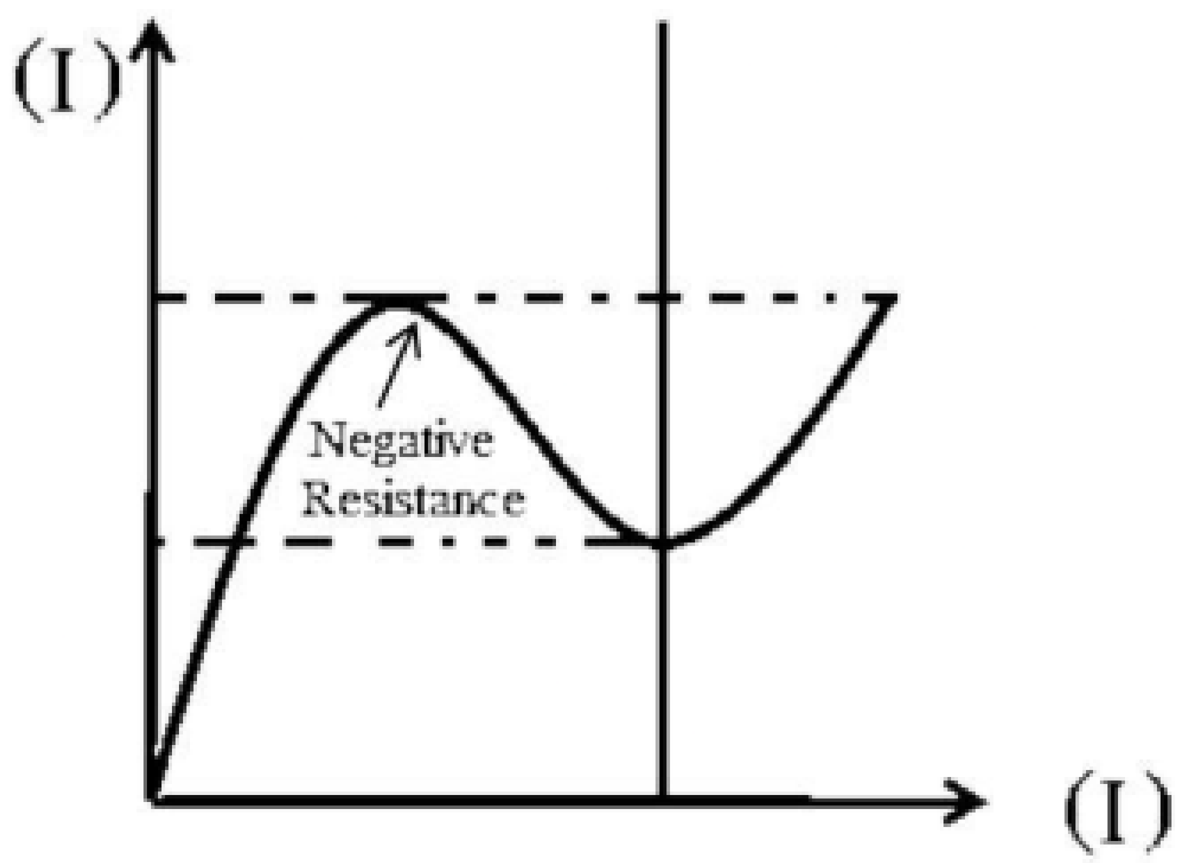


Fig :- Tunnel diode

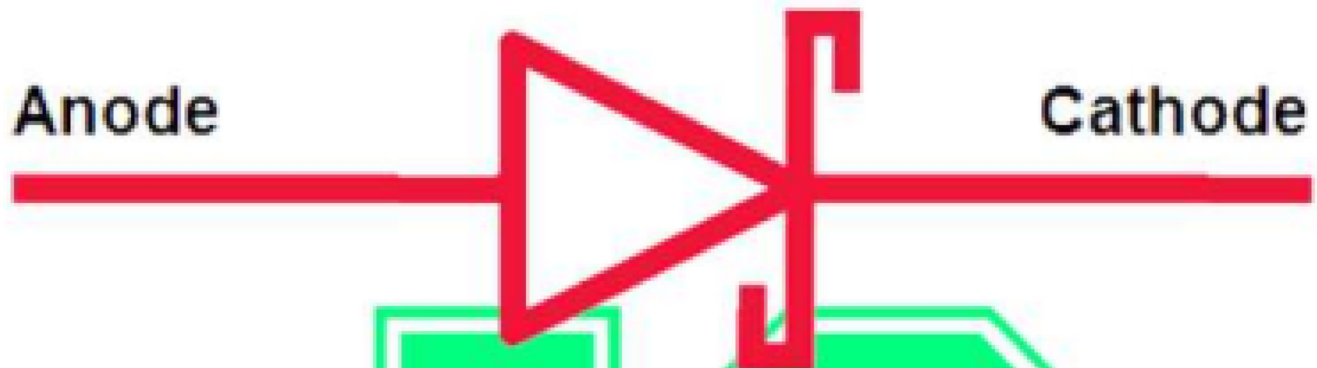
❖Application

It is used in Nano technology where switching in the order $10^{-8}sec$.



12) Schottky diode

➢ The schottky diode is a type of metal – semiconductor junction diode, which is also known as hot-carrier diode, low voltage diode or schottky barrier diode. The schottky diode is formed by the junction of a semiconductor with a metal. Schottky diode offers fast switching action and has a low forward voltage drop. As we are aware that in a PN junction diode, p-type and n-type are joined together to form a PN junction. Whereas, in a Schottky diode metals like platinum or aluminum are used instead of P type semiconductors.



Schottky diode symbol

❖ Advantages of Schottky diode :-

- The capacitance of the diode is low as the depletion region of the diode is negligible.
- The reverse recovery time of the diode is very fast, that is the change from ON to OFF state is fast.
- The current density of the diode is high as the depletion region is negligible.
- The turn-on voltage of the diode is 0.2 to 0.3 volts, which is very low.

❖ Disadvantages of Schottky diode :-

- The only disadvantage of Schottky diodes is that the reverse saturation current of the diode is large.

13) Difference between BJT and MOSFET

Parameter	BJT	MOSFET
Full form	BJT stands for **Bipolar Junction Transistor.**	MOSFET stands for **Metal Oxide Semiconductor Field Effect Transistor**.
Definition	BJT is a three-terminal semiconductor device used for switching and amplification of signals.	MOSFET is a four-terminal semiconductor device which is used for switching applications.
Types	Based on the construction, BJTs are classified into two types: NPN and PNP.	Based on the construction and operation, the MOSFETs are classified into four types: P-channel enhancement MOSFET, N-channel enhancement MOSFET, P-channel depletion MOSFET and N-channel depletion MOSFET.
Terminals	BJT has three terminals viz. emitter, base and collector.	MOSFET has four terminals, i.e., source, drain, gate and body (or substrate).
Charge carriers	In BJT, both electrons and holes act as charge carriers.	In MOSFET, either electrons or holes act as charge carriers depending on the type of channel between source and drain.
Polarity	BJT is a bipolar device.	MOSFET is a unipolar device.
Controlling quantity	BJT is a current controlled device.	MOSFET is a voltage controlled device.

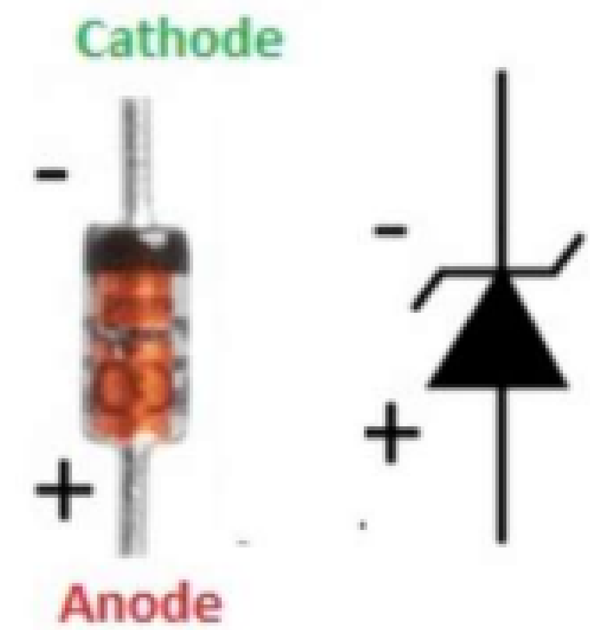
Input impedance	BJT has low input impedance.	MOSFET has relatively high input impedance.
Temperature coefficient	BJT has negative temperature coefficient.	MOSFET has positive temperature coefficient.
Switching frequency	The switching frequency BJT is low.	For MOSFET, the switching frequency is relatively high.
Power consumption	BJT consumes more power than MOSFET.	The power consumed by a MOSFET is less than BJT
Applications	BJT is preferred for the low current applications. It is widely used as **amplifiers**, **oscillators**, and **electronic switches**.	MOSFET is suitable for high power applications. It is used in **power supplies**, etc.

14) Difference between BJT and FET.

Parameter	**BJT**	**FET**
Full form	BJT stands for Bipolar Junction Transistor.	FET stands for Field Effect Transistor.
Definition	A type of transistor which uses two types of charge carries viz. electrons and holes for conduction is known as bipolar junction transistor (BJT).	A type of transistor in which electric field is used to control the flow of current in a semiconductor is known as field effect transistor (FET).
Drive type	In BJT, the current flow is due to both majority and minority charge carriers. Thus, it is a bipolar device.	In FET, the electric current flows only due to majority charge carriers. Thus, it is a unipolar device.
Terminals	BJT has three terminals viz. Emitter, Base and Collector.	FET also has three terminals viz. Source, Drain and Gate.
Suitability	BJT is suitable for low current applications.	FET is suitable for high current applications.

PN junction	BJT consists of two PN junctions viz. emitter-base junction and collector-base junction.	FET does not have PN junctions.
Control element	BJT is a current-controlled device.	FET is a voltage controlled device.
Types	BJT are of two types: NPN transistor and PNP transistor.	FET are also of two types: N-channel FET and P-channel FET.
Configuration	BJT has three configurations: common emitter (CE), common base (CB) and common collector (CC).	FET also has three configurations: common source (CS), common gate (CG) and common drain (CD).
Size	BJT is large in size and hence requires more space. Therefore, it is more complicated to fabricate as an IC	FET is comparatively smaller in size. Hence, it is easier to fabricate as an IC.
Sensitivity	BJT is more sensitive to the changes in the applied voltage.	FET is less sensitive to the variations in the applied voltage.
Relationship between input and output	BJT has linear relationship between input and output.	FET has non-linear relationship between input and output.
Thermal noise	BJT has more thermal noise.	The thermal noise in case of FET is much lower.
Thermal runway	Thermal runway exits in BJT.	Thermal runway does not exists in FET.
Thermal stability	BJT has less thermal stability.	FET has good thermal stability due to absence of minority charge carriers.
Switching speed	The switching speed of BJT is low.	FET has higher switching speed.
Effect of radiation	BJT is susceptible to radiation.	FET is relatively immune to radiation.
Cost	BJT is cheaper to manufacture.	FET is relatively expensive to manufacture.

15) Explain the Zener diode with symbol.



- **Zener diode** is a special type of semiconductor diode which works in breakdown region.
- When forward biased, it works as simple diode But Zener diode is only used in reverse biased condition.
- The Zener diode is backbone of voltage regulators.
- A Zener diode operate in reverse breakdown region.
- An ordinary diode operated in this region will usually be destroyed due to excessive current but this is not the case for Zener diode.
- A Zener diode is like an ordinary diode except that it is properly doped so as to have a sharp breakdown voltage.
- A Zener diode has sharp breakdown voltage called 'Zener voltage' V_Z.

16) Explain the Zener and Avalanche breakdown.

❖Zener breakdown:

- In a heavily doped PN junction diode, zener effect occurs due to spontaneous generation of hole electron pairs with in the depletion region by the effect of intense electric field (potential gradient) across it, a phenomenon known as ionization due to electric field.
- It is a negative temperature coefficient (NTC) type.
- Less energy is required to breakdown the bonds when temperature is increased.

❖Avalanche breakdown:

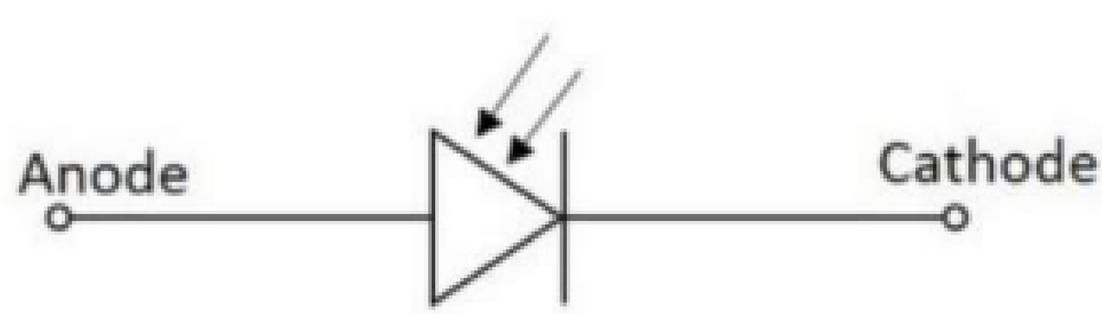
- In a lightly doped PN junction diode, the high speed drifting electrons due to a large reverse bias voltage collide with valence electrons of atoms fixed in the crystal lattice of depletion region
- As a result some valence electrons are liberated out of a covalent bonds, thus creating further hole electron pairs; a phenomenon known as ionization due to collision of high speed moving electrons with positive temperature coefficient (PTC) types.

- Larger voltage is required to ionize the diode when temperature is increased.

Zener breakdown	Avalanche breakdown
• Highly doped PN junction diode • The covalent bond breaks spontaneously due to high electric field • Low reverse potential is required for breakdown • Here electric field is very strong to rupture the covalent bonds thereby generating electron-hole pairs. So even a small increase in reverse voltage is capable of producing large number of current carriers. i.e. why the junction has a very low resistance. This leads to Zener breakdown.	• Lightly doped PN junction diode • As a result of collision of electrons and holes with the valence electrons • Higher reverse potential is required • Here minority carriers collide with semi conductor atoms in the depletion region, which breaks the covalent bonds and electron-hole pairs are generated. Newly generated charge carriers are accelerated by the electric field which results in more collision and generates avalanche of charge Carriers. This results in avalanche breakdown.

17) Explain the Photodiode with Characteristics.

- A **photodiode** is a reverse-biased silicon or germanium PN junction in which reverse current increases when the junction is exposed to light.
- The reverse current in a photodiode is directly proportional to the intensity of light falling on its PN junction. This means that greater the intensity of light falling on the PN junction of photodiode, the greater will be the reverse current.
- A photodiode differs from a rectifier diode in that when its PN junction is exposed to light, the reverse current increases with the increase in light intensity and vice-versa.
- The schematic symbol of a photodiode is as shown in figure:-



➢ Characteristics of Photodiode

There are two important characteristics of photodiode

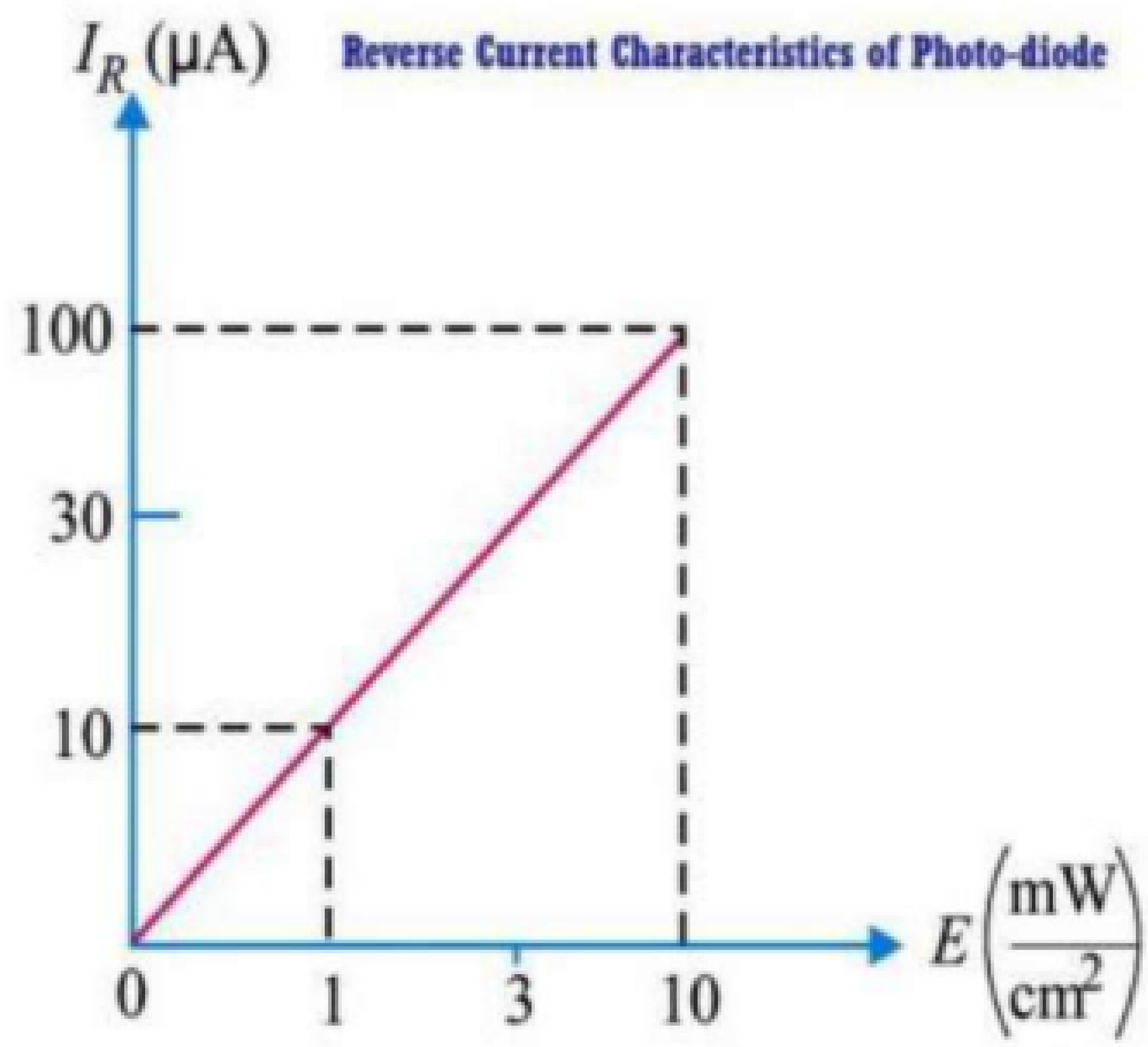
a) Reverse current-Illumination curve

Following figure shows the graph between reverse current (I_R) and illumination (E) of a photodiode

