



GANESH INSTITUTE OF ENGINEERING AND TECHNOLOGY

Basic Electrical Engineering (Th- 04)

(As per the 2024-25 syllabus prepared by the
SCTE&VT, Bhubaneswar, Odisha)



Second Semester Electrical Engineering

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BASIC ELECTRICAL ENGINEERING

CHAPTER WISE DISTRIBUTION OF PERIODS & MARKS

Sl No.	Chapter No.	Topics	Periods as per Syllabus	Expected marks
01	01	Fundamentals	05	12
02	02	A.C Theory	08	12
03	03	Generation Of Electric Power	03	08
04	04	Conversion Of Electrical Energy	07	08
05	05	Wiring And Power Billing	04	05
06	06	Measuring Instruments	03	05
Total			30	50

CHAPTER NO:-01

FUNDAMENTALS

Learning Objectives:

- 1.1 Concept of current flow.
- 1.2 Concept of source and load.
- 1.3 State Ohm's law and concept of resistance.
- 1.4 Relation of V, I & R in series circuit.
- 1.5 Relation of V, I & R in parallel circuit.
- 1.6 Division of current in parallel circuit.
- 1.7 Effect of power in series & parallel circuit.
- 1.8 Kirchhoff's Law.
- 1.9 Simple problems on Kirchhoff's law.

CHARGE:-

- The most basic quantity in an electric circuit is the electric charge.
- Electric charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field.
- Charge is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).
- Charge may be positive or negative, is denoted by the letter q or Q.
 - electron = -ve charge
 - proton = +ve charge
 - neutron = having no charge
$$e = -1.6 \times 10^{-19} \text{ C}$$

1.1 Concept of current flow :

Current:-

The rate of flow of charge or electrons in a closed circuit is called as current.

Mathematically : $I = Q / t$.

Where Q is the charge measured in Coulombs (C),

I is the current in amperes (A)

t is the time in second (s).

- Generally currents are of Two types :
 - 1) A direct current (DC) is a current that remains constant with time.
 - 2) An alternating current (AC) is a current that varies with time.

Voltage (Or) Potential Difference(V) :-

A Charged body has capacity to do work by moving other charges by force of attraction or repulsion.

The capacity of a charged body to do work is called electric potential.

It is also called as voltage.

Electric potential of a charged body is given by :

$$\text{Potential}(V) = \frac{\text{work done}(W)}{\text{charge}(Q)}$$

Unit of electric potential is joule/coulomb or volt.

Power(P) :

Power is the rate of doing work in an electric circuit.

$$\text{Electric power} = \frac{\text{work done}}{\text{time}}$$

Or

The electric power is the product of voltage and current.

i.e power= voltage * current .(P = V * I), watt

watt = volt * ampere.

Unit of power is joule/second or Watt.

- Bigger unit of power are Kilowatt and Megawatt.
- 1KW = 1000W , 1MW= 10⁶ W
- 1HP(HORSE POWER) = 746W

Energy(E):

Energy is the capacity to do work.

In electrical circuit the energy is the product of power and time.

$$\begin{aligned}\text{Electrical Energy} &= \text{power} * \text{Time} \\ &= P * t = V * I * t = I^2 R t = \frac{V^2}{R} t\end{aligned}$$

It's unit is Watt-hour or KWh.

1.2 Concept of source and load:

1. Energy Sources:-

The energy sources which are having the capacity of generating the energy. The most Important energy sources are voltage or current sources that generally deliver power/energy to the circuit connected to them.

Example: generator, battery, alternator.

There are two kinds of sources

- a) Independent sources
- b) Dependent sources

a) Independent Sources:

An ideal independent source is an active element that provides a specified voltage or current that is completely independent of other circuit elements.

b) **Dependent (Controlled) Sources:**

An ideal dependent (or controlled) source is an active element in which the source quantity is controlled by another voltage or current.

2. **Electrical Load:-**

The electrical load is a device that consumes electrical energy in the form of the current and transforms it into other forms like heat, light, work etc.

The electrical load are (a) Resistive (b) Inductive (c) Capacitive

Resistive Load – The resistive load obstructs the flow of electrical energy in the circuit and converts it into thermal energy.

Ex- Lamp, Heater

Inductive Load-The inductive load has a coil which stores magnetic energy when the current pass through it.

Ex- Generator, motor, transformer

Capacitive Load- The capacitive load include energy stored in materials and device.

Ex- capacitor bank and synchronous condenser.

1.3 **State Ohm's law and concept of resistance.**

Ohm's law:-

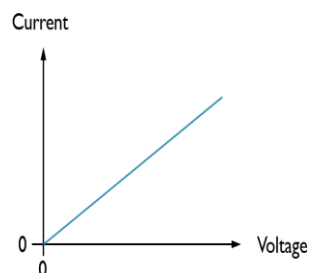
Statement: It states that“ At constant temperature, the current(I) flowing through a metallic conductor is directly proportional to the potential difference(V) between the two ends of the conductor ”.

Mathematically : $I \propto V$

$$\Rightarrow V/I = R, \Rightarrow V = IR$$

Where R is a constant of proportionality and is called resistance of the conductor.

The V-I relation for resistor according to Ohm's law is



Example-1.1. An electrical iron carrying 2A at 120V. Find resistance of the device?

Solution:

$$R = \frac{V}{I} = \frac{120}{2} = 60 \text{ Ohm}$$

Concept of resistance:-

This physical property, or ability of a material to resist the flow of current, is known as resistance and is represented by the symbol R.

The Resistance is measured in ohms (Ω).

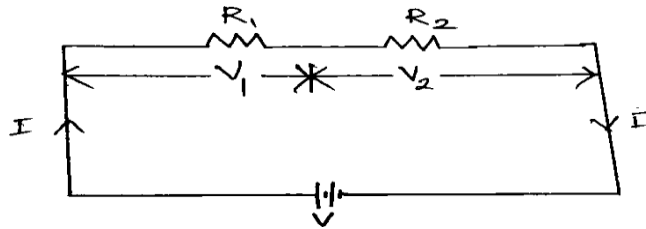
Laws of resistance : The resistance R of a conductor depends on the following factors:

- It varies directly as its length 'l'.
- It varies inversely as the cross-section 'A' of the conductor.
- It depends on the nature of the material.
- It also depends on the temperature of the conductor.

$$R = \rho (L/A), \quad \text{Where } \rho = \text{specific resistance or resistivity.}$$

1.4 Relation of V, I & R in series circuit :

The resistors are said to be connected in series ,if they are joined cascaded or end –on –end.



The two resistors are in series, since the same current i flow in both of them.

Applying Ohm's law to each of the resistors, we obtain $V_1=iR_1$, $V_2= iR_2$ ----- (1)

Here total voltage becomes

$$V= V_1 + V_2 \text{-----}(2)$$

Combining equation(1) and (2), we get

$$V = V_1 + V_2 = iR_1 + iR_2 = i(R_1+R_2) \text{-----} (3)$$

Equation (3) can be written as $V = iR_{eq}$ -----(4)

Where $R_{eq} = R_1 + R_2$ i.e. the summation of two resistors.

From equation(3), we get $i= \frac{V}{R_{eq}} = \frac{V}{R_1+R_2}$ ----- (5)

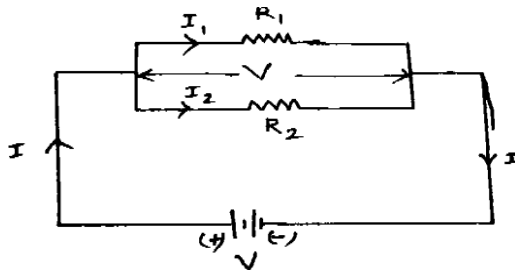
In general, the equivalent resistance of any number of resistors connected in series is the sum of the individual resistances.