$I_R = mE$ Where,

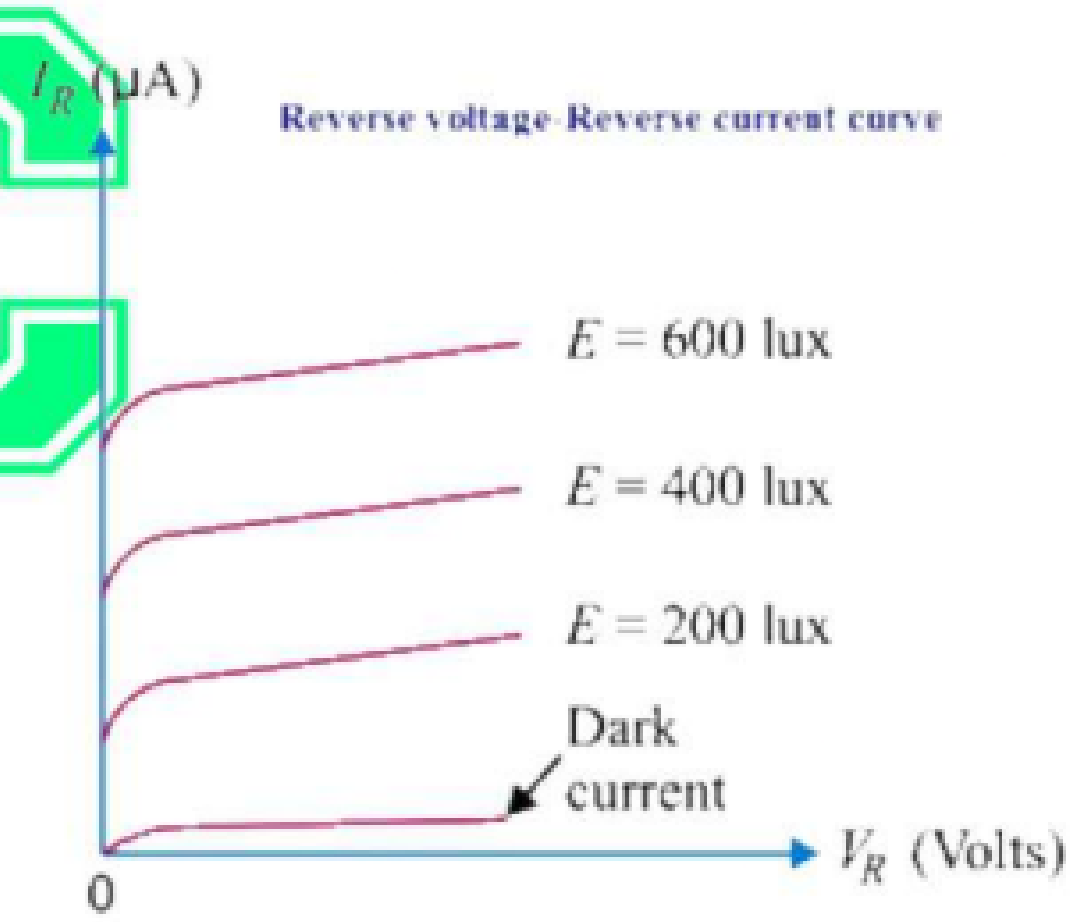
m = Slope of the straight line

The quantity 'm' is called the sensitivity of the photodiode



b) Reverse voltage-Reverse current curve

- The graph between reverse current (I_R) and reverse voltage (V_R) for various illumination levels.
- It is clear that for a given reverse biased voltage V_R, the reverse current I_R increases as the illumination (E) on the PN-junction of photodiode is increased.
- Dark current is that current that will exist with no applied voltage

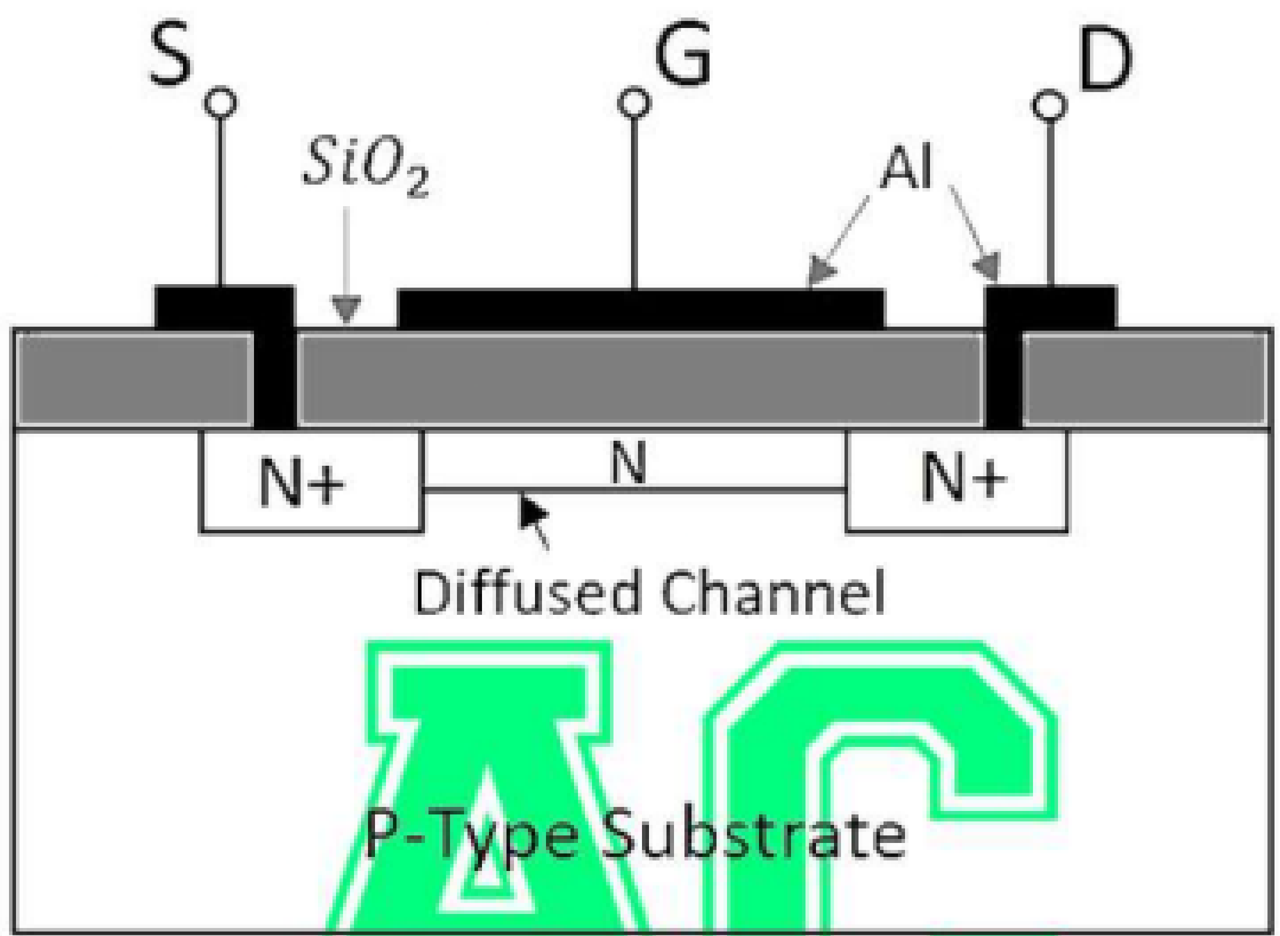


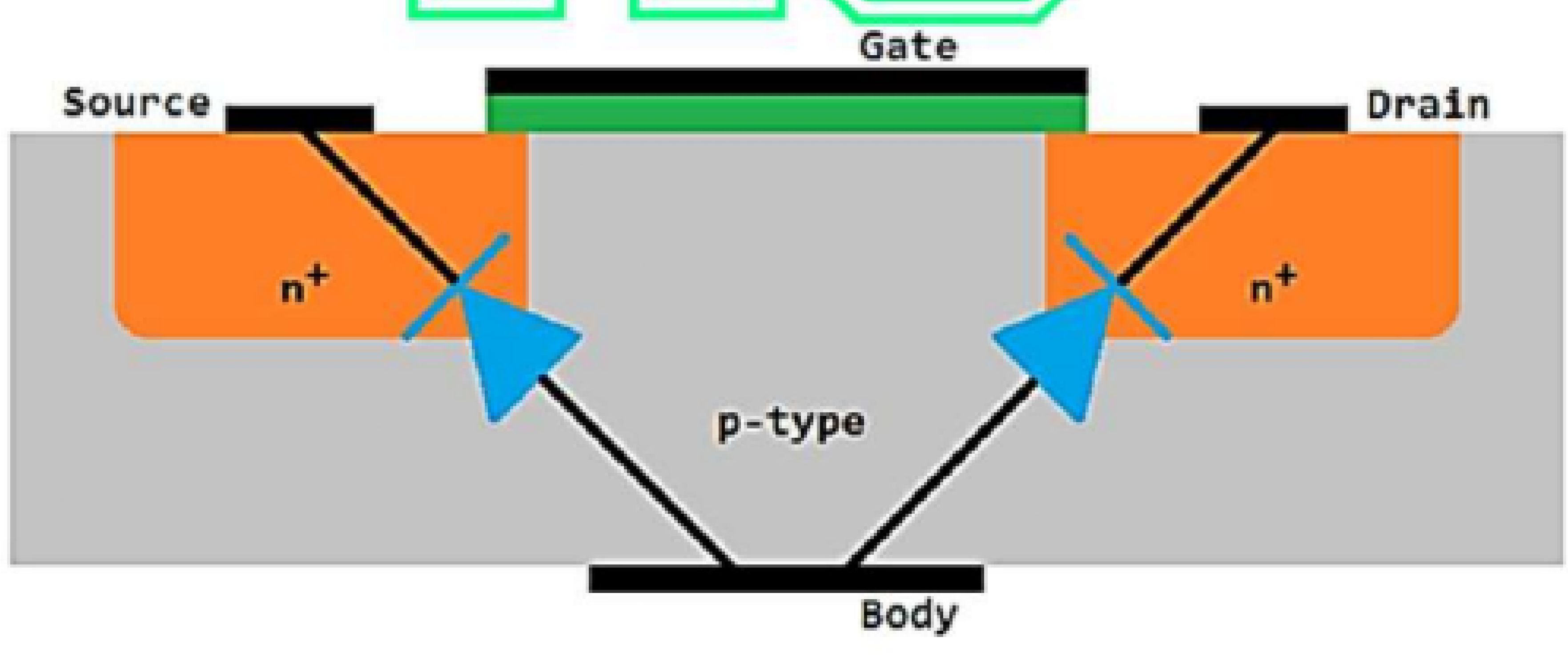
18) Explain the construction of N- channel MOSFET in detail.

➢ Construction of N- channel MOSFET :-

- It is fabricated on a P-type substrate.
- Drain and source regions are highly doped with n- type material.
- A thin layer of silicon dioxide (SO2) is grown on the surface of the substrate covering the area between the source and drain regions.

- Metal is deposited on top of the oxide layer to form the gate electrode of the device.
- Four terminals: Gate (G), Drain (D), Source (S) and body (substrate) (B) are brought out of the device.
- The physical structure of n-channel Enhancement type MOSFET is shown :-





- The substrate forms pn junctions with the source and drain regions.
- In normal operation, these pn junctions are kept reversed biased at all times.
- Since, the drain will be at a positive voltage relative to the source, the two pn-junction can be effectively cut off by simply connecting the substrate terminal to the source terminal.

Depletion MOSFET (D-MOSFET) VS Enhancement MOSFET (E-MOSFET)

Sr. No.	Depletion MOSFET (D-MOSFET)	Enhancement MOSFET (E-MOSFET)
1	It is called a depletion MOSFET because of channel depletion.	It only works in enhancement mode and is therefore called Enhancement MOSFET.
2	It can be used as E-MOSFET.	It can not be used as a D-MOSFET.
3	If Vgs = 0 V, Ids flows due to Vds.	If Vgs = 0V, Ids = 0, although Vds is applied.
4	N-type semiconductors exist in the structure itself between source and drain.	There is no n-channel between source and drain.
5	Do not occur	When Vgs = Vt, the MOSFET is turned on.

-The End-

Electrical Engineering

(For Diploma I Yrs. II Part)

2^{nd} & 3^{rd} Semester

(DCOM/IT)

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1. a) Show the analogy between magnetic circuit and electric circuit. State and explain Kirchhoff's law.

➢The analogy between magnetic circuit and electric circuit :-

Magnetic circuit	Electric circuit
The closed path for magnetic flux is called a magnetic circuit.	The closed path for electric current is called as electric circuit.
The Flux = MMF / Reluctance	The current I = EMF / Resistance
Unit of Flux (ϕ) is measured in weber(wb).	Unit of current (I) is measured in amperes.
Kirchhoff mmf law and flux law are applicable to the magnetic flux.	Kirchhoff current law and voltage law is applicable to the electric circuit.
Flux density (B)=$\frac{\phi}{a}$ ϕ = Flux, a = area of cross section.	Current density(δ)=$\frac{I}{a}$, I = current, a = area of cross section.

i) First law

- The algebraic sum of currents meeting at any point in circuit is zero. Let 'A', 'B', 'C', 'D' and 'E' are conductors joining at a point 'O'. The currents are flowing towards and away from the Point 'O'. Then, algebraic sum currents meeting at the point 'O' is;

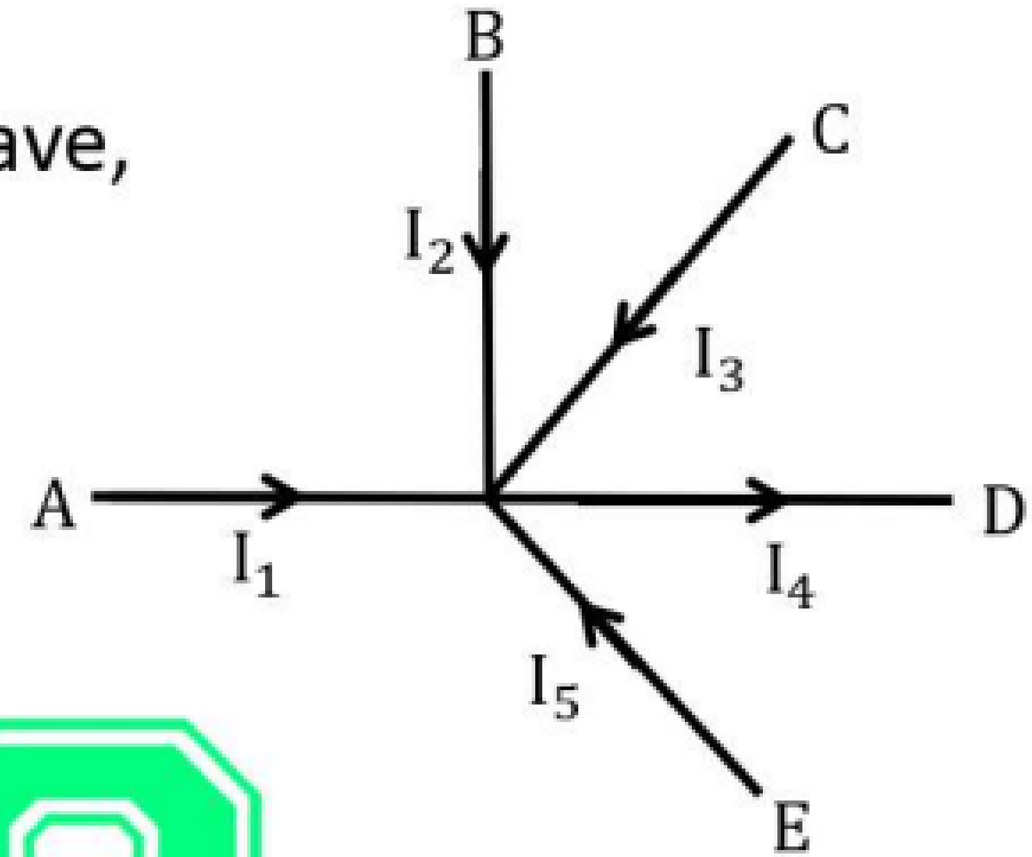
  $$I_1 + I_2 + I_3 - I_3 - I_5$$

  According to Kirchhoff's Law; we have,

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

  In general;

  $$\sum I = 0$$



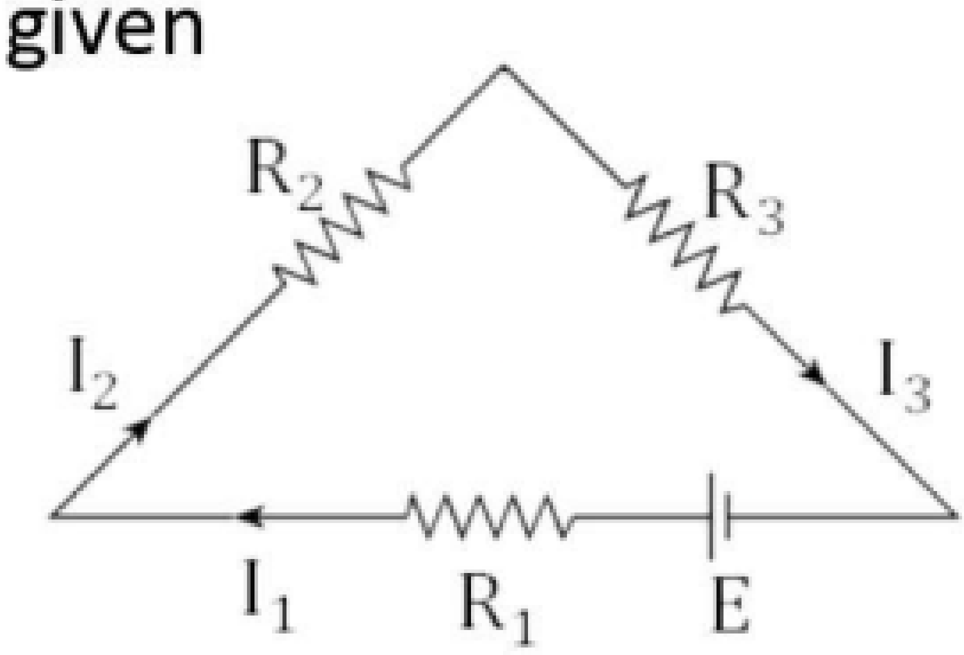
ii) Second law

- *According to Kirchhoff's Voltage Law,* In any closed circuit the algebraic sum of the products of the currents and resistance of each part of the circuit is equal to the algebraic sum of e.m.f.'s in that circuit. *For example*; In the circuit given

  $$I_1R_1 + I_2R_2 + I_3R_3 = E$$

  In general;

  $$\sum IR = \sum E$$



The equation is true for any closed circuit

b) State Thevenin's theorem. State and explain Norton's theorem with necessary expression and diagram.

Thevenis's theorem

- **State:-** Any two output terminals (A and B) of an active linear network containing independent sources (voltage and current sources) can be replaced by a simple voltage source of magnitude V_{th} in the series with a single resistor R_{th}, where R_{th} is the equivalent resistance of the network, when looking from the output terminals A and B, with all sources (voltage and current) removed and replaced by their internal resistance and the magnitude of V_{th} equal to the open circuit voltage across the A and B terminals.

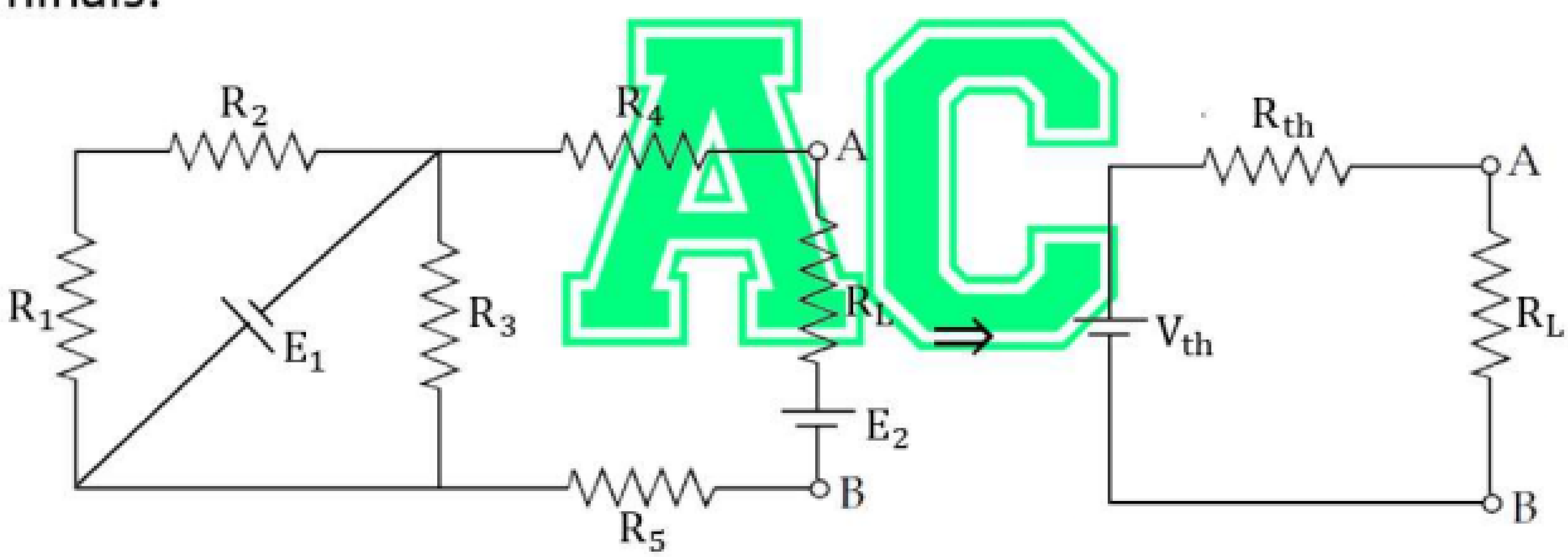


Figure:- Any electric circuit **Thevenin's equivalent circuit**

Norton's theorem

- **Statement:-** It may be stated as any linear electric network or complex circuit with current and voltage sources can be replaced by an equivalent circuit containing of a single independent current source I_N and parallel resistance R_N.