Voltage Division Rule

To determine the voltage across each resistor in above fig, we substitute Eq. (5) in to Eq. (1) and obtain

$$V_1 = \frac{V}{R_1+R_2} R_1 \quad \text{and} \quad V_2 = \frac{V}{R_1+R_2} R_2$$

1.5 Relation of V,I and R in parallel circuit :



The resistors are said to be connected in parallel, if the starting points of all resistors are connected in one point and finishing points are connected in one point .

where two resistors are connected in parallel and therefore have the same voltage across them.

$$v = i_1 R_1 = i_2 R_2 \text{ ----- (1)}$$

$$i_1 = \frac{v}{R_1} \text{ and } i_2 = \frac{v}{R_2} \text{ --- --- --- (2)}$$

Here total current ,

$$i = i_1 + i_2 \text{ ----- (3)}$$

Substituting Equation 2 into 3, we get

$$i = \frac{V}{R_1} + \frac{V}{R_2} = V \left(\frac{1}{R_1} + \frac{1}{R_2} \right) = \frac{V}{R_{eq}} \text{ --- --- --- (4)}$$

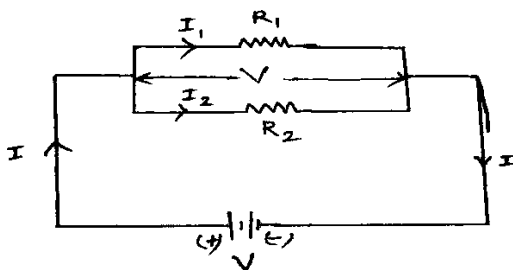
Where R_{eq} is the equivalent resistance of the resistors in parallel.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

If a circuit with N resistors in parallel then the equivalent resistance is

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \text{--- --- ---} + \frac{1}{R_N}$$

1.6 Division of current in parallel circuit:



Let,

V= Supply voltage in V.

I= Circuit current in A.

I₁= Branch current at R₁ in A.

I₂= Branch Current at R₂ in A.

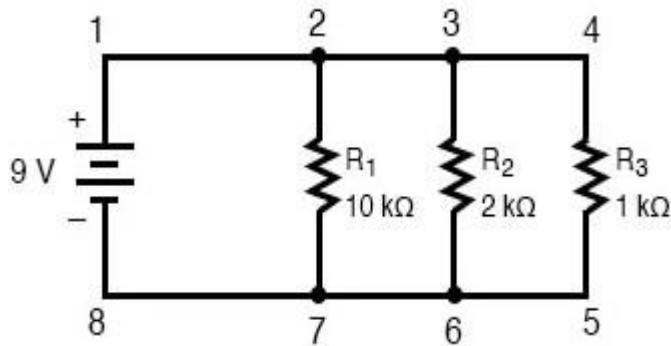
We know that the equivalent resistor has the same voltage.

$$V = I R_{eq} = I * \frac{R_1 R_2}{R_1 + R_2} \text{-----(5)}$$

Substituting equation (5) in equation(2) we get

$$I_1 = \frac{I * R_2}{R_1 + R_2} \quad \text{and} \quad I_2 = \frac{I * R_1}{R_1 + R_2}$$

Q.1 Find the current I passing through and the current passing through each of the resistors in the circuit below.



Solution:

$$\begin{aligned} \text{Equivalent resistance, } \frac{1}{R_{eq}} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \\ &= \frac{1}{10 * 10^3} + \frac{1}{2 * 10^3} + \frac{1}{1 * 10^3} \\ &= 0.0016 \end{aligned}$$

$$R_{eq} = 625 \text{ ohm.}$$

$$I = V/R_{eq} = 9/625 = 0.0144, A = 14.4 \text{ mA}$$

$$I_{R1} = V/R_1 = 9/ 10 * 10^3 = 0.9 \text{ mA}$$

$$I_{R2} = V/R_2 = 2/ 10 * 10^3 = 4.5 \text{ mA}$$

$$I_{R3} = V/R_3 = 1/ 10 * 10^3 = 9 \text{ mA}$$

1.7 Effect of power in series & parallel circuit:

(a) Series Combinations:- If the electrical appliances of power P₁& P₂ are connected in series with main voltage V having resistance R₁& R₂, then

$$R_1 = \frac{V^2}{P_1} \quad \text{and} \quad R_2 = \frac{V^2}{P_2} \quad \text{as } P = \frac{V^2}{R}$$

When connected in series, then their effective resistance is R = R₁ + R₂

$$\text{So } \frac{V^2}{P} = \frac{V^2}{P_1} + \frac{V^2}{P_2}$$

$$\Rightarrow \frac{1}{P} = \frac{1}{P_1} + \frac{1}{P_2}$$

(b) Parallel Combinations:- If the electrical appliances of power P_1 & P_2 are connected in parallel with main voltage V having resistance R_1 & R_2 , then

$$R_1 = \frac{V^2}{P_1} \quad \text{and} \quad R_2 = \frac{V^2}{P_2} \quad \text{as } P = \frac{V^2}{R}$$

When connected in parallel, then their effective resistance is

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\text{so } \frac{P}{V^2} = \frac{P_1}{V^2} + \frac{P_2}{V^2}$$

$$\Rightarrow P = P_1 + P_2$$

Circuit: A circuit is a closed conducting path through which an electric current flow.

1.8 Kirchhoff's Law:

There are two types of Kirchhoff's law

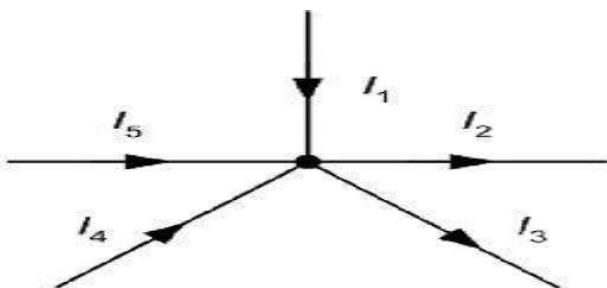
- i. Kirchhoff's current law (KCL) or point law
- ii. Kirchhoff's voltage law (KVL) or mesh law

Kirchhoff's current law (KCL) or point law:

Statement : " The algebraic sum of currents meeting at a point or junction is zero " .

Mathematically,

$$\sum_{i=1}^n I = 0$$



Sign convention :

Incoming current are taken as + ve.

Outgoing current are taken as - ve

In the above figure,

I_1 , I_4 and I_5 are incoming currents.

I_2 and I_3 are outgoing currents.

According to KCL,

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

$$\Rightarrow +I_1 +I_4 +I_5=I_2 +I_3$$

Hence Algebraic sum of currents entering a node=Algebraic sum of current leaving a node.

Kirchhoff's voltage law (KVL) or mesh law:

Statement : "The algebraic sum of emf's and potential drops across resistors in a closed circuit is zero".
Mathematically,

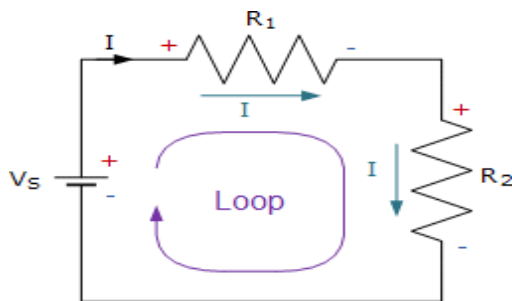
$$\Sigma V = 0$$

Sign convention for emf:

- From -ve to +ve terminal of battery ,there is a rise of potential .so emf is taken as +ve.
- From +ve to - ve terminal of battery ,there is a fall of potential.so emf is taken as -ve.

Sign convention of voltage drop:

- Along the direction of current in a closed circuit potential drop across the resistor is taken as -ve.
- Against the the direction of current voltage is taken as +ve



Consider the closed path ABCD in above figure .As we travel around the circuit in the clock wise direction different voltage drops will have the following signs.

Applying KVL on above circuit ,we get.

$$+V_S - IR_1 - IR_2=0$$

1.9 Simple problems on Kirchhoff's Laws:

Q-1 : If $R_1 = 2\Omega$, $R_2 = 4\Omega$, $R_3 = 6\Omega$, determine the electric current flows in the circuit below.

Given Data :

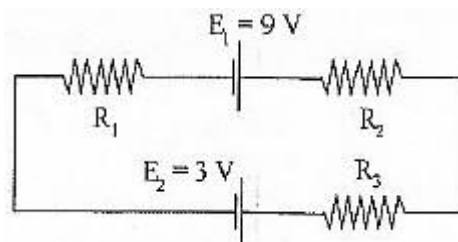
Resistor 1 (R_1) = 2Ω

Resistor 2 (R_2) = 4Ω

Resistor 3 (R_3) = 6Ω

Source of emf 1 (E_1) = 9 V

Source of emf 2 (E_2) = 3 V



Required Data : Electric current (I)

Assumption

- First, choose the direction of the current. You can choose the opposite current or direction in the clockwise direction.
- Second, when the current through the resistor (R) there is a potential decrease so that $V = IR$ signed negative.
- Third, if the current moves from low to high voltage (- to +) then the source of emf (E) signed positive because of the charging of energy at the emf source.
- If the current moves from high to low voltage (+ to -) then the source of emf (E) signed negative because of the emptying of energy at the emf source.

In this solution, the direction of the current is the same as the direction of clockwise rotation.

Solution :

Applying KVL to the above circuit we get :

$$- I R_1 + E_1 - I R_2 - I R_3 - E_2 = 0$$

$$- 2 I + 9 - 4 I - 6 I - 3 = 0$$

$$- 12 I + 6 = 0$$

$$- 12 I = - 6$$

$$I = -6 / -12$$

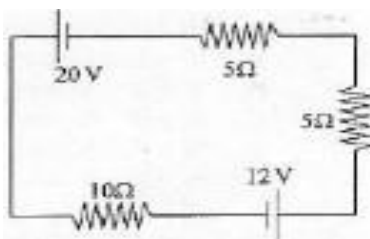
$$I = 0.5$$

The electric current flows in the circuit are 0.5 A.

The electric current signed positive means that the direction of the electric current is the same as the direction of clockwise rotation.

If the electric current is negative then the electric current is opposite to the clockwise direction.

Q. 2. Determine the electric current that flows in the circuit as shown in the figure below.



Solution :

In this solution, the direction of the current is the same as the direction of clockwise rotation.

$$-20 - 5I - 5I - 12 - 10I = 0$$

$$-32 - 20I = 0$$

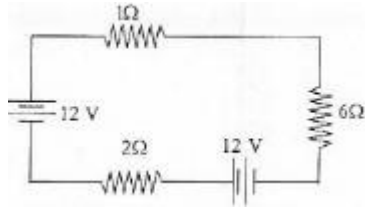
$$-32 = 20I$$

$$I = -32 / 20$$

$$I = -1.6 \text{ A}$$

Because the electric current is negative, the direction of the electric current is actually opposite to the clockwise(assumed) direction. The direction of electric current is not the same as estimation.

Q.3 : Determine the electric current that flows in the circuit as shown in the figure below.



Solution :

In this solution the direction of current is same as the direction of clockwise rotation.

$$-I - 6I + 12 - 2I + 12 = 0$$

$$-9I + 24 = 0$$

$$-9I = -24$$

$$I = 24 / 9$$

$$I = 8 / 3 \text{ A}$$

Q.4: An electric circuit consists of four resistors, $R_1 = 12 \text{ Ohm}$, $R_2 = 12 \text{ Ohm}$, $R_3 = 3 \text{ Ohm}$ and $R_4 = 6 \text{ Ohm}$, are connected with source of emf $E_1 = 6 \text{ Volt}$, $E_2 = 12 \text{ Volt}$. Determine the electric current flows in the circuit as shown in figure below.

Given Data :

Resistor 1 (R_1) = 12 Ω

Resistor 2 (R_2) = 12 Ω

Resistor 3 (R_3) = 3 Ω

Resistor 4 (R_4) = 6 Ω

Source of emf 1 (E_1) = 6 Volt

Source of emf 2 (E_2) = 12 Volt

Required Data : The electric current flows in the circuit (I)

Solution :

Resistor 1 (R_1) and resistor 2 (R_2) are connected in parallel. The equivalent resistor :

$$1/R_{12} = 1/R_1 + 1/R_2 = 1/12 + 1/12 = 2/12$$

$$R_{12} = 12/2 = 6 \text{ } \Omega$$

In this solution, the direction of current is same as the direction of clockwise rotation.

$$-I R_{12} - E_1 - I R_3 - I R_4 + E_2 = 0$$

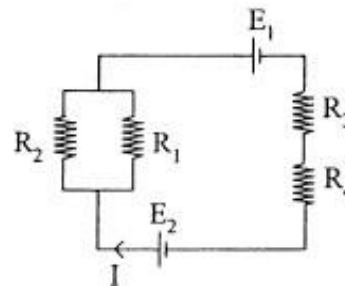
$$-6 I - 6 - 3I - 6I + 12 = 0$$

$$-6I - 3I - 6I = 6 - 12$$

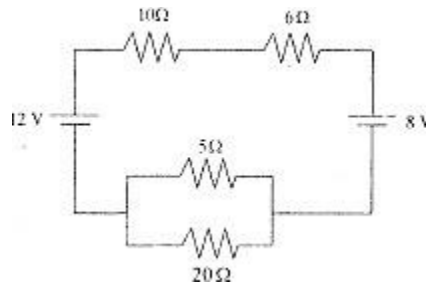
$$-15I = -6$$

$$I = -6/-15$$

$$I = 2/5 \text{ A}$$



Q.5. Determine the electric current that flows in circuit as shown in figure below.



Given Data:

Resistor 1 (R_1) = 10 Ω

Resistor 2 (R_2) = 6 Ω

Resistor 3 (R_3) = 5 Ω

Resistor 4 (R_4) = 20 Ω

Source of emf 1 (E_1) = 8 Volt

Source of emf 2 (E_2) = 12 Volt

Required Data : The electric current that flows in circuit

Solution :

Resistor 3 (R_3) and resistor 4 (R_4) are connected in parallel. The equivalent resistor :

$$1/R_{34} = 1/R_3 + 1/R_4 = 1/5 + 1/20 = 4/20 + 1/20 = 5/20$$

$$R_{34} = 20/5 = 4 \Omega$$

In this solution, the direction of current is same as the direction of clockwise rotation.

$$-I R_1 - I R_2 - E_1 - I R_{34} + E_2 = 0$$

$$-10I - 6I - 8 - 4I + 12 = 0$$

$$-10I - 6I - 4I = 8 - 12$$

$$-20I = -4$$

$$I = -4/-20$$

$$I = 1/5 \text{ A}$$

$$I = 0.2 \text{ A}$$

SHORT QUESTIONS WITH ANSWER:

Q-1 Define current . (W-17, S-19)

Ans: The rate of flow of charge or electrons in a closed circuit is called as current.

Mathematically : $I = q/t$

Unit of current is ampere (A).

Q-2 Define resistance. (W-17)

Ans: It may be defined as the property of a substance due to which it opposes the flow of electrons through it.

• The unit of resistance is ohm (Ω).

Q-3 Define Ohm's Law . (W-17, S-18,19,W-20)

Ans: : Statement:“ At constant temperature, the current flowing through a metallic conductor is directly proportional to the potential difference between the two ends of the conductor ”.

Mathematically : $I \propto V$

$$\Rightarrow V/I = R$$

Q-4 Define load.

Ans: The device which consumes electrical energy is called as load.

Example: DC motor, electric bulb, AC motor ,ceiling fan, table fan, washing machine etc.

Q-5 Define source.

Ans: The device which supplies electrons to keep the current flowing in the external circuit is called as source.

Example: Generator, Battery, Alternator.

Q-6 State KCL. (S-18,19)

Ans: **Statement** : " The algebraic sum of currents meeting at a point or junction is zero“ .

Mathematically,

$$\sum_{i=1}^n I = 0$$

Q-7 State KVL. (S-18,19)

Ans: Statement “The algebraic sum of emf 's and potential drops across resistors in a closed circuit is zero”.

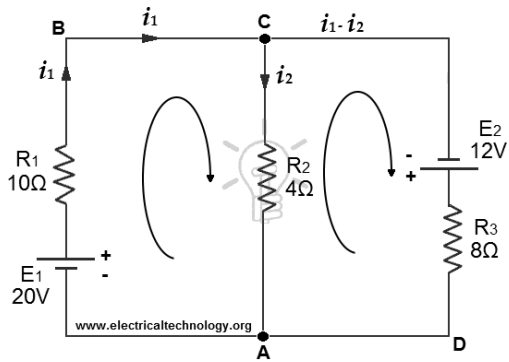
Mathematically,

$$\Sigma V = 0$$

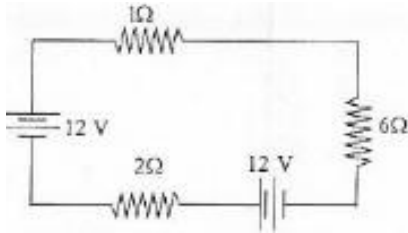
LONG QUESTIOS :

Q-1 State and explain about Kirchhoff's laws. (W-16)

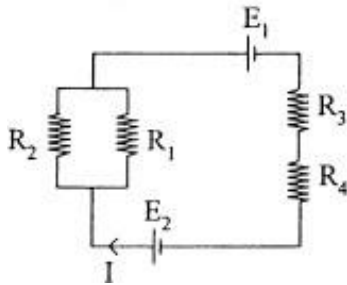
Q-2 Resistors of $R_1 = 10\Omega$, $R_2 = 4\Omega$ and $R_3 = 8\Omega$ are connected up to two batteries (of negligible resistance) as shown. Find the current through each resistor.