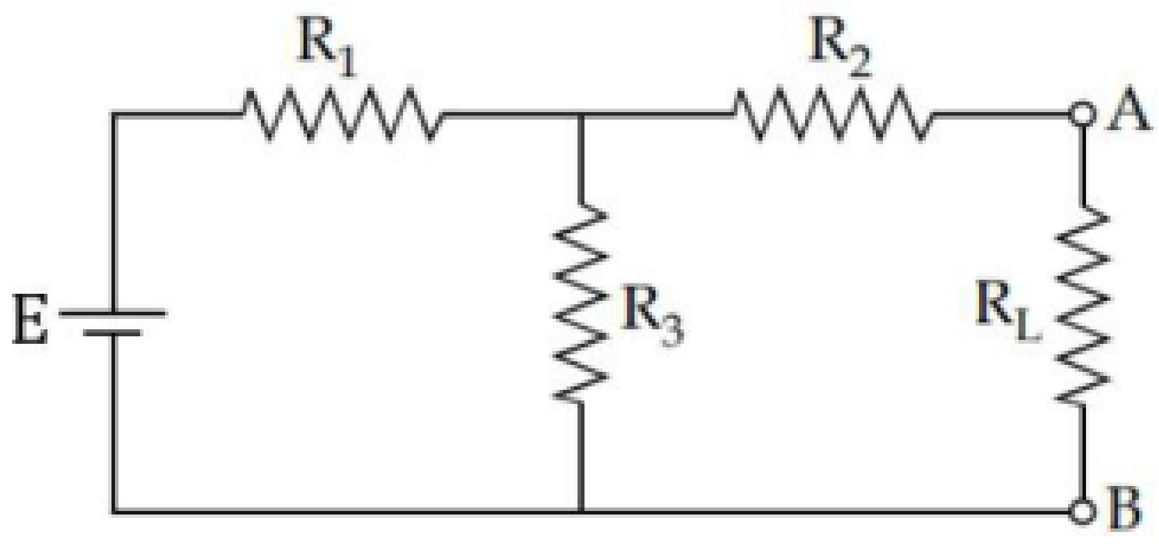


Figure:- Any electric circuit

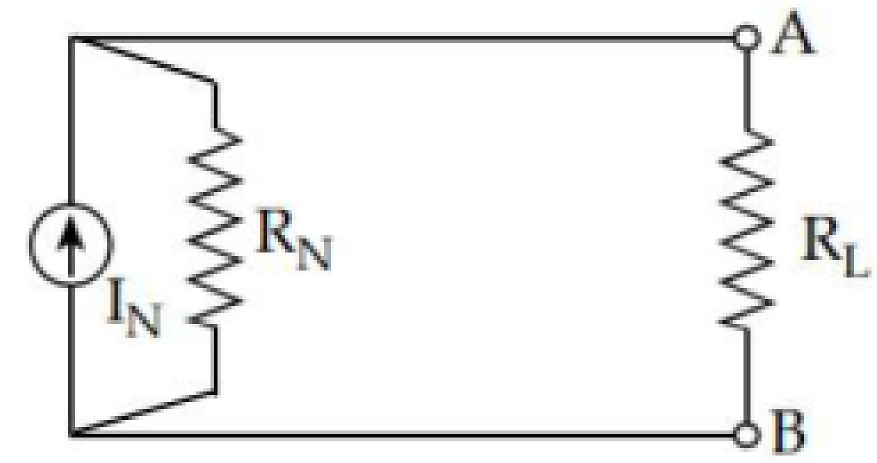


Figure:-Norton's equivalent circuit

➢ **Steps used to analyse electric circuit using Norton theorem :-**

- Short the terminals at which Norton equivalent is required.
- Calculate the short circuited current. This is the Norton current I_N.
- Then, to get R_N, open current sources, short the voltage sources and remove load resistance. Then measure open circuit resistance, which is Norton's resistance (R_N).
- Now, redraw the circuit with Norton's current and resistance in parallel and add load resistance at terminals.
- Then use any rules to get current/voltage at load.

2. a) Define following terminology:

i) Instantaneous values

➢ The alternating quantity changes at every time. At any particular time, its value is called instantaneous value at time t, it is given as;

$$V(t) = V_m \sin \omega t$$

ii) RMS values

- The RMS value of an alternating quantity is that steady current (dc) which when flowing through a given resistance for a given time period, produces the same amount of heat, that produced by the alternating current flowing through the same resistance for the same time.

iii) Active power

- The power due to the active component of current is called active power. It is the product of voltage V and in phase component of current $I\cos\theta$.

iv) Power factor

- The cosine of angle between voltage and current in an AC circuit is known as power factor. i.e. $\cos\theta$ is power factor

b) State and explain the maximum power transfer theorem.

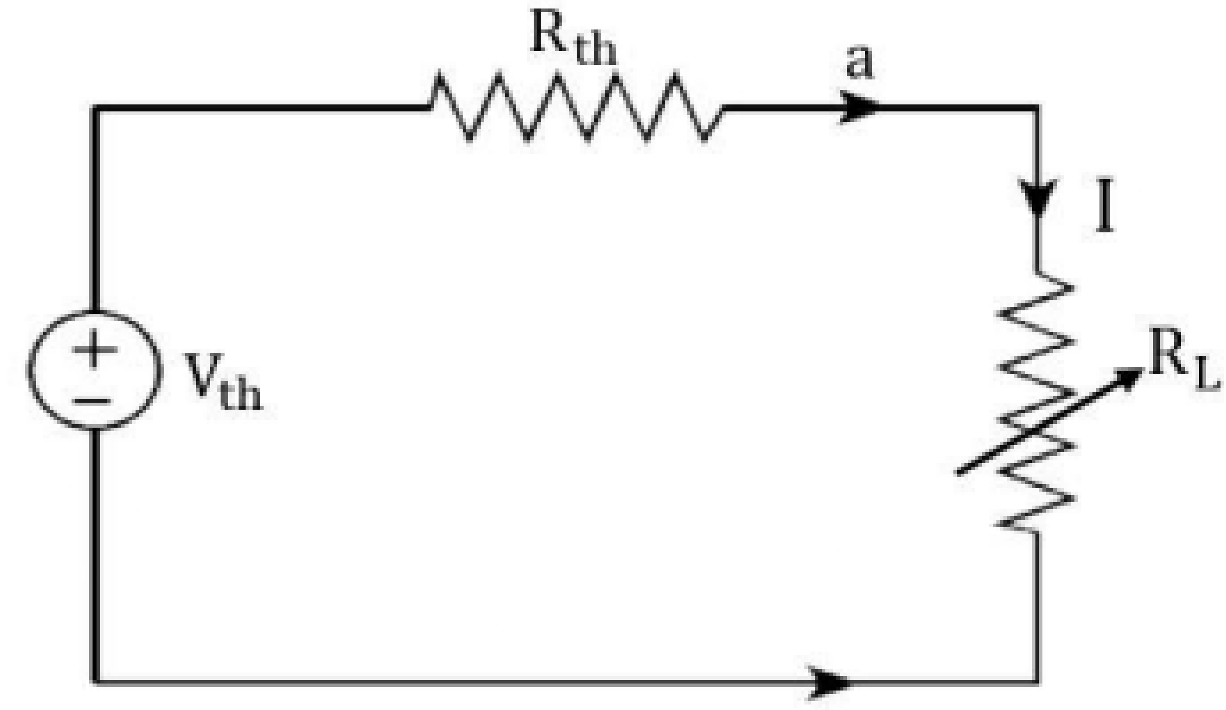
- Maximum power transfer theorem states that the DC voltage source will deliver maximum power to the variable load resistor only when the load resistance is equal to the source resistance. i.e $R_L = R_{th}$

Here,

$$I = \frac{V_{th}}{R_{th}+R_L}$$

Now, power can be given as

$$P = I^2 R_L$$



Equivalent Thvenin Circuit

or, $P = \left(\frac{V_{th}}{R_{th}+R_L}\right)^2 \times R_L = V_{th}^2 \times \frac{R_L}{(R_{th}+R_L)^2}$ ……………… (i)

To Proof,maximum power transfer theorem, differentiating equation (i), wrt R_L we get,

$$\frac{dP}{dR_L} = V_{th}^2 \times \frac{d}{dR_L}\left[\frac{R_L}{(R_{th}+R_L)^2}\right]$$

$$= V_{th}^2 \times \frac{[(R_{th}+R_L)^2 - 2R_L(R_{th}+R_L)]}{[(R_{th}+R_L)^2]^2}$$

$$= V_{th}^2 \times \frac{(R_{th}+R_L)[(R_{th}+R_L) - 2R_L]}{(R_{th}+R_L)^4}$$

$$\therefore \frac{dP}{dR_L} = (V_{th})^2 \times \frac{[(R_{th}-R_L)]}{(R_{th}+R_L)^3}$$

Now, For maximum power, $\frac{dP}{dR_L} = 0$

So, $(V_{th})^2 \times \frac{[(R_{th}-R_L)]}{(R_{th}+R_L)^3} = 0 \quad [\because As, V_{th} \neq 0]$

or, $\boxed{R_{th} = R_L}$ ………… (iii)

Hence, the maximum power takes place when the load resistance R_L equals to the Source resistanceR_{th}

Now, From equation (i) and (iii) ,

or, $$P_{max} = \frac{V_{th}^2}{(R_{th} + R_{th})^2} \times R_{th}$$

$\therefore$ $Hence$, maximum power is , $$\boxed{P_{max} = \frac{V_{th}^2}{4R_{th}}}$$

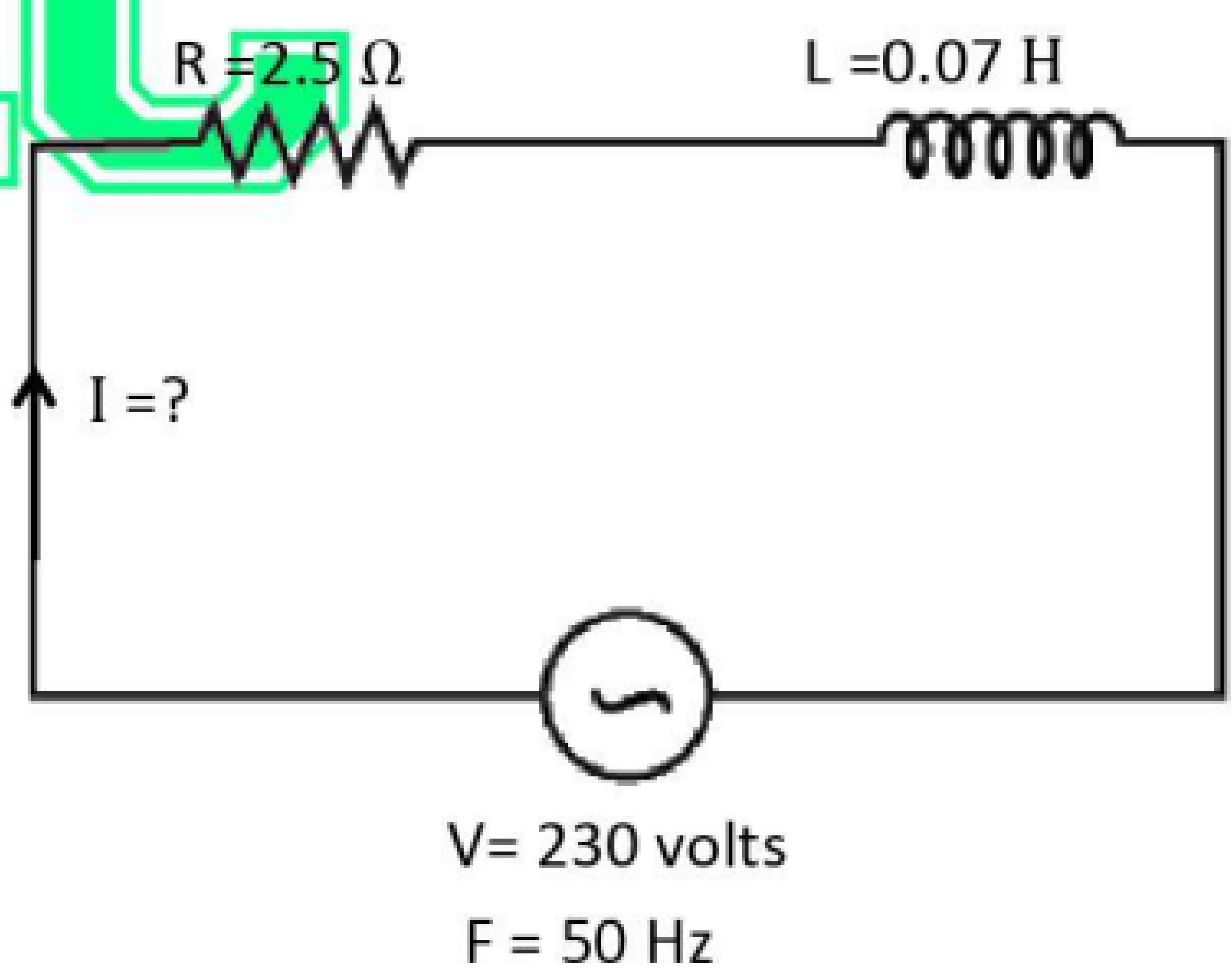
3 a) A 230V, 50HZ ac supply is applied to a coil of 0.07H inductive and 2.5 Ω resistor in series. Calculate the i) impedance ii) current iii) phase angle factor iv) power

- **Solution;**

Given,

Inductance, L = 0.07 H

Resistor, R = 2.5 Ω



To Find,

i) Impedance , z = ?

ii) current , I = ?

iii) phase angle, ϕ=?

iv) factor power , Cosϕ=?

Inductive reactance, $X_L = W_L = 2\pi\, f\, L$

$$= 2\pi \times 50 \times 0.07$$

$$= 21.99\ \Omega$$

Now,

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

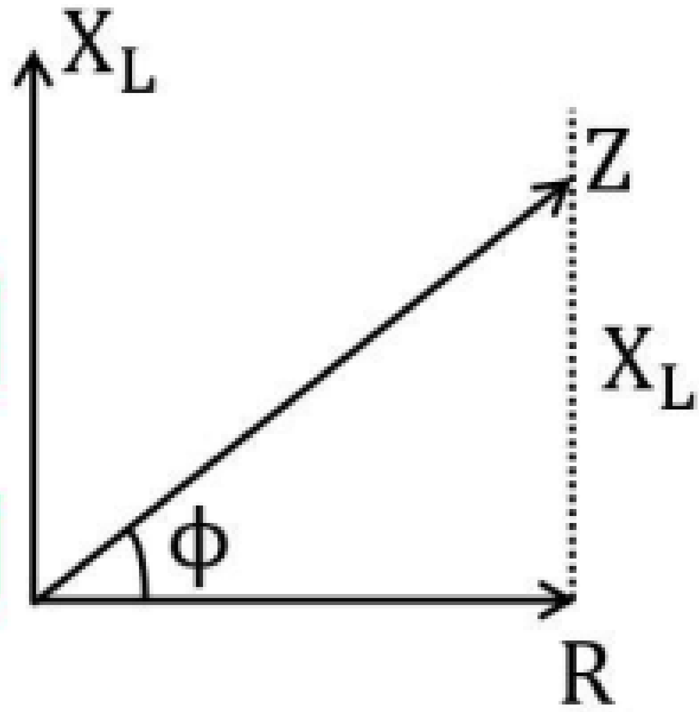
$$Z = \sqrt{21.99^{\ 2} + 2.5^{\ 2}}$$

$$Z = 22.13\ \Omega$$

Also,

Current is given by

$$I = \frac{V}{Z} = \frac{230}{22.13} = 10.393\ A$$



From Figure,

$$\tan\phi = \frac{X_L}{R}$$

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$$

$$\phi = \tan^{-1}\left(\frac{21.99}{2.5}\right)$$

$$\phi = \tan^{-1}(8.796)$$

$$\phi = 83.51°$$

The cosine of angle between voltage and current in an AC circuit,

Power factor $= \cos\phi = \cos(\ 83.51)$,

Power factor $= 0.113$.

b) Explain delta connection of 3-phase and also derive the expression for line and phase qualities.

- If the six ends of the three phases are so connected that one end of the first coil is connected to the start end of the second coil and so on, a closed mesh is formed. If three lines are taken from the three connected points, then this method is called delta connection.

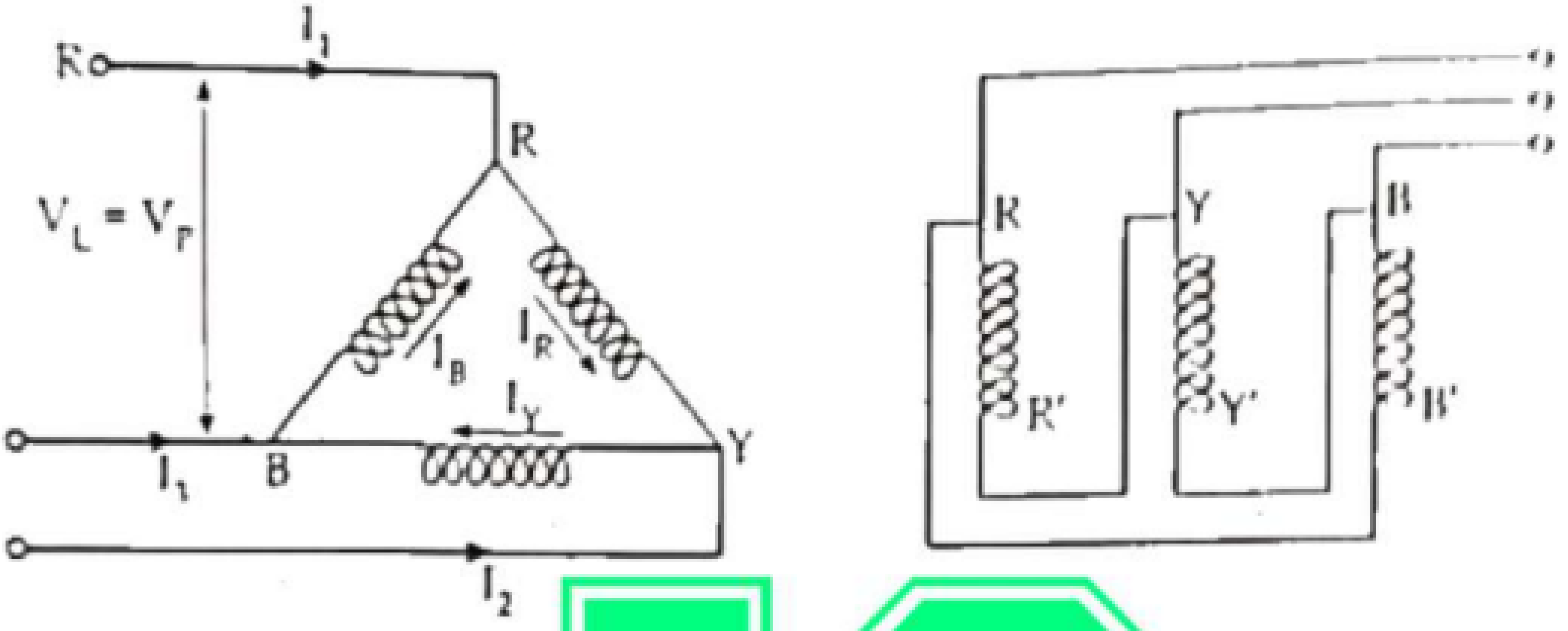


Figure: Delta connection system

Phase and line quantities for delta connection

i) Phase voltage (V_P) = V_{RY}, V_{YB}, V_{BR}

ii) Phase current: I_R, I_Y, I_B

iii) Line voltage: V_{RY}, V_{YB}, V_{BR}

iv) Line current: I_1, I_2, I_3

As only one phase winding is in between any two lines, phase voltage will be equal to the line voltage.