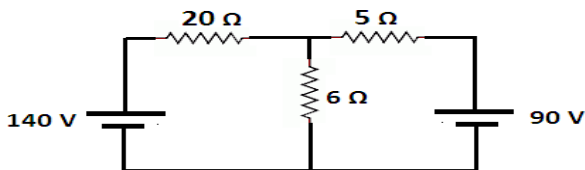
Q-3. Determine the electric current that flows in the circuit as shown in the figure below.



Q-4. An electric circuit consists of four resistors, $R_1 = 12 \text{ Ohm}$, $R_2 = 12 \text{ Ohm}$, $R_3 = 3 \text{ Ohm}$ and $R_4 = 6 \text{ Ohm}$, are connected with source of emf $E_1 = 6 \text{ Volt}$, $E_2 = 12 \text{ Volt}$. Determine the electric current flows in the circuit as shown in figure below.



Q-5. Determine the electric current that flows in circuit as shown in figure below.



Q.6 Deduce the relation of V, I, R in parallel Circuit. (S-18)

CHAPTER NO:-02

A.C THEORY

Learning Objectives:

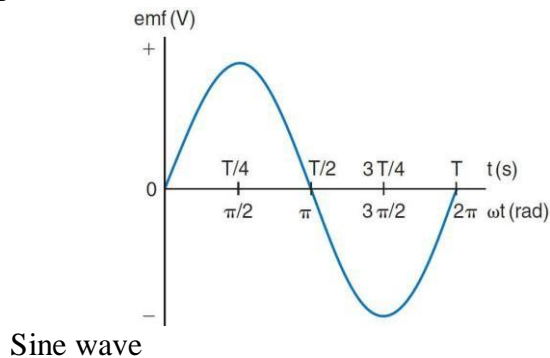
- 2.1 Generation of alternating emf.
- 2.2 Difference between D.C. & A.C.
- 2.3 Define Amplitude, instantaneous value, cycle, Time period, frequency, phase angle, phase difference.
- 2.4 State & Explain RMS value, Average value, Amplitude factor & Form factor with Simple problems.
- 2.5 Represent AC values in phasor diagrams.
- 2.6 AC through pure resistance, inductance & capacitance
- 2.7 AC through RL, RC, RLC series circuits.
- 2.8 Simple problems on RL, RC & RLC series circuits.
- 2.9 Concept of Power and Power factor
- 2.10 Impedance triangle and power triangle.

Current: The rate of flow of electrons in a closed circuit is called as current.

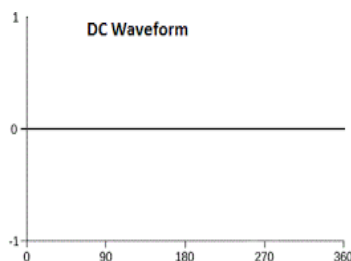
Types of current: According to the nature current may be A.C or D.C.

Alternating current(AC): The type of current in which magnitude and direction changes with time periodically is called AC.

Representation of AC



Direct current (DC): The type of current whose magnitude does not change with time is called dc or steady current.



2.1 Generation of alternating emf :

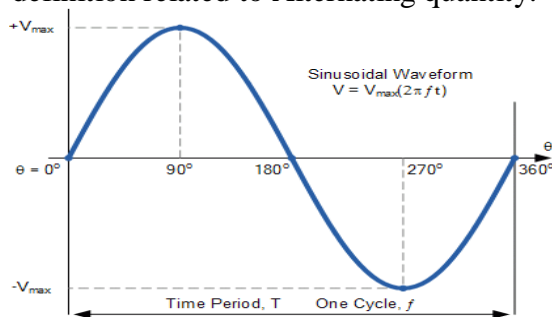
- Principle of alternating voltage and current is based upon Faraday's laws of electromagnetic induction .
- When armature is rotated within magnetic field an induced emf is established in conductors .
- When magnetic field is rotated by its prime mover (turbine) within stationary armature (stator), magnetic fluxes are cut by the stationary conductors alternatively .So induced emf which is alternatively in nature is set-up according to electromagnetic principle.

2.2 Difference between DC and AC:

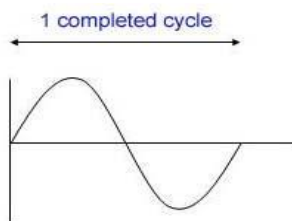
AC	DC
Here magnitude and direction changes periodically	Here magnitude and direction is always constant
Frequency of AC generation is 50 HZ in india.	Frequency on DC is zero.
It is more dangerous .	It is less dangerous.
AC usually used for several purposes .	DC is used for special purposes .
AC motor is small in nature.	DC motor is large in size of same rating.
Resistance ,inductance and capacitance comes into picture.	Only resistance.

2.3 Define Amplitude,Instantaneous value,Cycle,Time period,Frequency, Phase angle,Phase difference.

Some definition related to Alternating quantity:



Cycle: One complete set of positive and negative values of an alternating quantity is called as cycle.
 1 cycle = 1 revolution = 2π radians = 360°



Time period (T): Time taken by an alternating quantity to complete one cycle is called time period.

or

It is the reciprocal of frequency (f)

It's unit is sec.

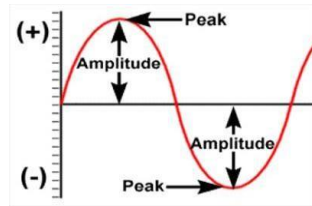
$$T = 1/f$$

Frequency (f): The number of cycles per second is called the frequency of the alternating quantity.

It's unit is Hertz (Hz).

$$f = 1/T$$

Amplitude: The maximum value, positive or negative of an alternating quantity is known as its amplitude, or peak value or crest value.



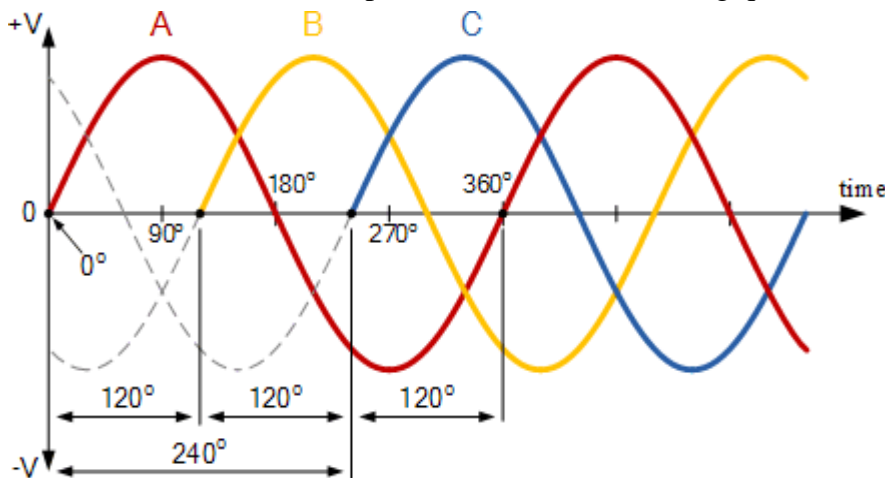
Instantaneous value: The value of an alternating quantity at any instant of time is called as instantaneous value.

Phase: Phase of an alternating quantity is meant the fraction of time period of that alternating quantity

Phase angle: Phase angle of an alternating quantity is the fraction of angle in radian.

Phase difference :

The difference between the phases of the two alternating quantities is called as phase difference.



Let, $V(t) = V_m \sin \omega t$, here the phase is zero as function starts from origin.

$V(t) = V_m \sin(\omega t - \theta)$, here the phase of function is θ degrees to right shift.

$V(t) = V_m \sin(\omega t + \theta)$, here the phase of the function is θ degrees to the left shift.

2.4 State and Explain RMS value, Average value , Amplitude factor and form factor with simple problems:

RMS value: It is that value of AC which produces same heat as that of dc for a given circuit and given time.

$$I_{RMS} = I_m / \sqrt{2}$$

$$V_{RMS} = V_m / \sqrt{2}$$

Where I_m = Maximum value of current.