Phase voltage (V_P) = Line voltage (V_L)

- **Relation between Line and phase qualities :-**

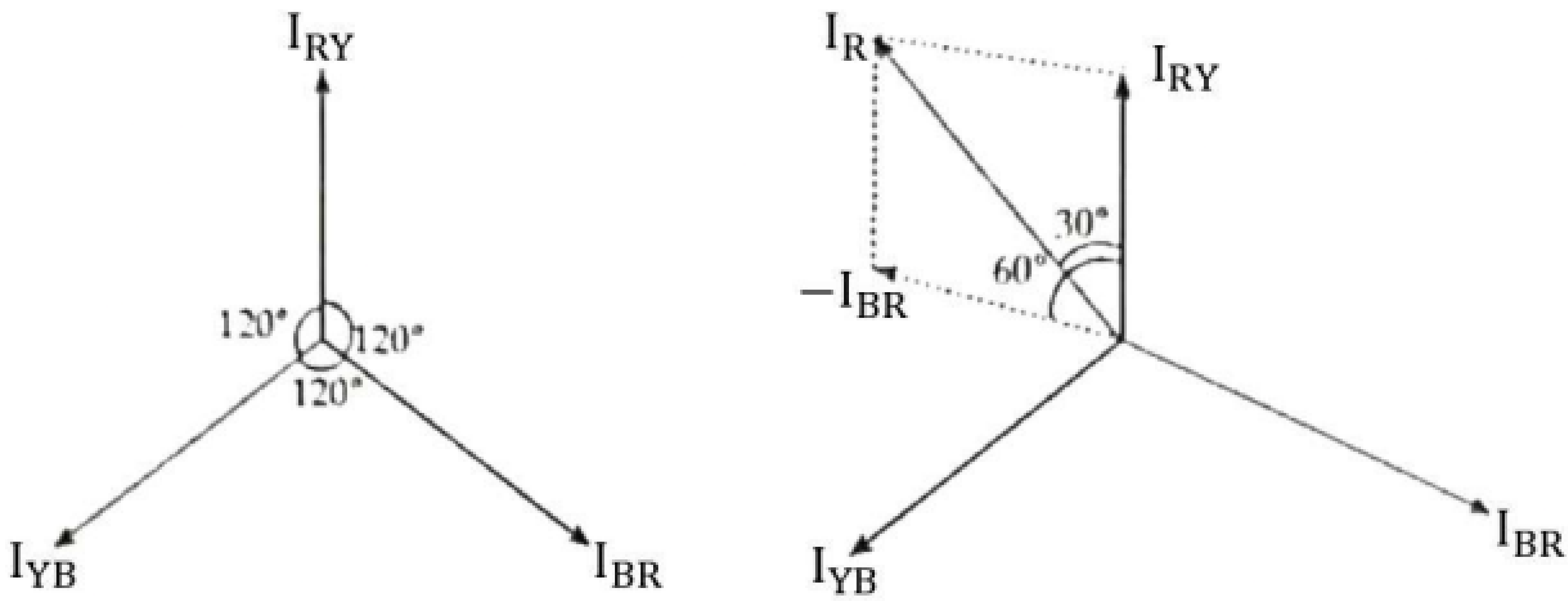


Fig:- 3-phase Δ connection and vector diagram

From second figure, the phase currents are I_{RY},I_{YB} , I_{BR} apparent from each other by 120° and their phase sequence. So,

The line currents,

$$\vec{I}_R = \vec{I}_{RY} - \vec{I}_{BR} \qquad \vec{I}_Y = \vec{I}_{YB} - \vec{I}_{RY} \qquad \vec{I}_B = \vec{I}_{BR} - \vec{I}_{YB}$$

Now, in the phasor diagram, the phase current I_{BR} is reversed and then added in that phasor.

Now, using trigonometrically,

$$I_R = I_{RY}\cos 30° + I_{BR}\cos 30° \qquad \text{[Take R phase]}$$

or, $I_R = I_{RY} \times \frac{\sqrt{3}}{2} + I_{BR} \times \frac{\sqrt{3}}{2}$

For balance load, We have,

$$Z_R = Z_Y = Z_B$$
$$I_R = I_Y = I_B = I_P$$

And, $I_{RY} = I_{YB} = I_{BR} = I_P$

Thus, $I_L = \frac{\sqrt{3}}{2}\, I_P + \frac{\sqrt{3}}{2}\, I_P$

$$\boxed{I_L = \sqrt{3}\, I_P}$$

Hence, line current will be equal to $\sqrt{3}$ times the phase current.

4. a) Define ideal transformer. Explain construction and working principle of single phase transformer.

- An **ideal transformer** is an imaginary transformer which does not have any loss in it, means no core losses, copper losses and any other losses in transformer. Efficiency of this transformer is considered as 100%.

- **Construction**: It consists of two windings or coils, the primary and secondary, wound on common laminated soft-iron core as shown in Figure. The coil connected to the a.c. source is called primary coil and the coil connected to the load is called secondary coil. The primary coil along with a source of alternating voltage is called primary circuit and the secondary coil along with load is called secondary circuit.

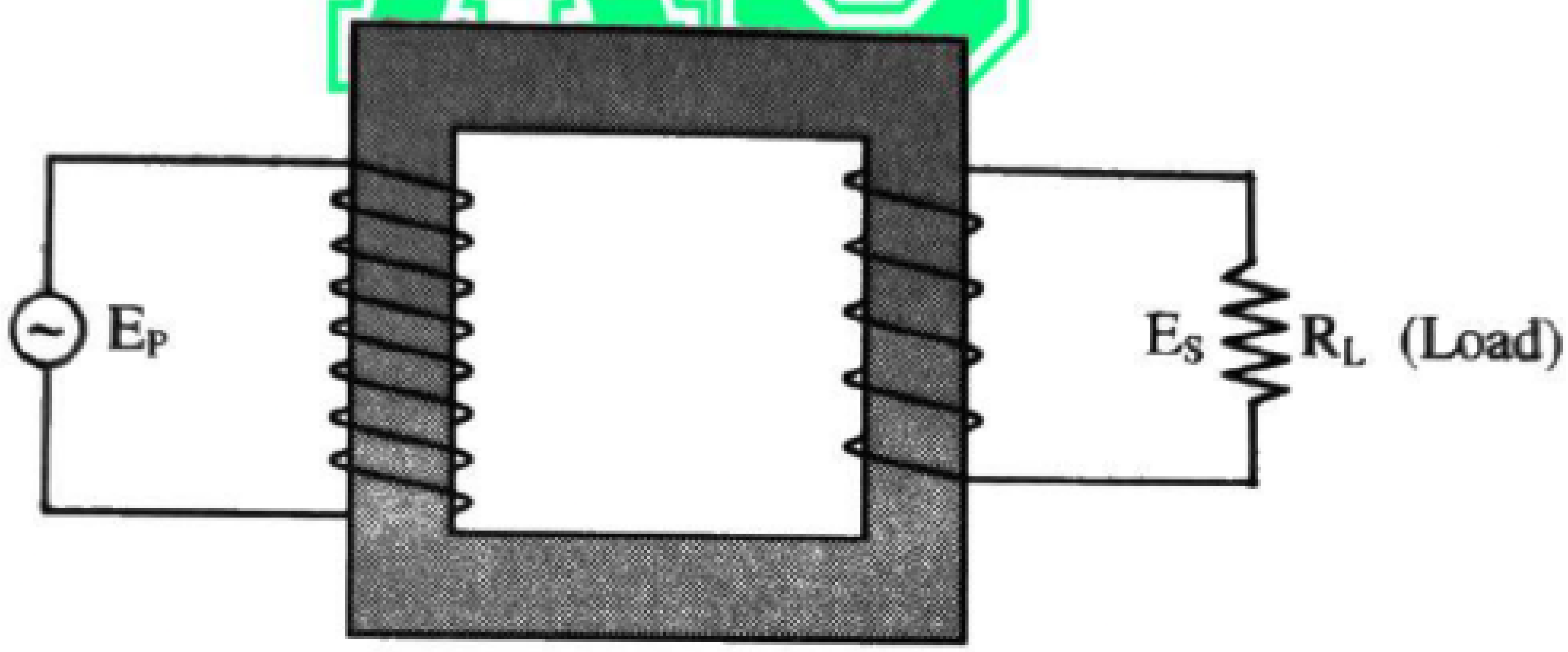


Fig :- Single phase transformer

Working Principle

- The basic principle behind working of a transformer is the phenomenon of mutual induction between two windings linked by common magnetic flux. The figure at right shows the simplest form of a transformer.

Basically a transformer consists of two inductive coils; primary winding and secondary winding. The coils are electrically separated but magnetically linked to each other. When, primary winding is connected to a source of alternating voltage, alternating magnetic flux is produced around the winding. The core provides magnetic path for the flux, to get linked with the secondary winding. As the flux produced is alternating (the direction of it is continuously changing), EMF gets induced in the secondary winding according to Faraday's law of electromagnetic induction. This emf is called 'mutually induced emf', and is same as that of supplied emf after, then mutually induced current flows through it, and hence the electrical energy is transferred from one circuit (primary) to another circuit (secondary).

b) Define induction motor. Explain construction and working principal of 3-phase induction motor.

- An alternating-current motor in which torque is produced by the reaction between a varying magnetic field generated in the stator and the current induced in the coils of the rotor.

- **Construction:-** The constructional of induction motor consists of a stationary part called stator and a rotating part called rotor. The stator part is supplied with AC source whereas the rotor part contains rotor coils which are short circuited in the rotor itself. This motor runs at variable speed less than synchronous speed and hence it is also known as asynchronous motor. The operational feature of induction motor is based on Faraday's laws of electromagnetic induction. Three-phase induction motor has stator part with provision for three-phase AC supply and rotating rotor. The sectional view of this motor is shown in Fig :-

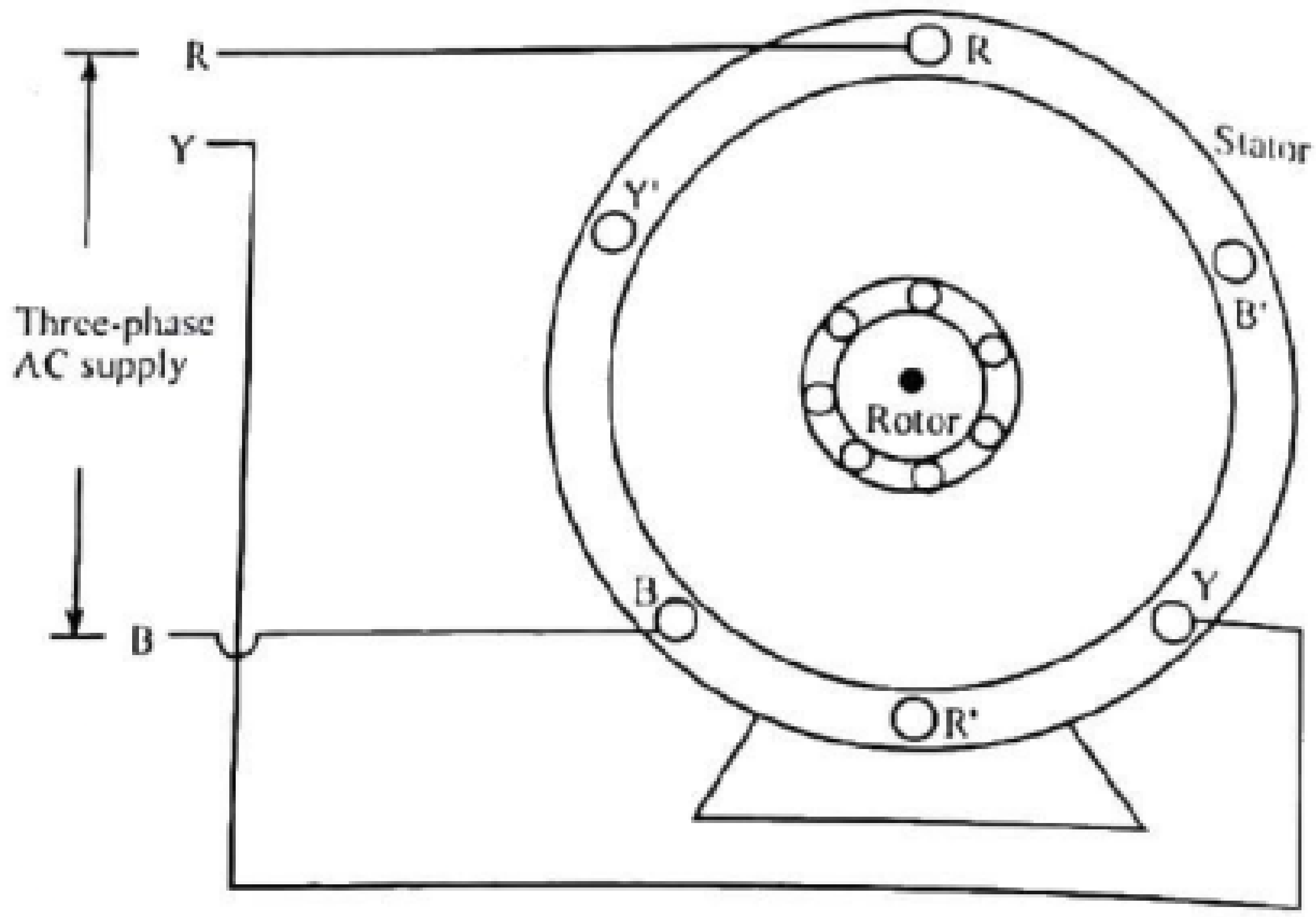


Fig:- 3-Phase induction motor

Working Principle :-

- When the 3 phase stator winding is energized from a 3 phase power supply. A rotating magnetic field is produce which rotates around stator at synchronous speed.
- The rotating magnetic field cuts the voter conductors which were stationary. Due to this the emf is induced in the rotor conductors and current flows in the rotor winding.
- Now, As per Lenz law, " the direction of the induced current will be such that it poses the very cause that produce it.
- Here, the cause of emf induction is the relative motion between the rotor, conductor and stator's magnetic field. Hence, to reduce this, the rotor starts rotating in the same direction as that of state field.
- It tries to caught the speed of stator winding speed. But can never caught Speed due to friction and therefore, the motors keep rotating.

5. a) Show the final expression for the RLC series circuit.

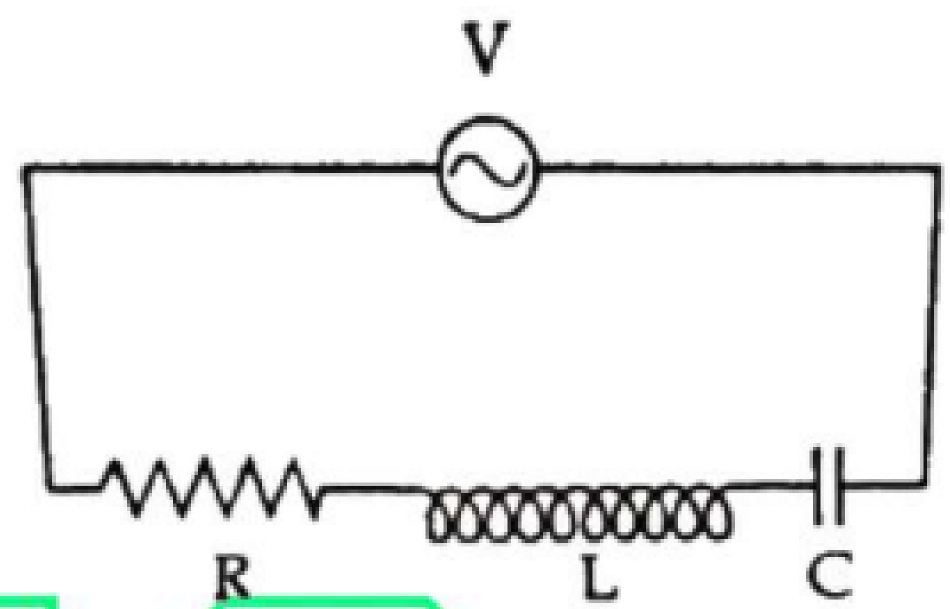
- Consider an a.c. circuit containing an,a resistor 'R', inductor 'L', and a capacitor 'C'.

  The voltage across 'R', V_R is in phase with the current. The voltage across 'L', leads the current by $90°$ .The voltage across 'C', V_C lags behind the current by $90°$, where,

  $V_R = IR$

  $V_L = IX_L$

  and $V_C = IX_C$



V_L and V_C are out of phase. Let us consider the circuit in which $X_L > X_C$, then$V_L > V_C$; resulting voltage between $V_L$and $V_C = V_L - V_C$ in the direction V_L. So, the applied voltage 'V' is given by,

$$V^2 = V_R^2 + (V_L - V_C)^2 = (IR)^2 + (IX_L - IX_C)^2$$

or, $I^2 = \frac{V^2}{R^2+(X_L-X_C)^2}$

or, $I = \frac{V}{\sqrt{R^2+(X_L-X_C)^2}}$

From above relation; we get, for 'R' ,'L', and 'C' circuit.

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

b) Define dry cell and mercury cell. Explain series and parallel connection of cell.

- A dry cell is a electrochemical cell. It has the electrolyte Immobilized as a paste with only enough moister in it to allow current to flow. A dry cell can operator in any orientation.

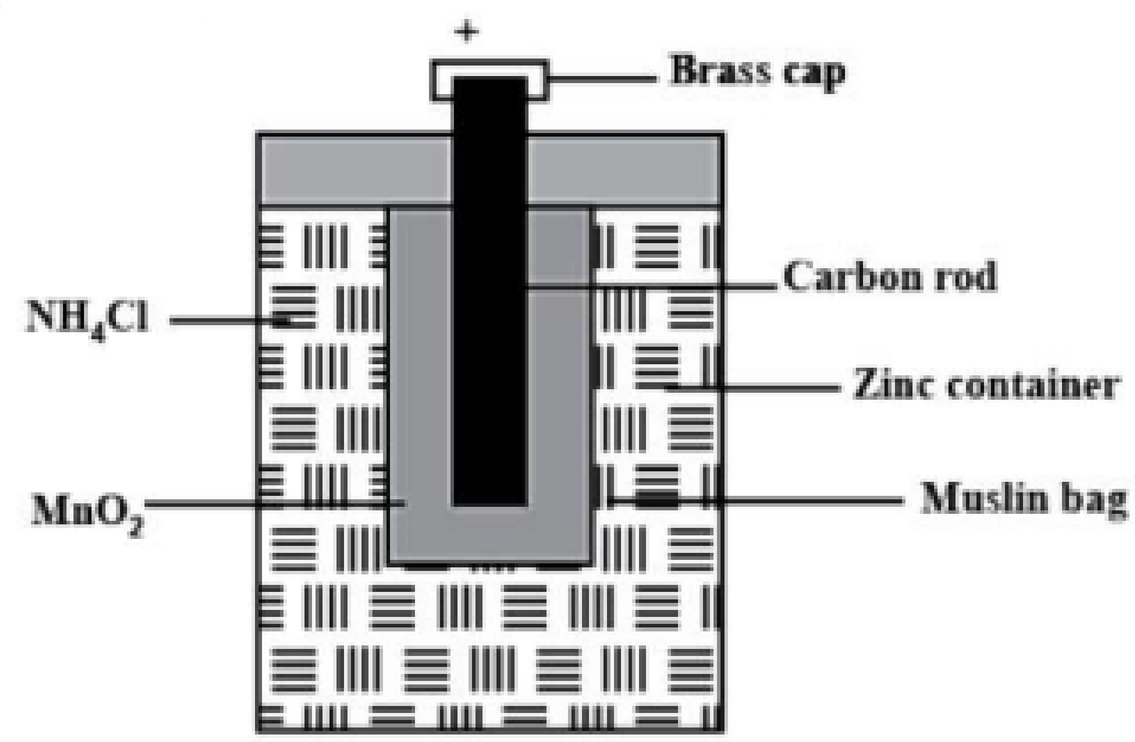


Fig :- Dry Cell

- A mercury cell is non-rechargeable electrochemical battery. They are generally used it watches, hearing aids, calculator and computers. They have advantage of life up to 10 Years and steady voltage output.