Average value : It is that value of AC which produces same charge as that of DC for a given circuit and given time.

$$I_{AV} = 2I_m / \pi \text{ for sine wave.}$$

$$I_{AV} = I_1 + I_2$$

Form factor: It is defined as the ratio of rms value to average value of an alternating quantity .

$$KF = \text{RMS value} / \text{average value} = 0.707 I_m / 0.637 I_m = 1.1$$

Crest or peak or amplitude factor : (K_a) It is defined as the ratio of maximum value to rms value of an alternating quantity.

$$K_a = \text{Maximum value} / \text{rms value} = I_m / (I_m / \sqrt{2}) = \sqrt{2} = 1.414$$

Simple problems:

Q-1: An alternating current of frequency 50Hz has a maximum value of 100A .Give its instantaneous expression .

Solution

Given data:

$$f = 50 \text{ HZ}$$

$$I_m = 100 \text{ A}$$

Required data:

Instantaneous current expression ?

Ans:

$$\omega = 2\pi f = 2\pi \times 50 = 100\pi = 100 \times 3.142 = 314.2 \text{ rad/sec}$$

We know $i = I_m \sin \omega t$

$$i = 100 \sin 314.2t \text{ A (Ans)}$$

Q-2: An alternating voltage is expressed as $V = 300 \sin 314t$. Find (i) Peak voltage (ii) frequency (iii) rms voltage (iv) Find the instantaneous value of 1/600 sec.

Solution:

Given data:

$$V = 300 \sin 314t$$

$$t = 1/600 \text{ sec}$$

Required data:

(i) Peak voltage (V_m) = ?

(ii) Frequency (f) = ?

(iii) rms voltage (V_{rms}) = ?

(iv) $V = ?$

Ans:

(i) $V_m = 300 \text{ V (Ans)}$

(ii) $f = 314 / 2\pi = 50 \text{ Hz (Ans)}$

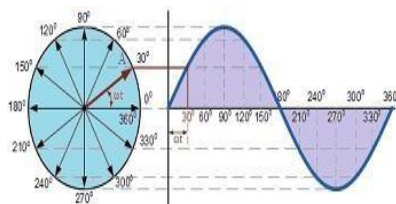
(iii) $V_{rms} = 300 / \sqrt{2} = 0.707 \times 300 = 212.1 \text{ V (Ans)}$

(iv) $V = 300 \sin 314 \times (1/600) = 2.74 \text{ V (Ans)}$

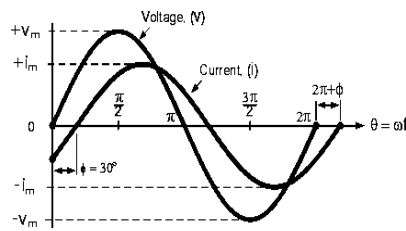
2.5 Represent AC values in phasor diagrams:

Phasor diagrams

- Phasor diagrams are the representations of voltage-current relationship in AC circuits.
- A phasor is a vector capable of rotating about the origin with (angular velocity) ' ω '
- The vertical component of phasor will represent the sinusoidally varying quantity.
- Considering $V = V_m \sin \omega t$ then the vertical component represents the instantaneous value of voltage.
- The magnitude (length of the vector) of the phasor is the peak value at that instant of time.



Phase Difference of a Sinusoidal Waveform

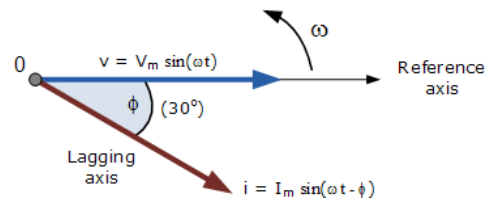


The generalised mathematical expression to define these two sinusoidal quantities will be written as:

$$v_{(t)} = V_m \sin(\omega t)$$

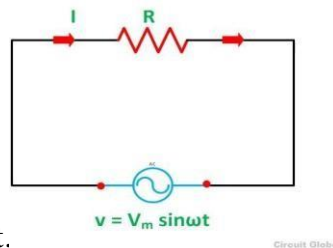
$$i_{(t)} = I_m \sin(\omega t - \phi)$$

Phasor Diagram of a Sinusoidal Waveform



2.6 AC through pure resistance ,inductance and capacitance :

AC through pure resistance:



In above figure ,

V= Applied voltage in volt.

I= Current in amp.

R= Resistance in ohm.

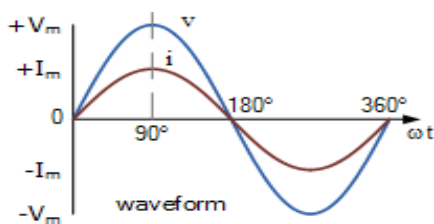
V_R =Drop across R in volt.

Here the voltage equation ,

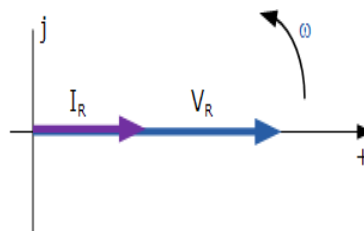
$$V = V_m \sin \omega t \dots \dots \dots (i)$$

$$I = I_m \sin \omega t \dots \dots \dots (ii)$$

From (i) and (ii) we found that v and I are in the same phase.

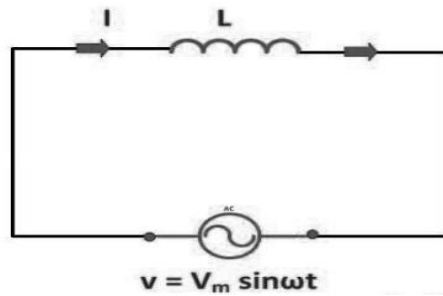


(wave diagram)



(phasor diagram)

AC through pure inductance :



Let,

v = applied voltage in volt.

i = circuit current in amp.

L = inductance in Henry.

V_L = voltage across inductor in volt.

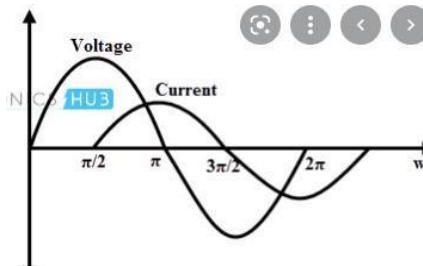
$v = V_m \sin \omega t$ (i)

$i = I_m \sin(\omega t - \pi/2)$ (ii)

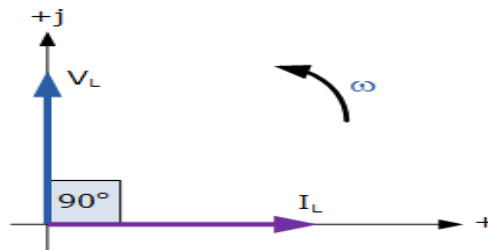
$X_L = \omega L$ = inductive reactance in ohm.

$I_m = V_m / \omega L = V_m / X_L$ = maximum value of current in amp.

From (i) and (ii) we found that current lags behind voltage by an angle 90° or $\pi/2$.

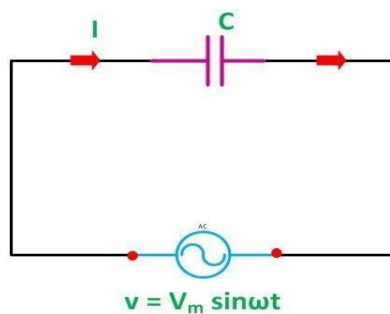


(Wave diagram)



(phasor diagram)

AC through pure capacitance:



Circuit Globe

Let ,

V = applied voltage in volt.

i = current in amp.

c = capacitance in farad.

V_C = voltage drop in capacitor in volt.

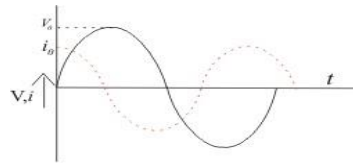
$v = V_m \sin \omega t$ (1)

$i = I_m \sin(\omega t + 90^\circ)$ (2)

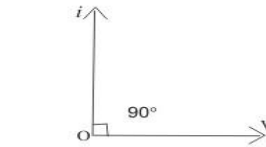
$I_m = V_m / X_C$ = maximum current in amp

$X_C = 1 / \omega c = 1 / 2\pi f c$ = capacitive reactance in ohm.

From (1) and (2) we found that current leads voltage by an angle 90° or $\pi/2$.



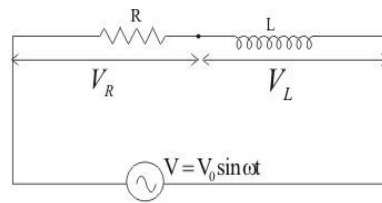
Sinusoidal representation



Phaser diagram representation

2.7 AC through RL , RC and RLC series circuit:

AC through R-L series circuit:



A.C. Circuit containing inductor and an resistor

In above fig,

v = supply voltage in volt.

i = circuit current in amp.