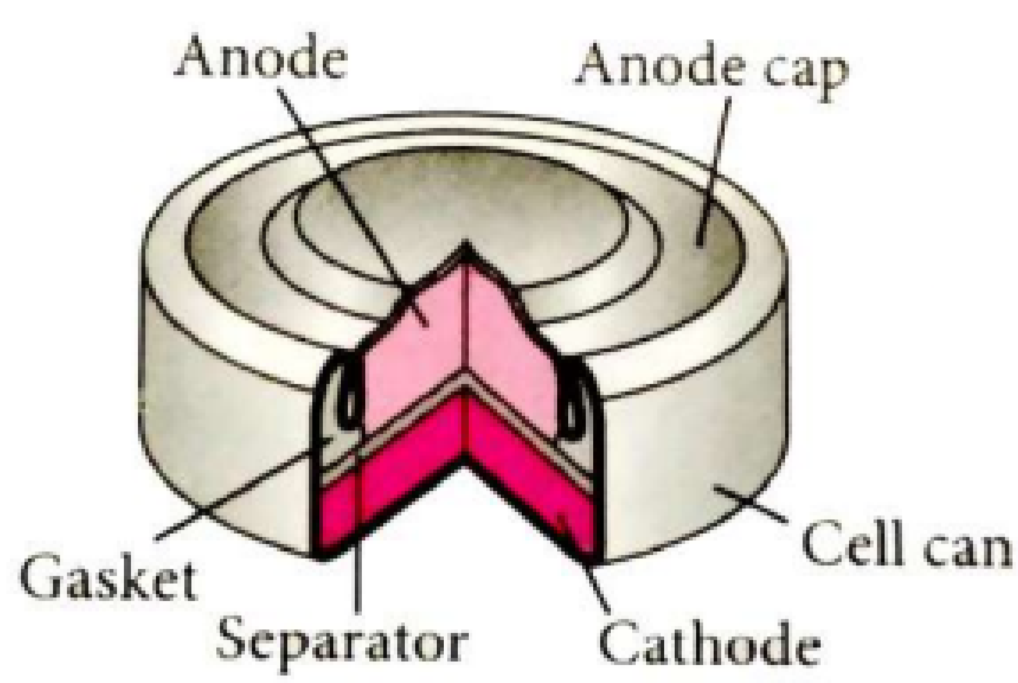
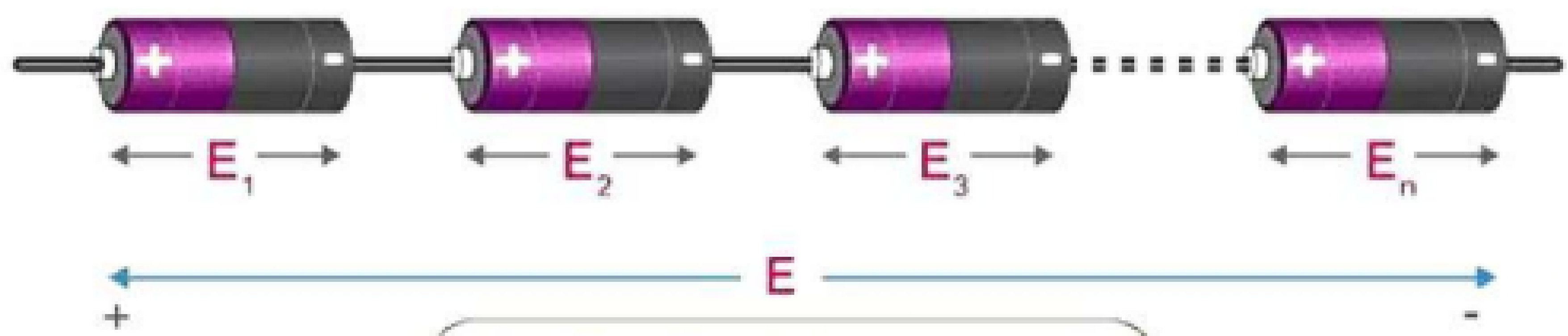


Fig :- Mercury Cell

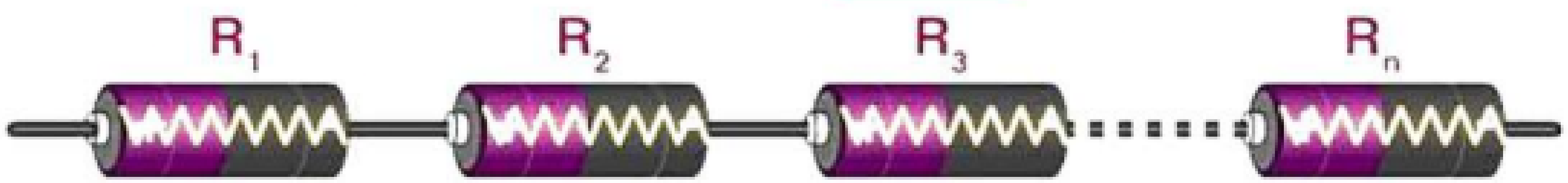
❖ Series connection of cells :-

- A set of cell is said to be connected in series when the positive terminal of one cell is connected to the negative terminal of the succeeding cell.
- The overall emf of the battery is the algebraic sum of all individual cells connected in series. i.e., If E is the overall emf of the battery combined by n number of cells, then



$$E = E_1 + E_2 + E_3 \dots\dots\dots + E_n$$

- Similarly, if r1, r2, r3 are the internal resistances of individual cells, then the internal resistance of the battery will be equal to the sum of the internal resistance of the individual cells.



$$R = R_1 + R_2 + R_3 \dots\dots\dots + R_n$$

❖ Connecting Cell in Parallel :-

- A set of cell are said to be connected in parallel when the positive terminals are connected together, and similarly, the negative terminals of these cells are connected. These combinations are referred to as parallel connection of cell.

- If the emf of each cell is identical, then the emf of the battery combined by n numbers of cells connected in parallel is equal to the emf of each cell.

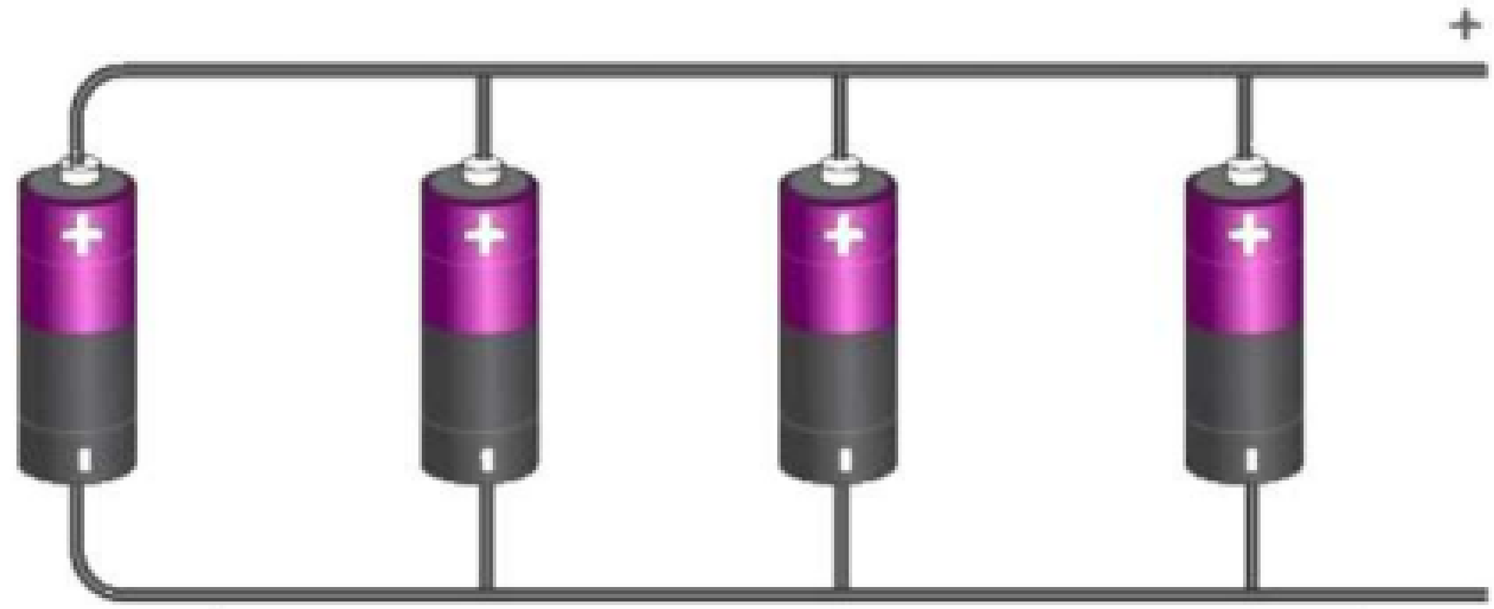
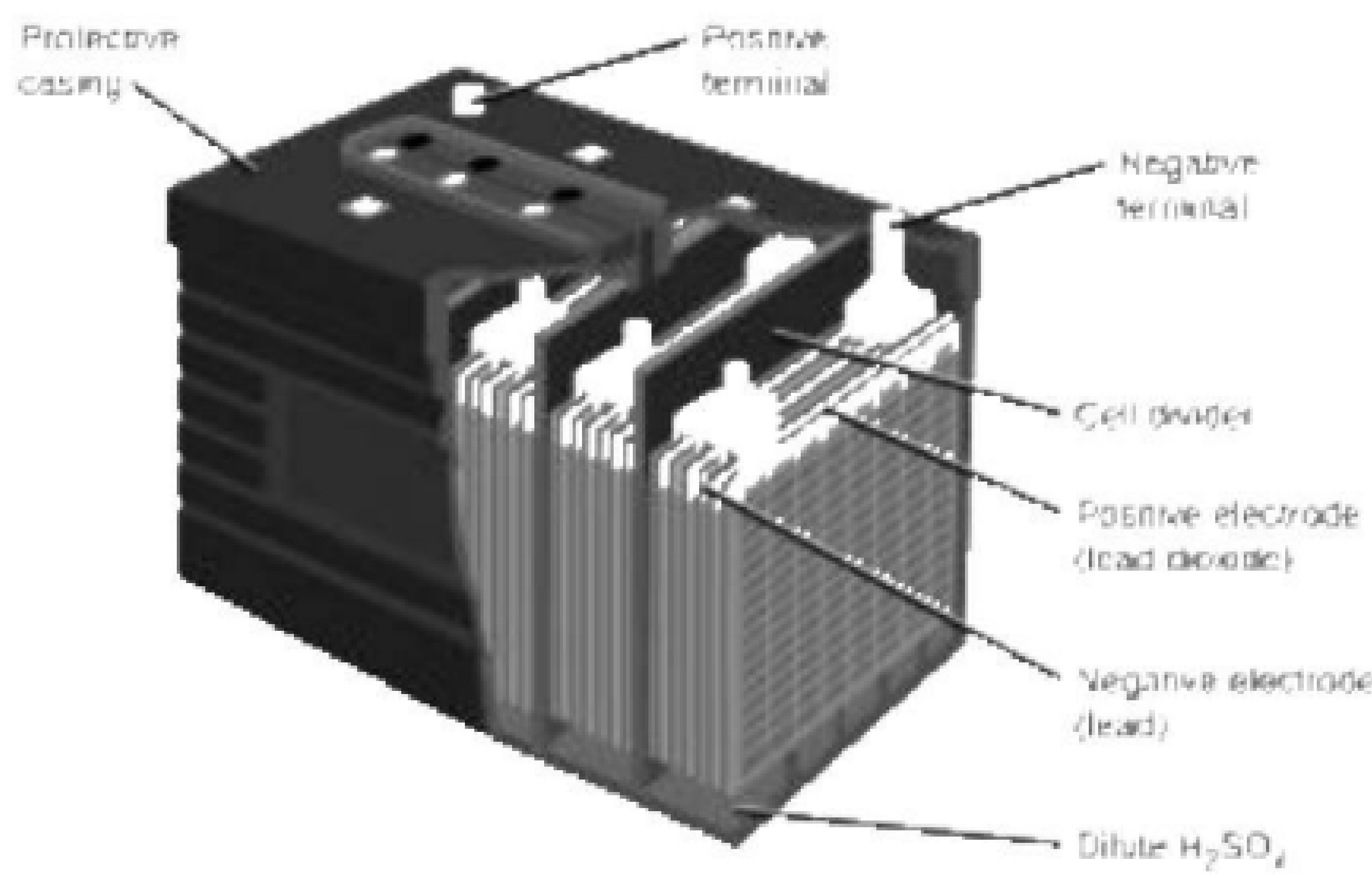


Fig :- Connecting Cell in Parallel

6. Write short notes on:

i) Lead acid cell

- The cell which uses sponge lead and lead peroxide for the conversion of the chemical energy into electrical power, such type of cell is called a lead acid cell. The lead acid cell is most commonly used in the power stations and substations because it has higher cell voltage and lower cost.



ii) Emf

- Electromotive force is defined as the electric potential produced by either an electrochemical cell or by changing the magnetic field. EMF is the commonly used acronym for electromotive force.

  A generator or a battery is used for the conversion of energy from one form to another. In these devices, one terminal becomes positively charged while the other becomes negatively charged. Therefore, an electromotive force is a work done on a unit electric charge. Electromotive force is used in the electromagnetic flow meter which is an application of Faraday's law. The electromotive force symbol is ε.

iii) Single phase AC motor

- An AC motor is an electrical motor driven by an alternating current. The AC motor commonly consists of two basic parts and outside stator having coil supplied with alternating current to produce rotating magnetic field and an inside rotor attached to the output shaft producing a secondary rotating magnetic field.

  The single phase AC motor is driven by single phase AC current. Single phase AC motor can be classified into
  - Induction motor (asynchronous motor)
  - Synchronous motor

iv) Lenz's law

- It states that the direction of induced current is always such that it opposes the change or cause which produces it. It is used to find out the direction of current due to induced emf.

  Note that Lenz's law is reflected mathematically in the minus sign on the R.H.S. of Faraday's second law i.e. $\varepsilon = \frac{d\phi}{dt}$. Here minus sign shows opposing nature of induced e.m.f.

  To understand it, consider a closed coil placed near a bar magnet north pole pointing towards it. As the magnet is moved towards the coil, flux linked with the coil change, so that e.m.f. is induced and an induced current flows in the coil. This current produced in the coil opposes the moving magnet as shown in Fig (a). But as the magnet is moved away from the coil, the induced e.m.f. again produces current but in opposite direction as before. So, the magnet will be attracted by the magnetic field due to induced current.

  Hence this shows that current due to induced e.m.f. produces magnetic field such that it opposes the motion of the magnet which is the cause producing the current.

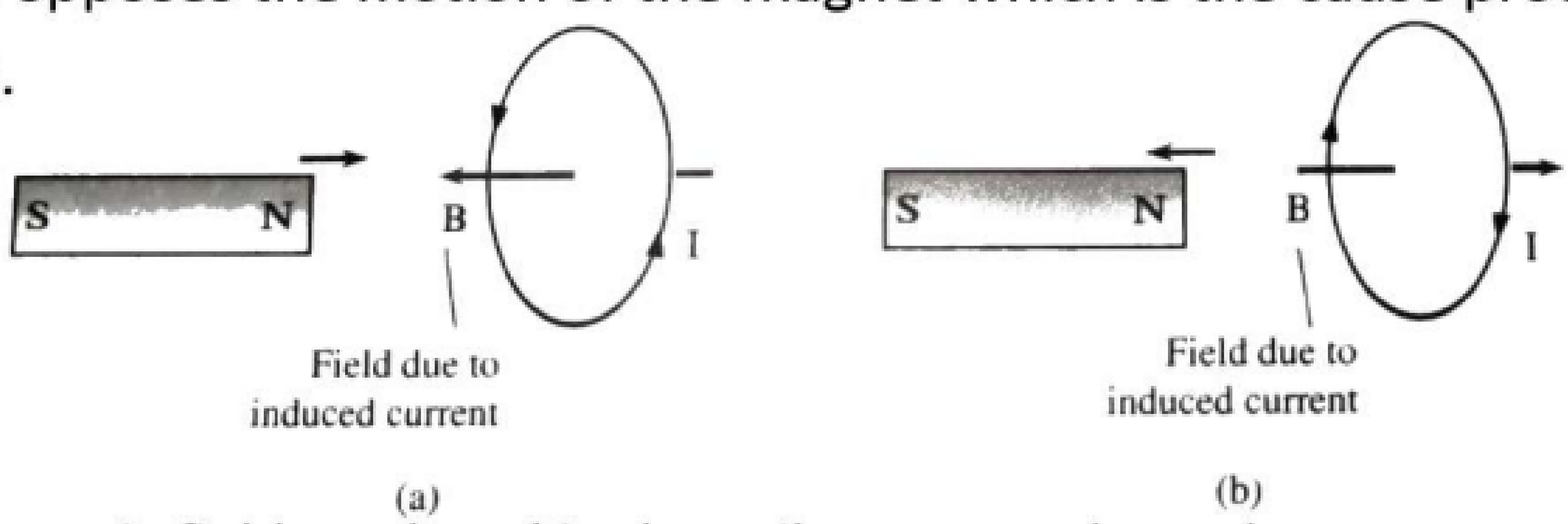


Figure:- (a) Magnetic field produced in the coil opposes when a bar magnet is moved toward the coil.

(b) Magnetic field produced in the coil attracts when a bar magnet is moved away from the coil.

v) Generation of sinusoidal EMF

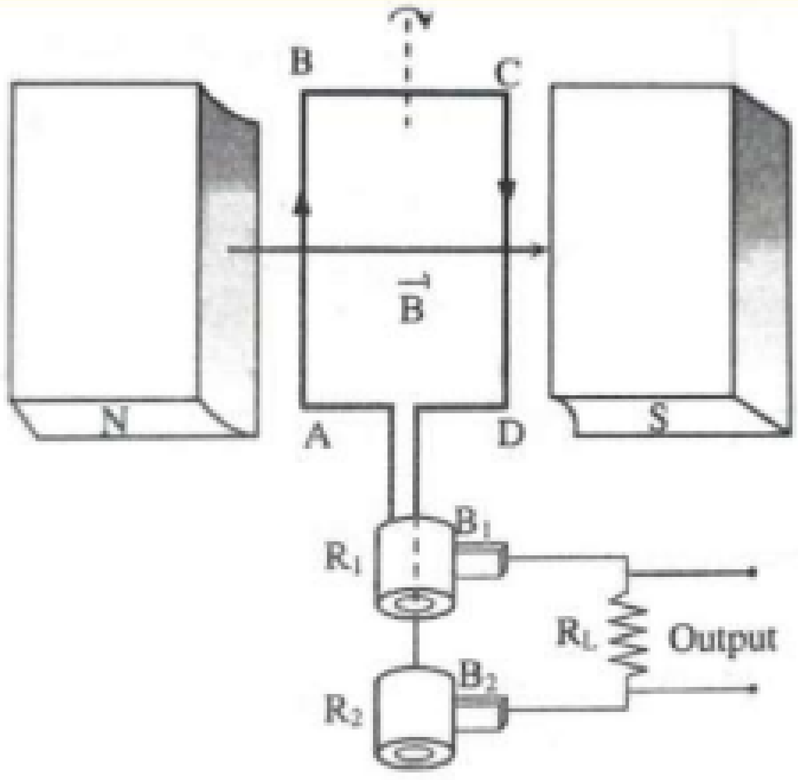


Fig :- (a)

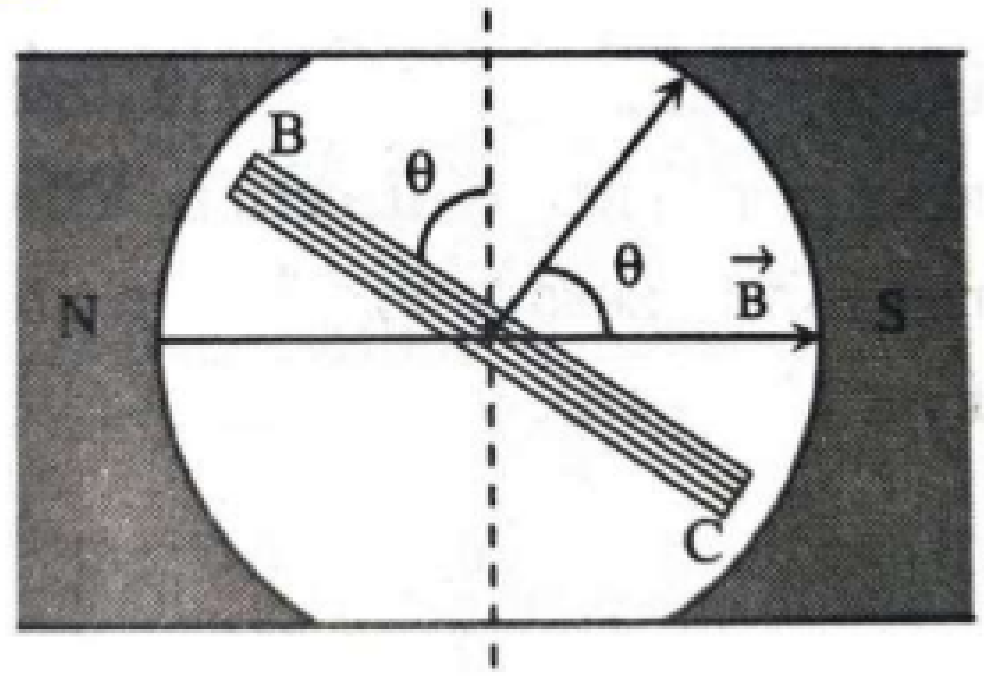


Fig :- (b)

- In figure (a) A coil fixed as to rotate in magnetic field. In figure (b) A magnetic field fixed as to rotate inside the coil.

  If coil rotate in magnetic field or magnet rotate inside the coil, there is an alternating e.m.f. generated in the coil. The generated e.m.f. is proportional to the number of turns of coil, magnetic field strength and the angle between the coil and magnetic field.

  According to Faraday's lave of electromagnetic induction, the induced e.m.f. in the coil is

$$E = -N\frac{d}{dt}(\phi_m \cos \omega t) = N\phi_m \, \omega \sin \omega t$$

$$\therefore \quad \boxed{E = E_m \sin \omega t}$$

Where, N= number of turns and $E_m = N\phi_m \, \omega$ is the maximum e.m.f. induced in the coil.

-The End-

Electrical Engineering----(DCOM/IT) 2nd Sem

(2079) Question Paper Solution.

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1. Define:

a) Magnetic Flux

- Magnetic flux ϕ through any surface area in a magnetic field is defined as the number of magnetic lines of force crossing through that surface.

b. Resistance

- Resistance of a conductor may be defined as the property of conductor which opposes the flow of current through it. It is denoted by letter 'R' and its unit is ohm (Ω) . Resistance is measured by ohm meter.

c. RMS or Effective Value

- The effective or RMS value of an alternating quantity is that steady current (dc) which when flowing through a given resistance for a given time period, produces the same amount of heat, that produced by the alternating current flowing through the same resistance for the same time.

d. Time Period and Frequency

- The time taken by an alternating quantity to complete one cycle is called its time period. It is denoted by 'T'.
- The number of cycle per second is called the frequency of the alternating quantity. It is denoted by f and its unit is hertz (Hz).

e. Electric Power

- The rate of doing electrical work done is called electrical Power.

$$\text{Power (P)} = \frac{\text{Work}}{\text{Time}}$$

$$P = \frac{W}{t} = \frac{Vq}{t} = V \times I$$

We have,

$$V = IR$$

So, Power is given as,

$$P = (IR) \times R = I^2 R$$

And its unit is J/sec or wait.

f. Magnetic Field Intensity

- The strength of a magnetic field at a point is called the magnetic field intensity. It is defined as the force per unit North Pole acting on any pole, placed at that point.

g. Ohm's Law

➢ It states that 'the current flowing through a conductor is directly proportional to the potential difference across its two ends provided its other physical conditions remain unchanged.'

Let 'V' be the potential difference across two ends of a conductor and 'I' be the current flowing through it, then, according to ohm's law,

$$V \propto I$$

$$\therefore \quad V = IR$$

where, " R' is the resistance of conductor.

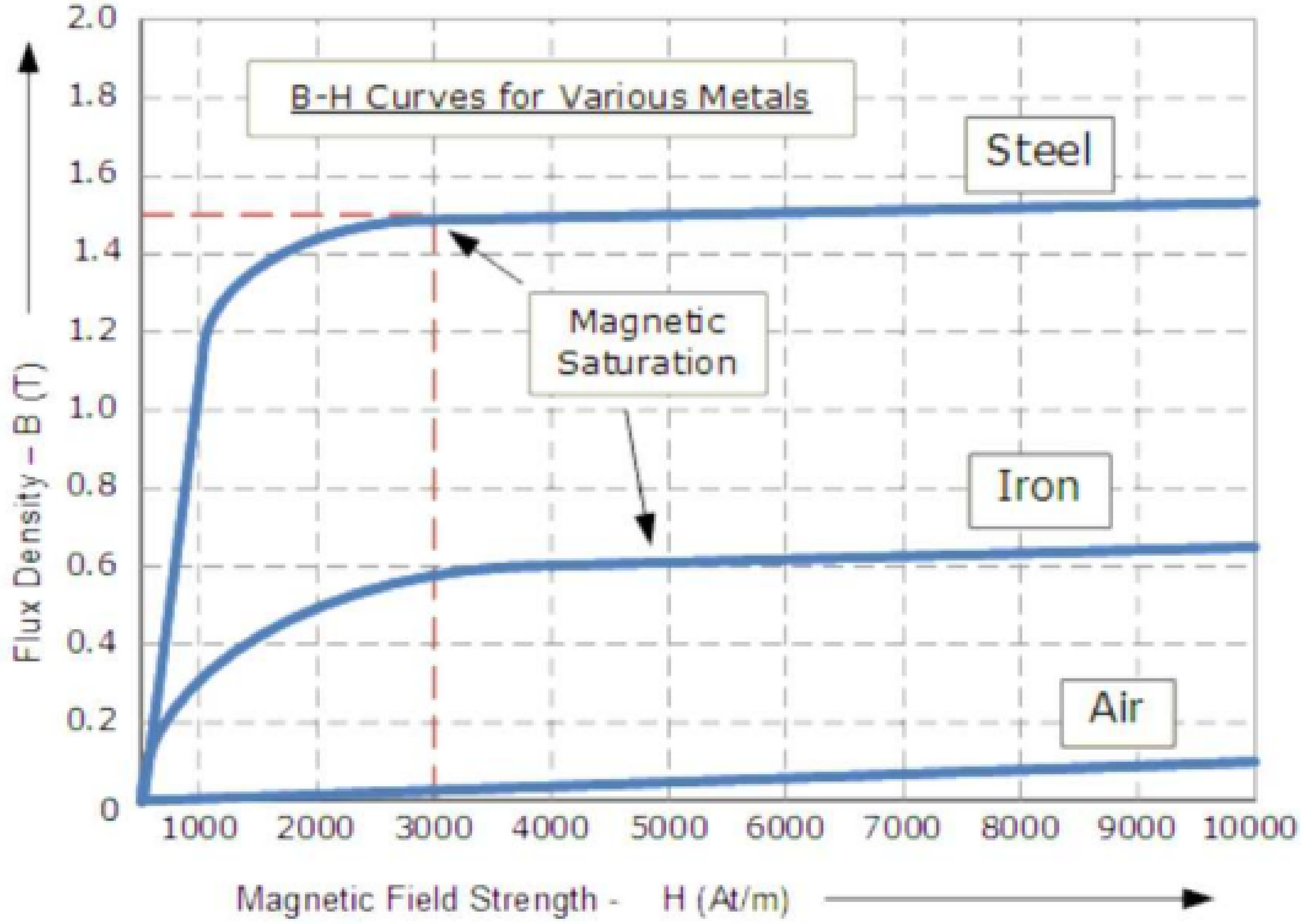
2. State Lenz's law. Explain the B-H curve for magnetic materials.

➢ It states that the direction of induced current is always such that it opposes the change or cause which produces it. It is used to find out the direction of current due to induced emf.

Note that Lenz's law is reflected mathematically in the minus sign on the R.H.S. of Faraday's second law $i.e., \ \varepsilon = \frac{d\phi}{dt}$. Here minus sign shows opposing nature of induced e.m.f.

B-H curve.

- The curve plotted between flux density B and magnetizing force H of a material is called magnetizing or B-H curve.
- The shape of curve is non-linear. This indicates that relative permeability (ur B/ µOH) of a material is not constant but it varies.
- B-H curves are very useful to analyze the magnetic circuit. If value of flux density and dimension of magnetic circuit is known than from B-H curve total ampere turn can be easily known.



- The set of magnetisation curves, M above represents an example of the relationship between B and H for soft-iron and steel cores but every type of core material will have its own set of magnetic hysteresis curves. You may notice that the flux density increases in proportion to the field strength until it reaches a certain value were it cannot increase any more becoming almost level and constant as the field strength continues to increase.

- This is because there is a limit to the amount of flux density that can be generated by the core as all the domains in the iron are perfectly aligned. Any further increase will have no effect on the value of M, and the point on the graph where the flux density reaches its limit is called **Magnetic Saturation** also known as **Saturation of the Core** and in our simple example above the saturation point of the steel curve begins at about 3000 ampere-turns per meter.

3. State Thevenin's Theorem. Explain the procedure for solving the circuit by Thevenin's Theorem.

Thevenis's theorem

- **State:-** Any two output terminals (A and B) of an active linear network containing independent sources (voltage and current sources) can be replaced by a simple voltage source of magnitude V_{th} in the series with a single resistor R_{th}, where R_{th} is the equivalent resistance of the network, when looking from the output terminals A and B, with all sources (voltage and current) removed and replaced by their internal resistance and the magnitude of V_{th} equal to the open circuit voltage across the A and B terminals.

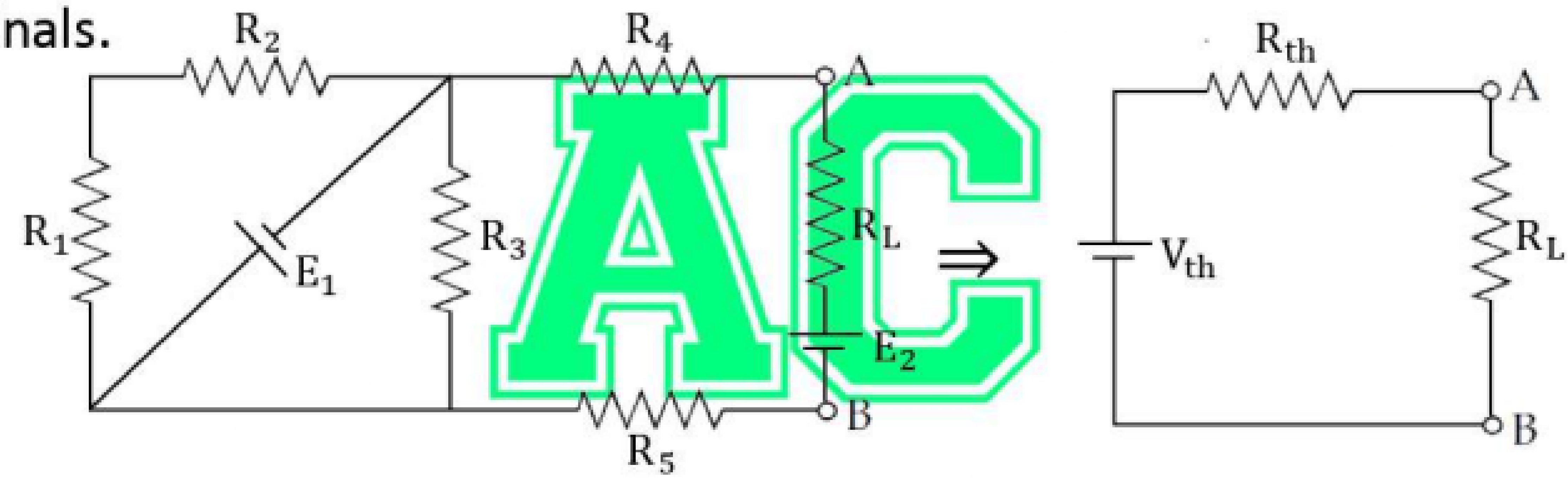


Figure:- Any electric circuit **Thevenin's equivalent circuit**

❖ **Steps to analyze electric circuit through Thevenin's theorem :-**

i) Remove the load resistance, (current through that resister is need to determine) and make open circuit terminal A and B.

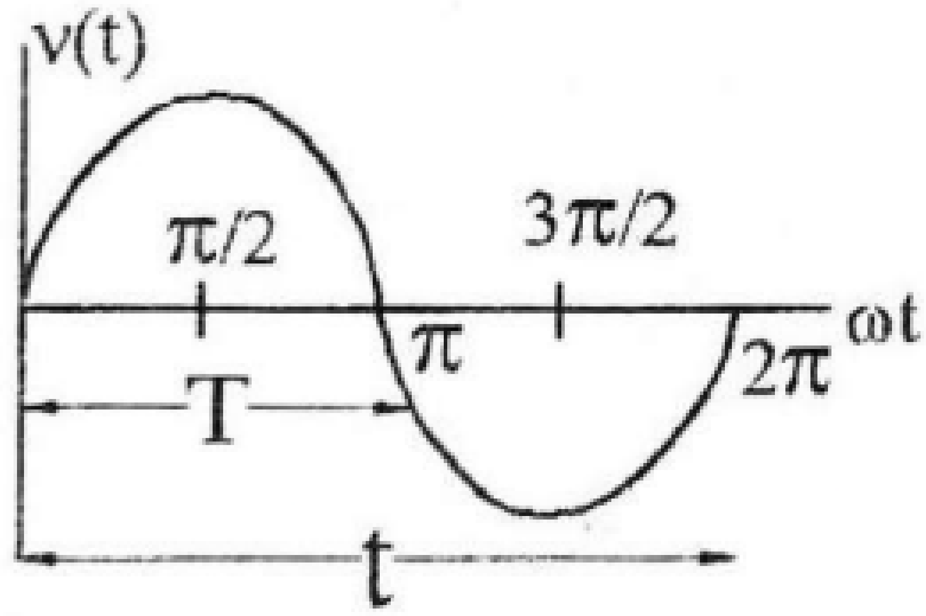
ii) Then find open circuit voltage, which is Thevenin's voltage (V_{in}).

iii) Then short voltage sources and open current sources and find open circuit resistance. This is Thevenin's resistance (R_{th}) .

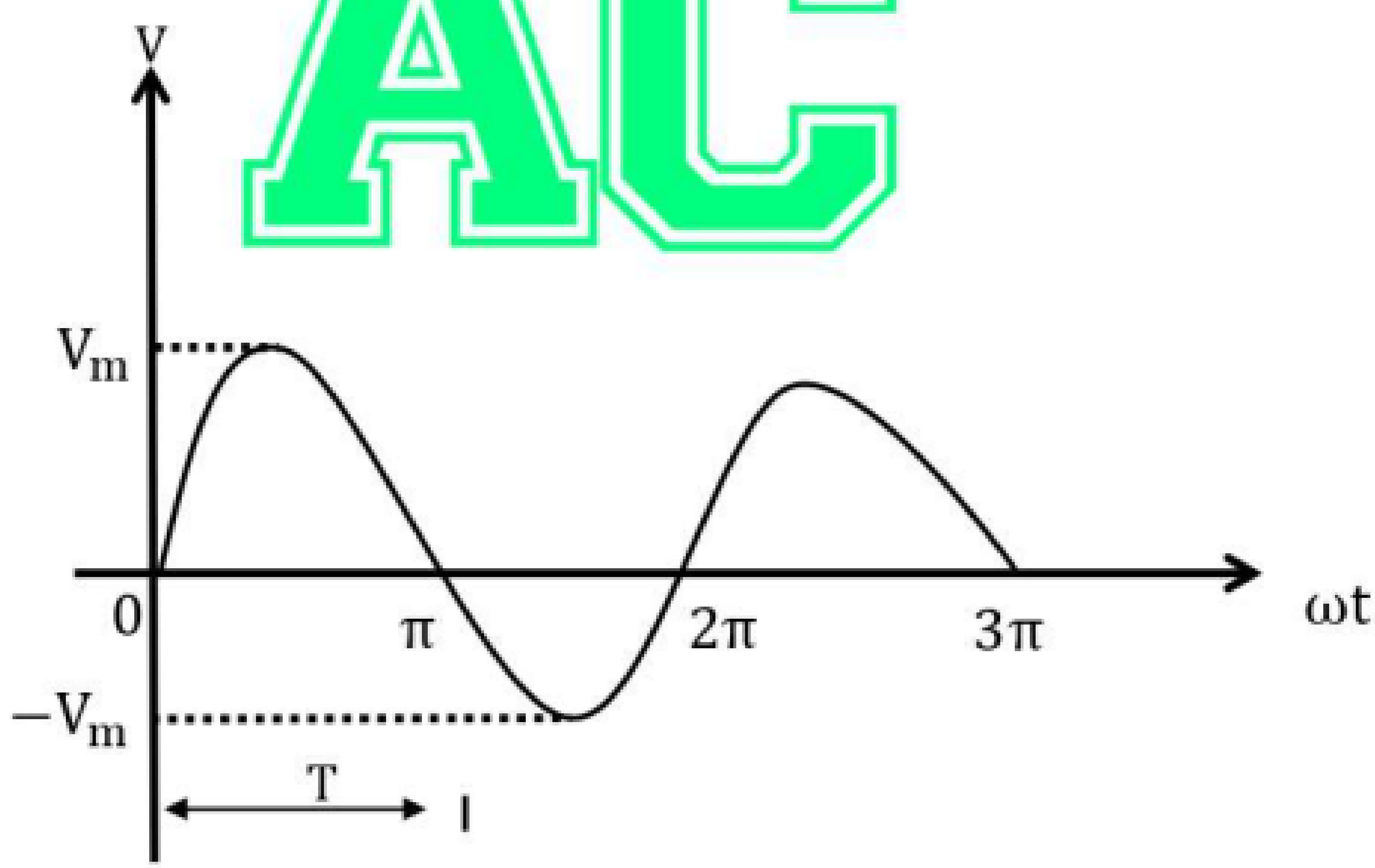
iv) Then redraw the circuit by placing R_{th} and V_{th} in series and connect to the load resistance R_L.

v) Now, find total current using ohm's law.

4. Define phasor. Find the average and RMS value of the sine wave as shown below.



- An alternating quantity can be represented by a rotating line, called phasor. A phasor is a line of definite length rotating in anticlockwise direction at a constant angular velocity. The diagram in which phasor represents current, voltage and their phase difference is known as phasor diagram.

- 

Solution:

As we know, sine wave is symmetrical, its average value over a complete Cycle zero. So, We have of take only half cycle to find the average value.

So, for half Cycle,

Time period (T) $= \pi$

Equation

$$V(\theta) = V_m \sin\theta$$

for $(0 < \theta < \pi)$

Then, to get V_{avg}, We know,

$$V_{avg} = \frac{1}{T}\int_0^T V(\theta)d\theta = \frac{1}{\pi}\int_0^\pi V_m \sin\theta\, d\theta = \frac{V_m}{\pi}[-\cos\theta]_0^\pi = \frac{V_m}{\pi}[-(-1-1)]$$

$$\therefore \boxed{V_{avg} = \frac{2\,V_m}{\pi}}$$

Again,

$$V_{rms}^2 = \frac{1}{T}\int_0^T V^2(\theta)d\theta = \frac{1}{\pi}\int_0^\pi (V_m\sin\theta)^2\, d\theta = \frac{V_m^2}{\pi}\int_0^\pi \left[\frac{1-\cos 2\theta}{2}\right] d\theta$$

$$= \frac{V_m^2}{2\pi}\left[\theta - \frac{\sin 2\theta}{2}\right]_0^\pi = \frac{V_m^2}{2\pi}\left[\left(\pi - \frac{0}{2}\right) - 0\right] = \frac{V_m^2}{2}$$

$$\therefore \boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$$

5. Explain 3-phase system with its advantages and compare star and delta connection with examples.

- A three phase AC system is carried by three conductors called lines. These wires are red, yellow and blue colored. The fourth wire of black color is used as neutral wire. In three phase system, there are two possible sequences in which the three phase voltages may pass through their maximum values. *i.e.*, Red $\rightarrow$ Yellow $\rightarrow$ Blue (RYB) or, Red $\rightarrow$ Blue $\rightarrow$ Yellow (RBY). By convention, sequence RYB is taken as positive and (RBY) negative.

❖ Advantages of Three Phase System :-

i) Three phase transmission is more efficient and requires less copper for transmitting same power over the same distance.

ii) Power produced by three phase motor is high as compared with that of same rating single phase motor.

iii) Three phase motors are self starting while single phase motors are not.

iv) Power factor of three phase motor is high.

v) Torque of three phase motor is uniform where as that of single phase motor is pulsating.

➢ Star Vs Delta Connection ;-

Star Connection (Y or Wye)	Delta Connection (Δ)
A Star Connection is a 4 – wire connection (4th wire is optional in some cases)	A Delta Connection is a 3 – wire connection.
Two types of Star Connection systems are possible: 4 – wire 3 – phase system and 3 – wire 3 phase system.	In Delta Connection, only 3 – wire 3 phase system is possible.
Out of the 4 wires, 3 wires are the phases and 1 wire is the neutral (which is the common point of the 3 wires).	All the 3 wires are phases in a Delta Connection.
In a Star Connection, one end of all the three wires are connected to a common point in the shape of Y, such that all the three open ends of the three wires form the three phases and the common point forms the neutral.	In a Delta Connection, every wire is connected to two adjacent wires in the form of a triangle (Δ) and all the three common points of the connection form the three phases.
The Common point of the Star Connection is called Neutral or Star Point.	There is no neutral in Delta Connection
Line Voltage is $\sqrt{3}$ times phase voltage	Line Voltage and Phase Voltage are same.
Line Current and Phase Current are same.	Line current is $\sqrt{3}$ times the phase current.

Usually, Star Connection is used in both transmission and distribution networks (with either single phase supply or three – phase.	Delta Connection is generally used in distribution networks.
Since insulation required is less, Star Connection can be used for long distances.	Delta Connections are used for shorter distances.
For Example ;- With a Star Connection, you can use two different voltages as VL and VP are different. For example, in a 230V/400V system, the voltage between any of the phase wire and neutral wire is 230V and the voltage between any two phases is 400V.	**For Example ;-** In a Delta Connection, we get only a single voltage magnitude.