R = Resistance in ohm.

L = Inductance in Henery.

V_R = Voltage drop across R in volt.

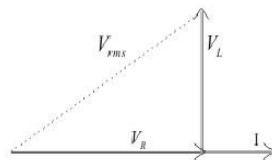
$V_R = IR$

V_L = voltage drop across L in inductor in volt = IX_L

$X_L = \omega L = 2\pi f L$ = inductive reactance in ohm.

For pure resistor I and V_R are in same phase.

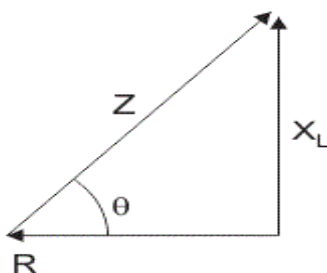
For pure inductor I lags behind V_L by 90° .



Voltage phasor diagram for LR series circuit

ϕ = phase angle between V and I .

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



(Impedance triangle)

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

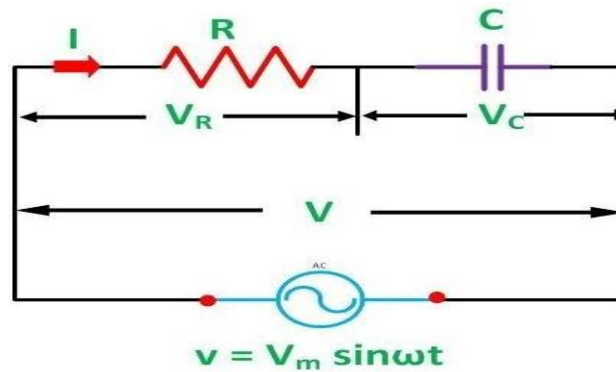
$$Z = R + jX_L$$

Where Z = impedance in ohm.

Impedance (Z): It is the phasor sum of resistance and inductive reactance.

From voltage triangle we see that I lags behind voltage by an angle ϕ .

AC through R-C series circuit :



In above figure,

v = supply voltage in volt.

i = current in amp.

R = resistance in ohm.

C = capacitance in farad.

V_R = voltage drop across R in volt = IR .

V_C = voltage drop across C in volt = IX_C .

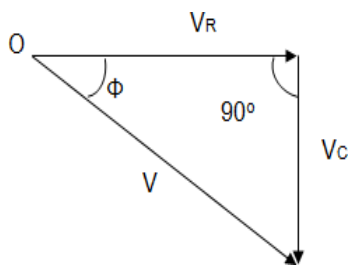
X_C = capacitive reactance in ohm.

$$X_C = 1/2\pi fc = 1/\omega c$$

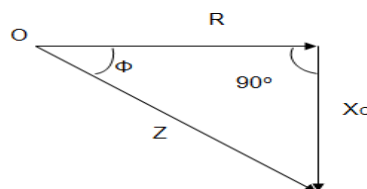
V_R and I are in same phase in a pure resistive circuit.

I and V_C by an angle 90° in a pure capacitive circuit.

Taking I as reference vector.



(Voltage triangle)



(Impedance triangle)

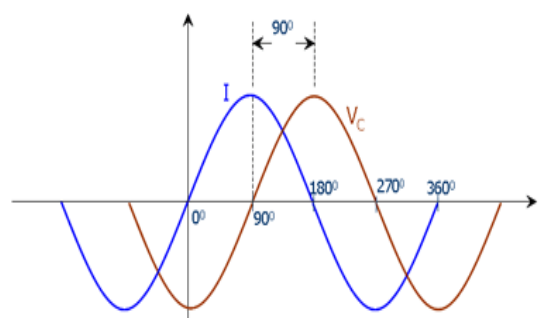
$$Z = R - jX_C$$

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

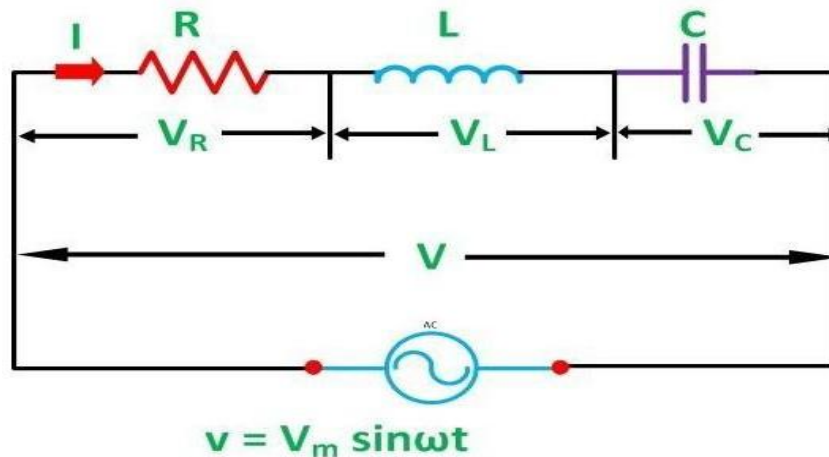
Impedance (Z): Impedance (Z) of an R-C series circuit is the phasor sum of resistance (R) and capacitive reactance (X_C).

From voltage triangle we see that I leads voltage by an angle ϕ .

Hence $i = I_m(\sin \omega t + \phi)$



AC through R-L-C series circuit:



Let,

v = supply voltage in volt.

V_R = potential drop in resistor in volt = IR .

V_L = potential drop in inductor in volt = IX_L

V_C = potential drop in capacitor in volt = IX_C

I = current in the circuit in amp.

R = resistance in ohm

L = Inductance in Henry.

C = Capacitance in Farad.

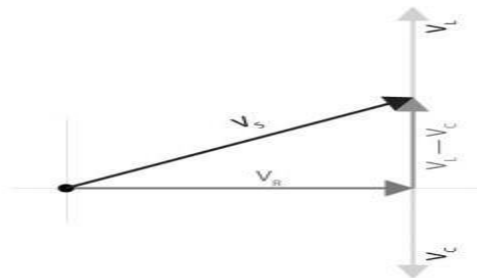
X_C = Capacitive reactance in ohm = $X_C = 1/2\pi fC = 1/\omega C$

X_L = Inductive reactance in ohm = $X_L = \omega L = 2\pi fL$

V_R and I in same phase .

I lags V_L by 90.

I leads V_C by 90.



Voltage triangle for an RLC Series circuit

From above OAB right angle triangle .

$$OB^2 = OA^2 + AB^2$$

$$\Rightarrow V^2 = (IR)^2 + (IX_L - IX_C)^2$$

$$= I^2 R^2 + I^2 X_L^2 + I^2 X_C^2 - 2IX_L IX_C$$

$$= I^2 R^2 + I^2 X_L^2 + I^2 X_C^2 - 2I^2 X_L X_C$$

$$= I^2 (R^2 + X_L^2 + X_C^2 - 2X_L X_C)$$

$$= I^2 [R^2 + (X_L - X_C)^2]$$

$$\Rightarrow V^2 / I^2 = [R^2 + (X_L - X_C)^2]$$

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

$$\Rightarrow Z = R + j(X_L - X_C)$$

$$\Rightarrow Z = \sqrt{R^2 + X^2}$$

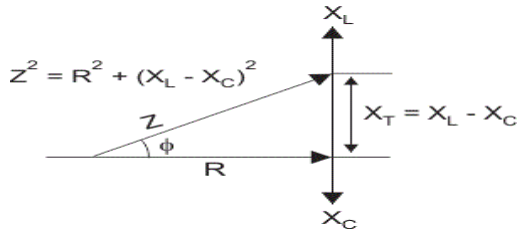
Where ,

Z= Impedance of R-L-C series circuit in ohm.

X= Net reactance of R-L-C series circuit in ohm.

X= $X_L - X_C$

Here impedance is the phasor sum of resistance (R) and net reactance (X) of R-L-C series circuit.



(Impedance triangle)

Circuit behaves

(a) like inductive ,if $X_L > X_C$

(b) like capacitive ,if $X_L < X_C$

So in R-L-C series circuit current lags or leads the supply voltage by angle ϕ .

2.8 Simple problems on RL , RC and RLC series circuits:

Q-1 : A 60 Hz voltage of 115 V (RMS) is impressed on a 100 Ω resistance .(i) Write the time equation for the voltage and the resulting current.Let the zero point of voltage wave be at $t = 0$.(ii) Show the voltage and current on a time diagram (iii) Show the voltage and current on a phasor diagram .