6. Define ideal transformer. Explain the construction and working principle of single phase transformer.

➢ **See the solution of 2078 R/B Q.no 4 (a) on Page no. 13**

7. With the help of neat diagram. derive the relation between the phase and line current, phase and line voltage in delta connection.

➢ **Relation between Line and phase qualities :-**

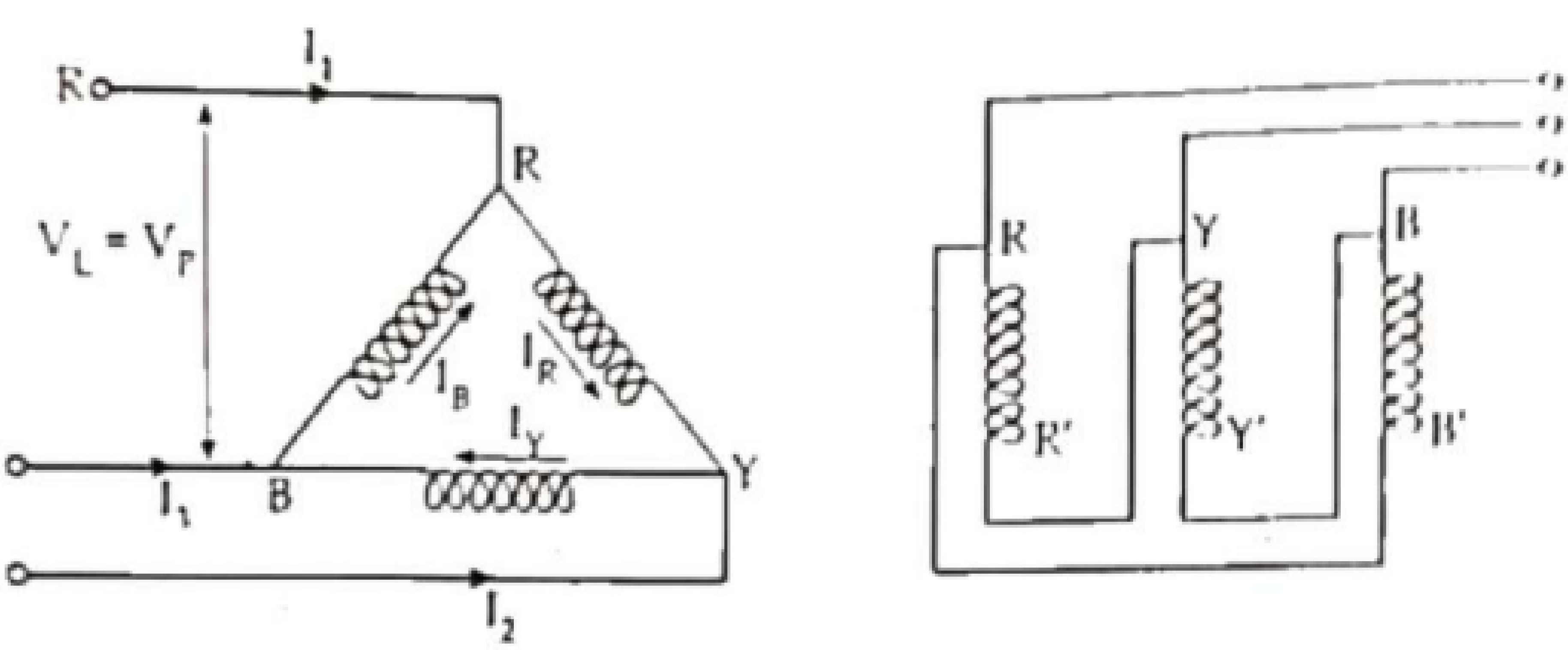
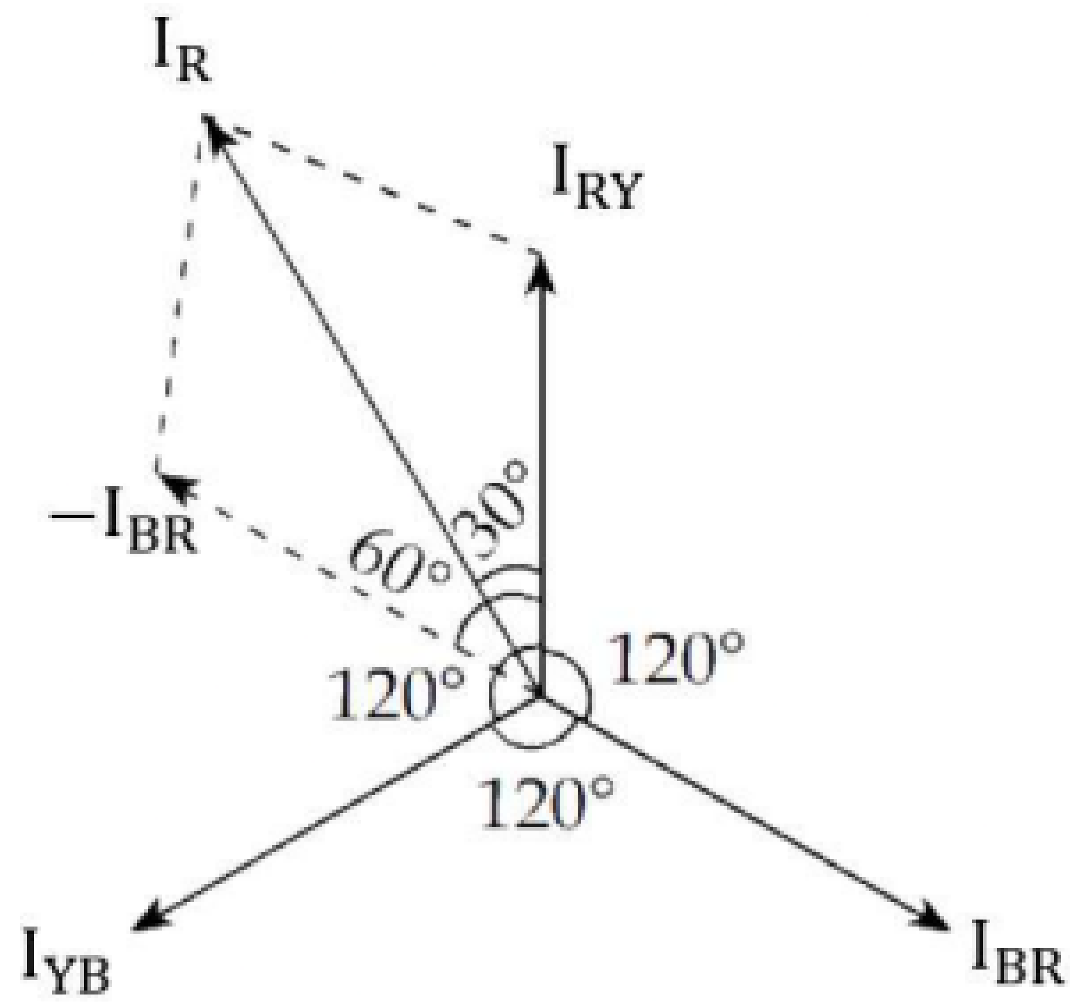


Figure: Delta connection system



❖Phase and line quantities for delta connection

i) Phase voltage $(V_P) = V_{RY}, V_{YB}, V_{BR}$

ii) Phase current: I_R, I_Y, I_B

iii) Line voltage: V_{RY}, V_{YB}, V_{BR}

iv) Line current: I_1, I_2, I_3

Since, The neutral does not exist in the delta connection, *i.e.* one phase winding is in between any two lines, phase voltage will be equal to the line voltage.

Phase voltage (V_P) = Line voltage (V_L)

From second figure, the phase currents are I_{RY},I_{YB} , I_{BR} apparent from each other by 120° and their phase sequence. So,

The line currents,

$$\vec{I}_R = \vec{I}_{RY} - \vec{I}_{BR} \qquad \vec{I}_Y = \vec{I}_{YB} - \vec{I}_{RY} \qquad \vec{I}_B = \vec{I}_{BR} - \vec{I}_{YB}$$

Now, in the phasor diagram, the phase current I_{BR} is reversed and then added in that phasor.

Now, using trigonometrically,

$$I_R = I_{RY} \cos 30° + I_{BR} \cos 30° \qquad \text{[Take R phase]}$$

or, $I_R = I_{RY} \times \frac{\sqrt{3}}{2} + I_{BR} \times \frac{\sqrt{3}}{2}$

For balance load, We have,

$$Z_R = Z_Y = Z_B$$
$$I_R = I_Y = I_B = I_P$$

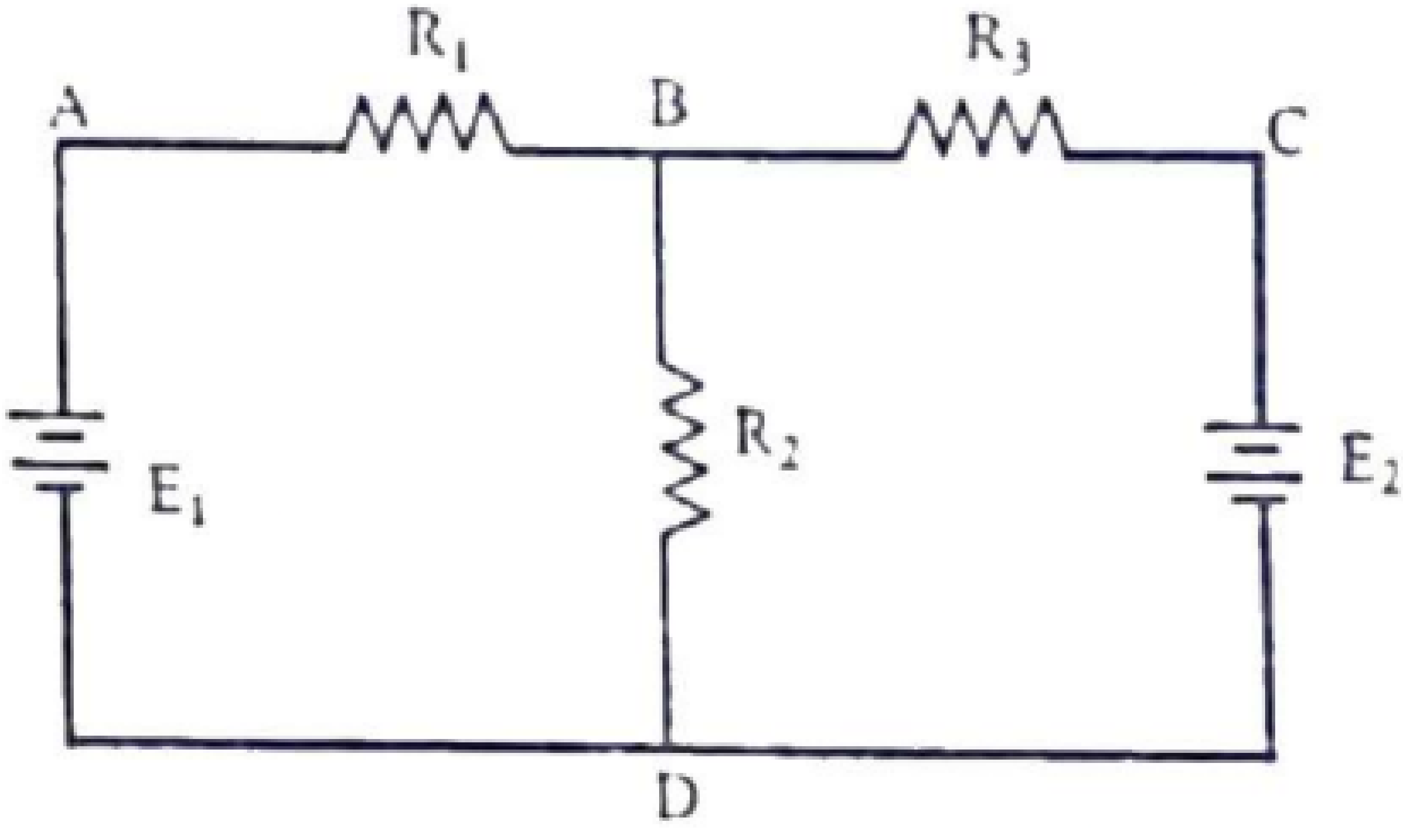
And, $I_{RY} = I_{YB} = I_{BR} = I_P$

Thus, $I_L = \frac{\sqrt{3}}{2} I_P + \frac{\sqrt{3}}{2} I_P$

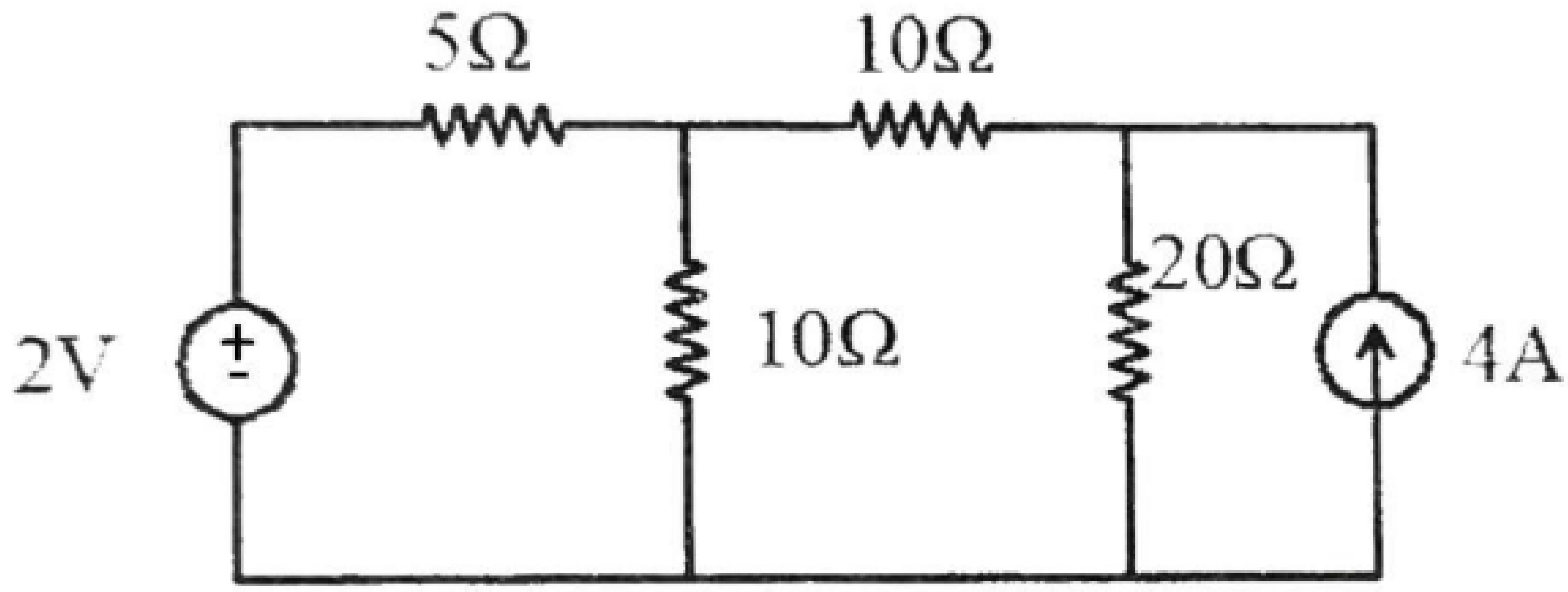
$$\boxed{I_L = \sqrt{3}\, I_P}$$

8. Define node. Find the current flowing through 20Ω resistor of the following circuit using nodal analysis.

❖**Node :-**



- A node of a network is an equipotential surface at which two or more circuit elements are joined. In Figure :- A, B, C and D are nodes.



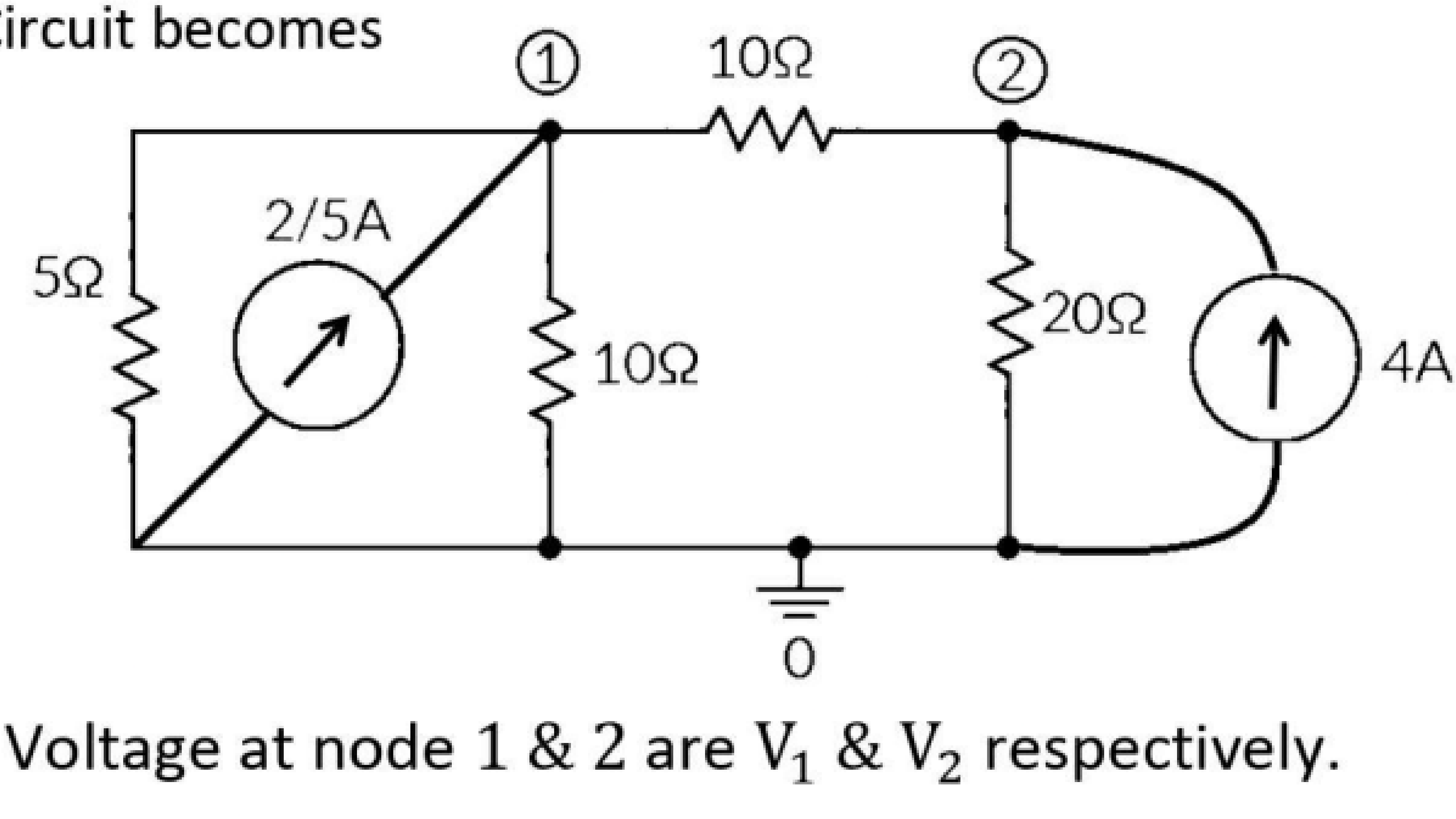
- **Solution :-**

Converting 2V Voltage Source to current source,

$$I = \frac{V}{R} = \frac{2}{5}\ A$$

So,

Circuit becomes



Let Voltage at node 1 & 2 are V_1 & V_2 respectively.

Using KCL at node (1)

$$\frac{2}{5} = \frac{(V_1 - 0)}{5} + \frac{(V_1 - 0)}{10} + \frac{V_1 - V_2}{10}$$

$$\frac{2}{5} = \frac{V_1}{5} + \frac{V_1}{10} + \frac{V_1 - V_2}{10}$$

$$\frac{2}{5} = \frac{V_1}{5} + \frac{V_2}{10} + \frac{2V_1 - V_2}{10}$$

$$\Longrightarrow 2 \times 2 = 2V_1 + 2V_1 - V_2$$

$$\mathbf{4 = 4V_1 - V_2 \cdots\cdots\cdots\cdots (\mathit{i})}$$

Using KCL at node (2)

$$4 = \frac{(V_2 - 0)}{20} + \frac{(V_2 - V_1)}{10}$$

$$4 = \frac{V_2 + 2\,(V_2 - V_1)}{20}$$

$$80 = V_2 + 2\,(V_2 - V_1)$$

$$80 = 3\,V_2 - 2\,V_1$$

$$\mathbf{80 = -2\,V_1 + 3\,V_2 \cdots\cdots\cdots (\mathit{ii})}$$

Now,

Solving (i) & (ii) using calculator We get,

$V_1 = 9.2$ Volts , $V_2 = 32.8$ Volts

Current (I) through 20Ω resistor $= \frac{V}{R} = \frac{V_2}{20}$

$$(I) = \frac{32.8}{20}$$

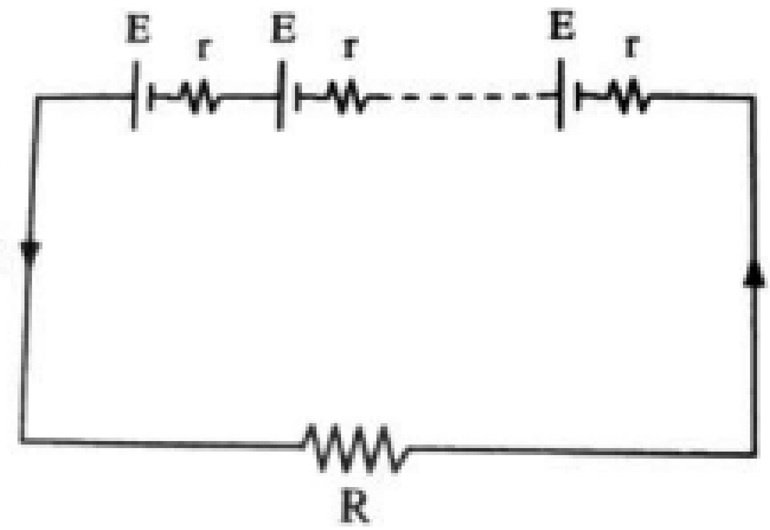
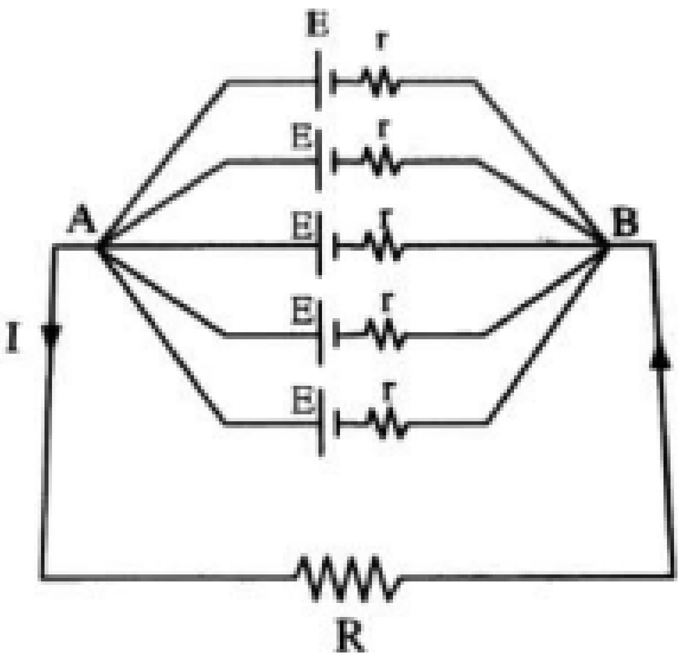
$$\therefore\ I = 1.64\ A$$

9. Describe primary and secondary cells. Differentiate series and parallel connection of cells.

- A primary cell is one in which the redox reaction occurs only once and the cell becomes dead after some time and cannot be used again. For E.g. :- dry cell etc.
- A secondary cell is a cell that is designed to be recharged with electricity and reused many times. In general, the electrochemical reaction occurring in the cell is reversible, and so these cells can be recharged. For E.g :- lithium ion Cell etc.

- **Series Vs Parallel connection of cell :-**

Series connection of cells	Parallel connection of cell
The cells are said to be connected in series if the negative terminal of one cell is connected to the positive terminal of the next cell and so on, so that the same current flows through each cell.	Cells are said to be connected in parallel combination if the positive terminals of all cells are connected together at one common point and negative terminals at another point across an external resistor.
Figure:- contains **n** cell in series	Figure:- contains **m** cell in Parallel

 Cells combined in series.	 Parallel combination of cells.
Total emf of Cells is equal to algebraic sum of individual emf of cell. i.e Total $emf\ = nE$	Total emf of battery between A and B is equal to emf of individual battery. i.e Total $emf = E$
Internal resistance of the cell is equal to algebraic sum of individual cell. i.e Internal resistance of the cell $= r + r + r + \cdots \ldots + r = nr$	Internal resistance of the battery is equal to algebraic sum of individual $\frac{1}{internal\ resistance\ of\ battery.}$ i.e Internal resistance of the cell=$\frac{1}{r} + \frac{1}{r} + \frac{1}{r} \ldots + \frac{1}{r} = \frac{m}{r}$
In series combination maximum current is obtained when external resistance is very high as compared to total internal resistance.	In parallel combination of cells maximum current is obtained when the external resistance is very low.
If any one of the cells is removed or not functioning properly it becomes an open circuit.	Even if anyone of them is removed the circuit remains closed.
In series connection, current has only one path. (i.e same current flow in circuit)	In parallel connection Current divide into more than one path.

10. Write short notes on:

a. Kirchhoff's Law

i) First law

- The algebraic sum of currents meeting at any point in circuit is zero. Let 'A', 'B', 'C', 'D' and 'E' are conductors joining at a point 'O'. The currents are flowing towards and away from the Point 'O'. Then, algebraic sum currents meeting at the point 'O' is;

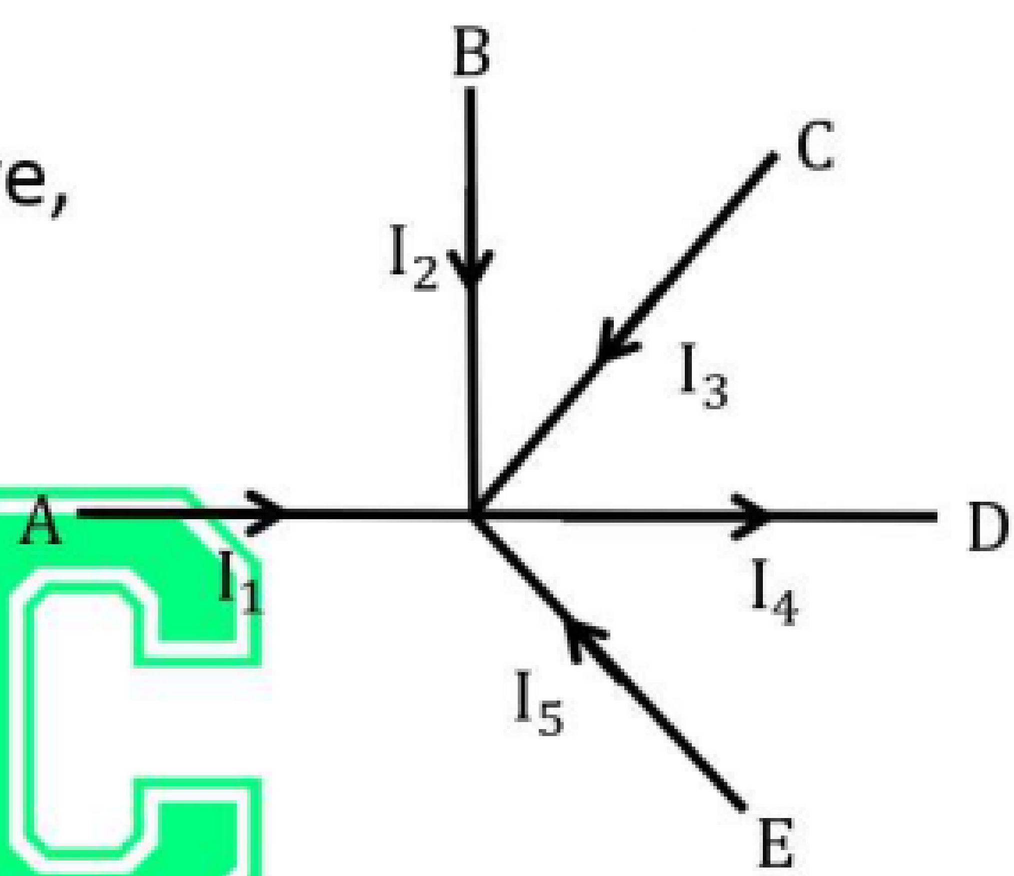
$$I_1 + I_2 + I_3 - I_3 - I_5$$

According to Kirchhoff's Law; we have,

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

In general;

$$\sum I = 0$$



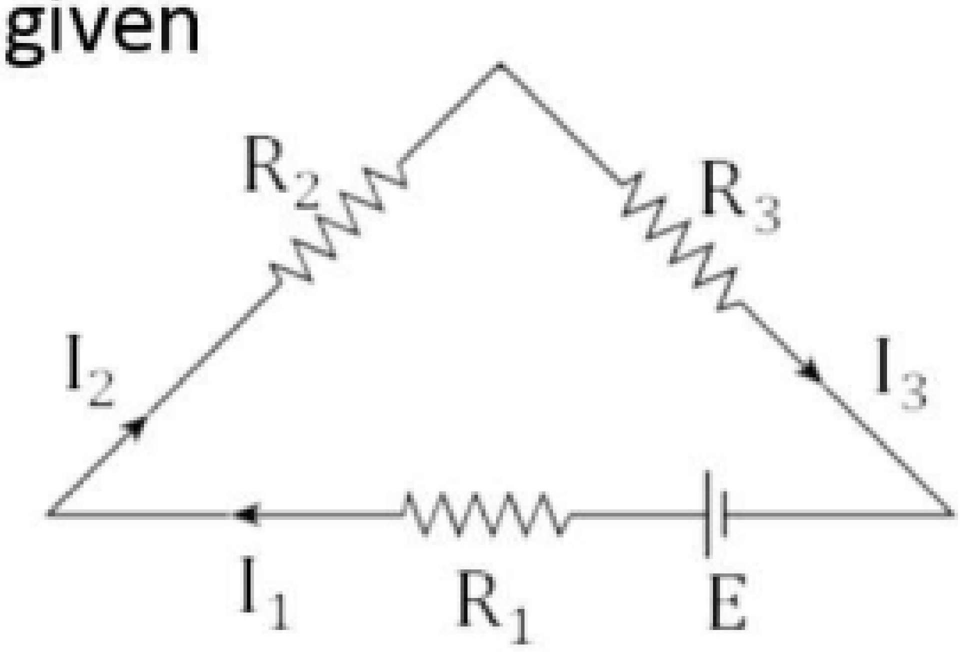
ii) Second law

- *According to Kirchhoff's Voltage Law,* In any closed circuit the algebraic sum of the products of the currents and resistance of each part of the circuit is equal to the algebraic sum of e.m.f.'s in that circuit. *For example*; In the circuit given

$$I_1R_1 + I_2R_2 + I_3R_3 = E$$

In general;

$$\sum IR = \sum E$$



The equation is true for any closed circuit

b. DC Generator

- It is a device which converts mechanical energy into electrical energy.

Principle: It is also based on the principle of electromagnetic induction i.e. whenever the amount of magnetic flux linking a coil changes, an e.m.f. is induced in the coil. *i.e.*, According to Faraday's law, whenever a conductor is placed in a fluctuating magnetic field (or when a conductor is moved in a magnetic field) an EMF is induced in the conductor. If the conductor is guided with a closed path, the current will get induced. The direction of the induced current (given by Fleming's right-hand rule) changes as the direction of movement of the conductor changes.

Constructions: A d.c. generator has the same parts as that of an a.c. generator except that slip ring arrangement is replaced by split rings or commutator. Thus a d.c. generator consists of (i) an armture (ii) strong field magnets (iii) commutator and (iv) brushes. As the armture rotates, alternating voltage is generated in the coil. The split rings convert alternating voltage into direct voltage across the brushes.

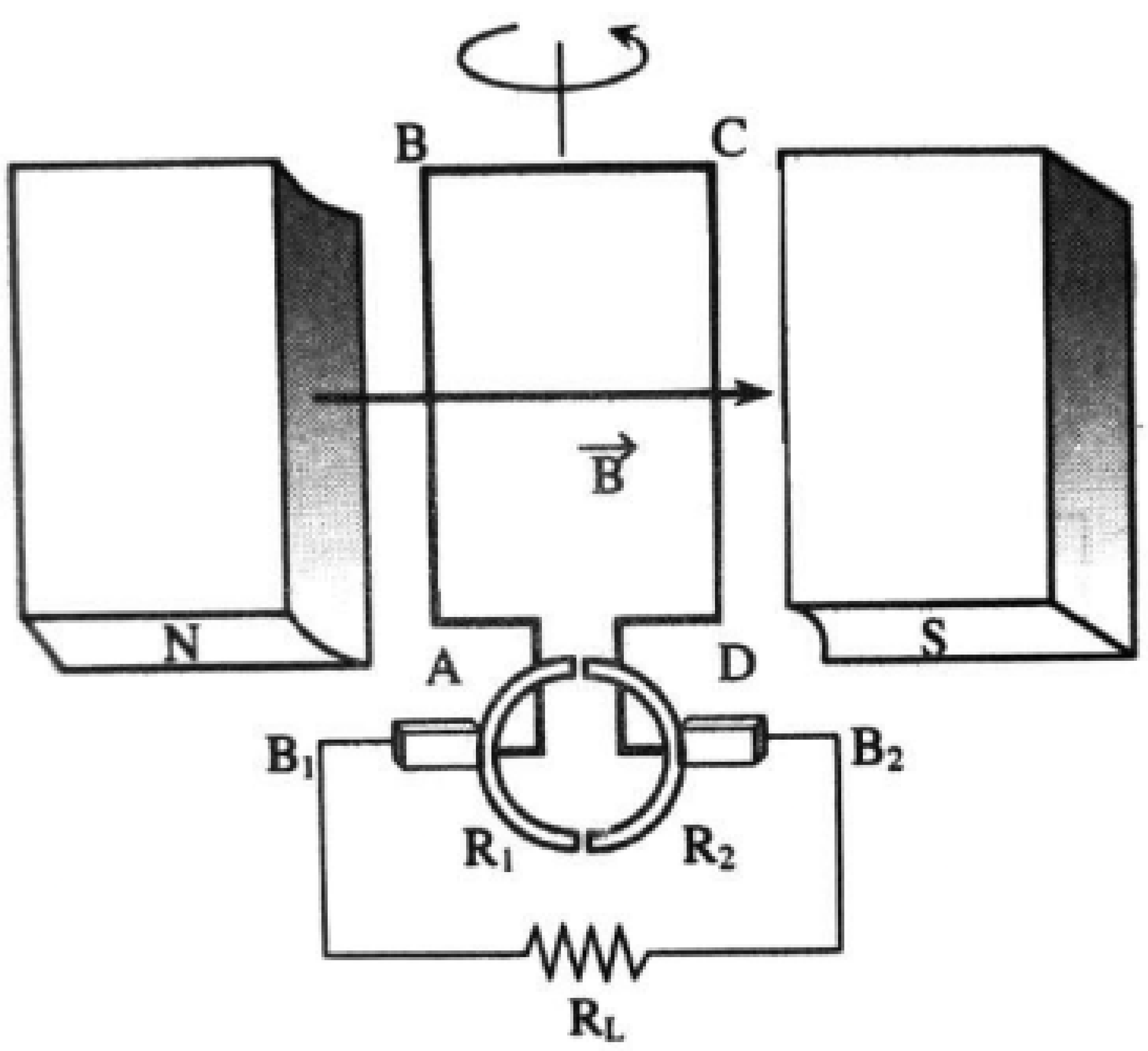


Figure:- DC generator

c. Use of 'J' Operator

➢ **The use of " j " operator are :-**

- Represent voltage and current as phasors (magnitude and phase).
- Describe impedance in components like capacitors and inductors.
- Apply Ohm's Law for AC circuits, considering phase differences.
- Calculate complex power (active and reactive power).
- Utilize Kirchhoff's laws for voltage and current in AC circuits.
- Match component impedance in RF and communication circuits.
- Analyze filters and frequency response.
- Simplify and solve complex AC circuit problems, especially in multi-component circuits.

d. Dry Cell

➢ A dry cell is a electrochemical cell. It has the electrolyte Immobilized as a paste with only enough moister in it to allow current to flow. A dry cell can operator in any orientation. Dry cells are commonly used in portable electronic devices, such as flashlights, radios, and many other battery-operated devices. They are also known as dry-cell batteries.

➢ Advantages:-

- Portable and self-contained.
- Convenient and maintenance-free.
- Long shelf life.
- Low self-discharge.
- Widely available.

➢ Disadvantages:-

- Disposable, not rechargeable.
- Limited energy capacity.
- Environmental impact and disposal concerns.
- Voltage decay over time.
- Lower efficiency compared to some battery types.

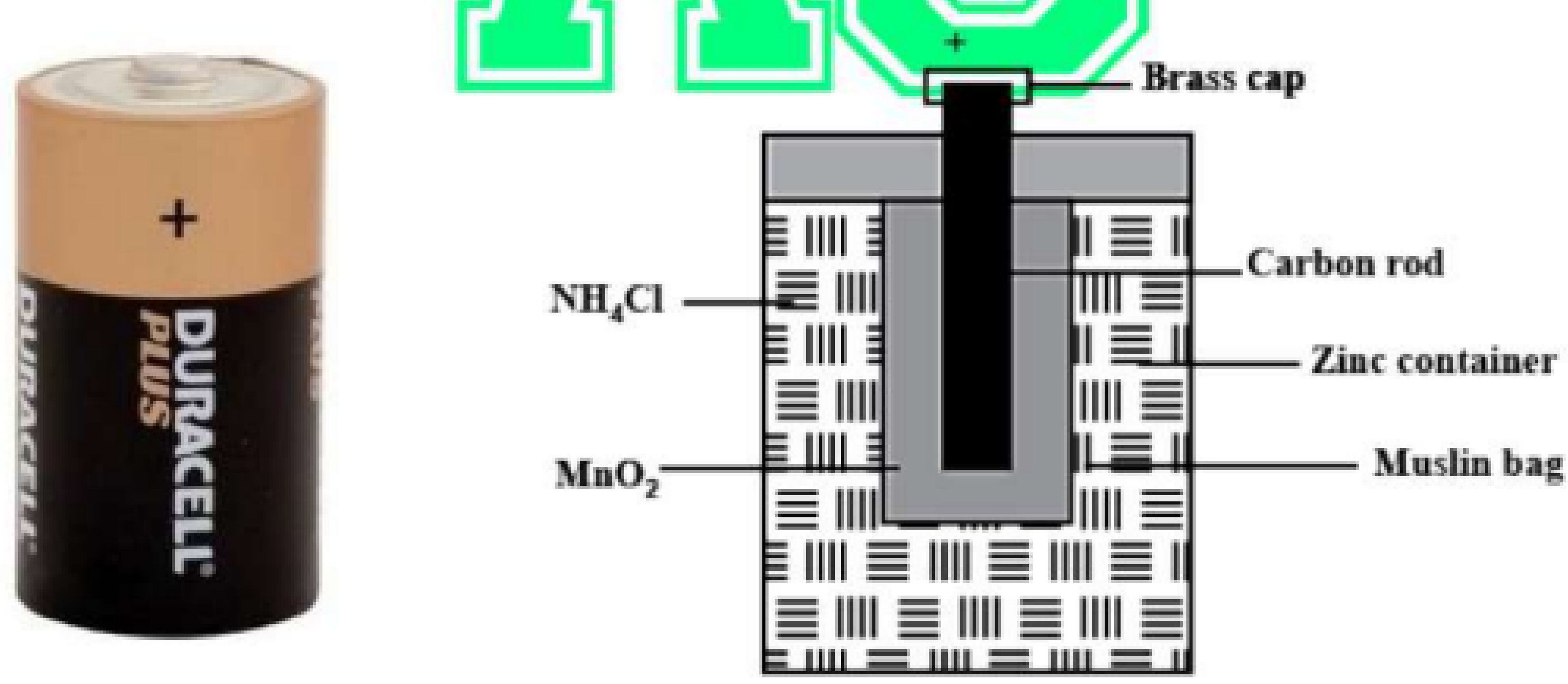


Fig :- Dry Cell

-The End-