Solution:

Given data:

$f = 60 \text{ Hz}$

$V_{rms} = 115 \text{ V}$

$R = 100 \Omega$

$\phi = 0$

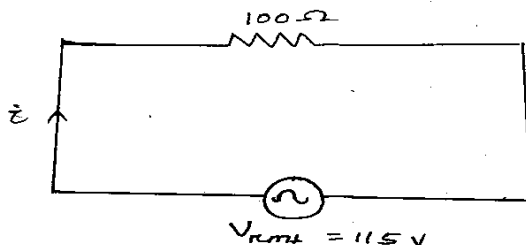
Required data:

(i) Write V and I time equation

(ii) Show V and I time diagram

(iii) Show V and I Phasor diagram

Ans:



(i) We know

$$V_m = V_{rms} \times \sqrt{2} = 115 \times \sqrt{2} = 162.63 \text{ V}$$

$$\omega = 2\pi \times f = 2\pi \times 60 = 376.99 = 377 \text{ rad/s}$$

So the time equation for the voltage ,

$$V(t) = 163 \sin 377t \text{ (Ans)}$$

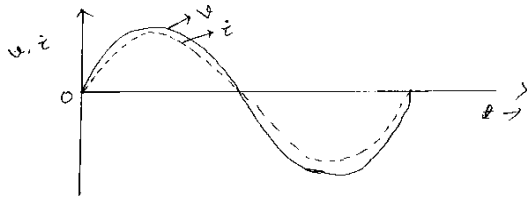
Then we know $i(t) = I_m \sin \omega t$

$$I_m = V_m / R = 163 / 100 = 1.63 \text{ A}$$

So the time equation for the current ,

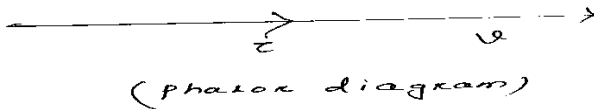
$$i(t) = 1.63 \sin 377t \text{ (Ans)}$$

(ii)



wave diagram or time diagram

(iii)



Q -2 : The reactance of a capacitor at 50 Hz is 5 Ω. If the frequency is increased to 100 Hz .Calculate the new capacitive reactance .

Solution :

Given data:

$$X_C = 5 \Omega$$

$$f = 50 \text{ Hz}$$

$$R = 5 \Omega$$

Required data:

$$X_{C1} = ?$$

Ans:

$$X_C = 1/2\pi fC$$

$$\Rightarrow C = 1/(2\pi f \times X_C)$$

$$\Rightarrow C = 1/(2\pi \times 50 \times 5) = 0.00063 \text{ F}$$

$$X_{C1} = 1/(2\pi \times 100 \times 0.00063) = 0.25 \Omega \text{ (Ans)}$$

Q-3 : A 50 μF capacitor is connected across a 230 V, 50 Hz supply .Calculate (a) the reactance offered by the capacitor (b) the maximum current and (c) the rms value of the current drawn by the capacitor .

Solution:

Given data:

$$C = 50 \mu\text{F} = 50 \times 10^{-6} \text{ F}$$

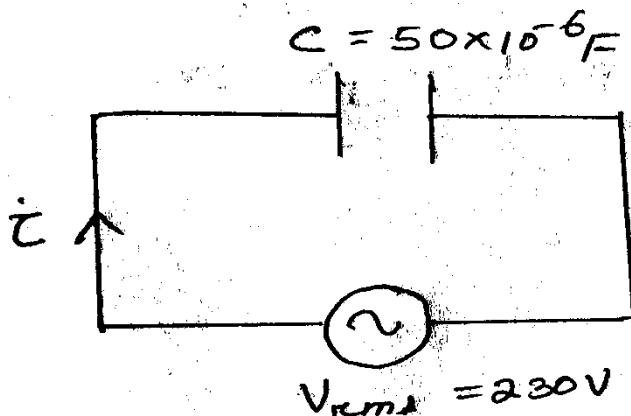
$$V_{\text{rms}} = 230 \text{ V}$$

$$f = 50 \text{ Hz}$$

Required data:

$$(a) X_C = ? \quad (b) I_m = ? \quad (c) I_{\text{rms}} = ?$$

Ans:



We know,

$$(a) X_C = 1/2\pi fc = 1/(2\pi \times 50 \times 50 \times 10^{-6}) = 63.66 \Omega \text{ (Ans)}$$

$$(b) V_m = V_{rms} \times \sqrt{2} = 325.26 \text{ V}$$

$$I_m = V_m / X_C = 325.26 / 63.66 = 5.10 \text{ A (Ans)}$$

$$(c) I_{rms} = I_m / \sqrt{2} = 5.10 / \sqrt{2} = 3.61 \text{ A (Ans)}$$

Q-4 A choke coil takes 4A from AC source of 20V and 50Hz .The power factor of the coil is 0.8 lagging .Find the resistance and inductance of the circuit .

Solution:

Given data:

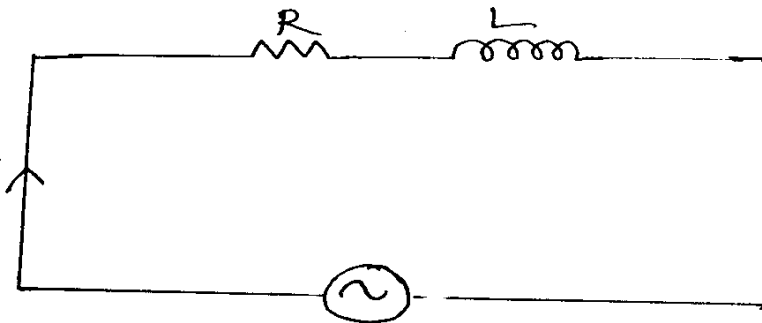
R-L series circuit

$$I = 4 \text{ A}, V = 20 \text{ V}, f = 50 \text{ Hz}, \text{ pf} = 0.8 \text{ (lagging)}$$

Required data:

$$(a) R = ? \quad (b) L = ?$$

Ans:



$$(a) \text{ we know } Z = V/I = 20/4 = 5 \Omega,$$

$$\cos \theta = R/Z \Rightarrow R = Z \cos \theta = 5 \times 0.8 = 4 \Omega \text{ (Ans)}$$

$$Z^2 = R^2 + X_L^2$$

$$\Rightarrow 5^2 = 4^2 + X_L^2$$

$$\Rightarrow X_L^2 = 25 - 16$$

$$\Rightarrow X_L = \sqrt{9} = 3 \Omega \text{ (Ans)}$$

$$X_L = \omega L = 2\pi fL$$

$$\Rightarrow L = X_L / 2\pi f = 3 / (2\pi \times 50) = 0.0095 \text{ H (Ans)}$$

Q-5 A pure resistance of 50Ω is in series with a pure capacitance of 100μF. The series combination is connected across 100V, 50Hz supply. Find (a) the impedance (b) current (c) power factor (d) phase angle (e) voltage across resistor (f) voltage across capacitor.

Solution:

Given data:

$$V = 100 \text{ V}$$

$$f = 50 \text{ Hz}$$

$$C = 100 \mu\text{F} = 100 \times 10^{-6} \text{ F}$$

$$R = 50 \Omega$$

$$C = 100 \mu\text{F} = 100 \times 10^{-6} \text{ F}$$

Required data:

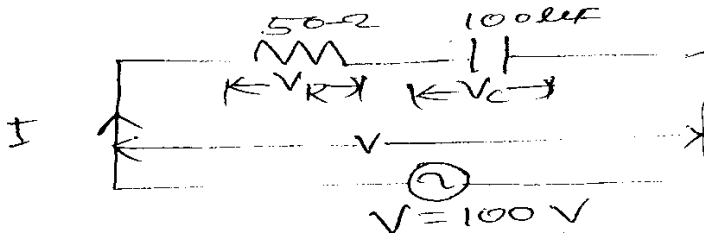
$$(a) Z = ?$$

$$(b) I = ?$$

$$(c) \text{ pf} = ?$$

- (d) $\phi=?$
 (e) $V_R=?$

Ans:



We know,

$$X_C = 1/2\pi fC = 1/(2\pi \times 50 \times 100 \times 10^{-6}) = 31.83 \Omega$$

(a) $Z = \sqrt{R^2 + X_C^2} = \sqrt{50^2 + 31.83^2} = 59.27 \Omega$ (Ans)

(b) $I = V/Z = 100/59.27 = 1.687 \text{ A}$ (Ans)

(c) $p.f = R/Z = 50/59.27 = 0.843$ (Lead) (Ans)

(d) $\phi = \cos^{-1}(0.843) = 32.54^\circ$ (Ans)

(e) $V_R = IR = 1.687 \times 50 = 84.35 \text{ V}$ (Ans)

(f) $V_C = IX_C = 1.687 \times 31.83 = 53.69 \text{ V}$ (Ans)

Q-6 A series circuit consists of resistance of 10Ω and inductive reactance of 50Ω and capacitive reactance of 30Ω . It is connected to a $230\text{V}, 50\text{Hz}$ ac supply. calculate (i) the current (ii) active and reactive power consumed (iii) power factor (iv) apparent power of the circuit .

Solution:

Given data:

R-L-C series circuit (i) $I=?$

$R=10\Omega$

$X_L=50\Omega$

$X_C=30\Omega$

$V=230\text{V}$

$f=50\text{Hz}$

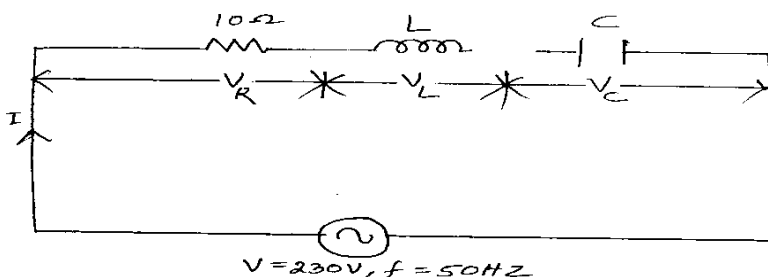
Ans:

Required data:

(ii) $\cos\phi=?$

(iii) $P=?$ and $Q=?$

(iv) $S=?$



We know,

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{10^2 + (50 - 30)^2} = \sqrt{100 + 400} = \sqrt{500} = 22.36 \Omega$$

(i) $I = V/Z = 230/22.36 = 10.28 \text{ A}$ (Ans)

(ii) $\cos\phi = R/Z = 10/22.36 = 0.44$ (lagging) (Ans)

$\phi = \cos^{-1}(0.44) = 63.89^\circ$

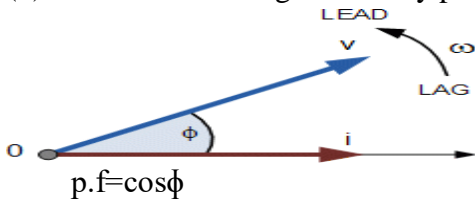
(iii) Active power, $P = VI\cos\phi = 230 \times 10.28 \times 0.44 = 1040.33 = 1.043 \text{ KW}$ (Ans)

Reactive power , $Q=VI \sin\phi=230\times 10.28\times \sin 63.89=2123.11 \text{ VAR}=2.123 \text{ KVAR (Ans)}$

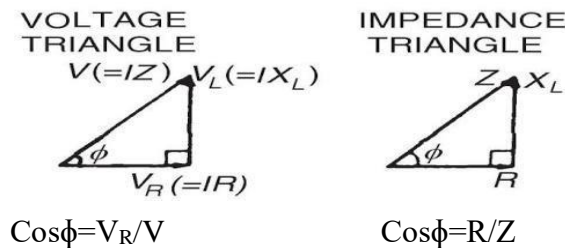
(iv) Apparent power , $S = \sqrt{P^2+Q^2}=\sqrt{1.043^2+2.123^2}=2.36 \text{ KVAR(Ans)}$

2.9 Concept of power and Power factor (p.f): Power factor can be defined as follows :

(1) It is the cosine angle made by phase voltage and phase current.



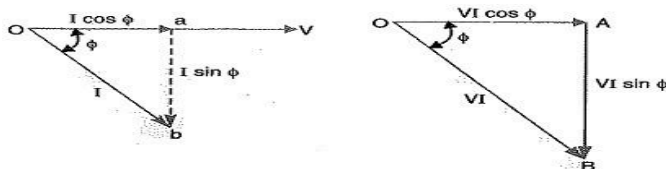
(2)p.f: It is the ratio of resistance to impedance.



Power in A.C circuit:

Power (p) is known to be three types

- (i) Active power or real power or actual power.
- (ii) Reactive power or virtual power .
- (iii) Total power or apparent power.



Active power(p): It is the product of voltage and active component of current .

$P=V I \text{ COS}\phi$

Its unit is watt,kilowatt,megawatt in SI unit.

Reactive power (Q): It is the product of voltage and reactive component of current .

$Q= VI \sin \phi.$

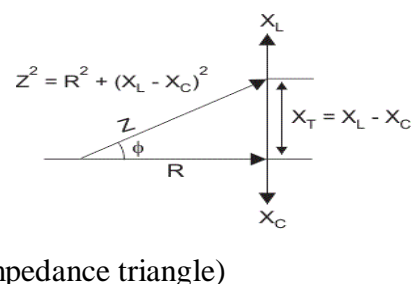
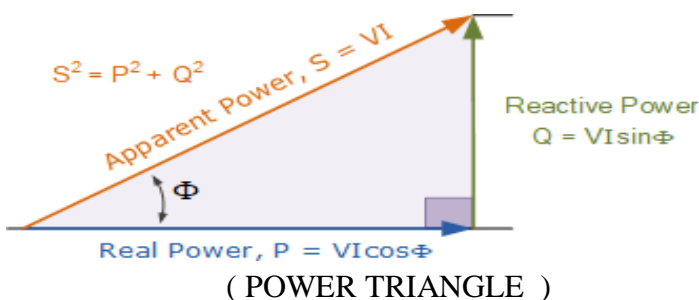
Its unit is VAR,KVAR,MVAR in SI system.

Apparent power (S): It is the product of voltage and current.

$S= V I.$

Its unit is VA,KVA,MVA in SI system.

2.10 Impedance triangle and power triangle:



SHORT QUESTIONS WITH ANSWER:

Q-1 Define AC current.

Ans: The type of current in which magnitude and direction changes with time periodically is called as AC.

Q-2 Define frequency. (S-18)

Ans: The number of cycles per second is called the frequency of the alternating current.

Q-3 Define amplitude . (W-17)

Ans: The maximum value of positive or negative o an alternating quantity is known as its amplitude or peak value or crest value.

Q-4 Define time period .

Ans: Time taken by an alternating quantity to complete one cycle is called time period .

Q-5 Define form factor . (S-18,19)

Ans: It is defined as the ratio of rms value to average value of an alternating quantity .

Q-6 Define Amplitude factor or crest factor . (S-18,19)

Ans: It is defined as the ratio of maximum value to rms value of an alternating quantity.

Q-7 Define impedance.

Ans: It is the phasor sum of resistance and net reactance of the R-L-C series circuit.

Q-8 Define power factor. (S-19, W-19)

Ans: It is the cosine of angle made by phase voltage and phase current.

$$\cos\phi = \frac{R}{Z}$$

Q-9 Define active power.

Ans: It is the product of voltage and active component of current.

$$P=VI\cos\phi, W$$

Q-10 Define reactive power.

Ans: It is the product of voltage and reactive component of current.

$$Q=VI\sin\phi, VAR$$

Q-11 Define apparent power .

Ans: It is the product of voltage and current .

$$S=VI, VA$$

LONG QUESTIONS:

Q-1 Write the difference between AC and DC. (W-19)

Q-2 : A 60 Hz voltage of 115 V (RMS) is impressed on a 100 Ω resistance .(i) Write the time equation for the voltage and the resulting current.Let the zero point of voltage wave be at t =0 .(ii) Show the voltage and current on a time diagram (iii) Show the voltage and current on a phasor diagram .

Q-3 The reactance of a capacitor at 50 Hz is 5 Ω .If the frequency is increased to 100 Hz .Calculate the new capacitive reactance .

Q-4 A 50 μ F capacitor is connected across a 230 V, 50 Hz supply .Calculate (a) the reactance offered by the capacitor (b) the maximum current and (c) the rms value of the current drawn by the capacitor.

Q-5 A series circuit consists of resistance of 10 Ω and inductive reactance of 50 Ω and capacitive reactance of 30 Ω .It is connected to a 230V,50Hz ac supply. calculate (i) the current(ii) active and reactive power consumed (iii) power factor(iv)apparent power of the circuit .

Q.6 Explain a.c through R-C series circuit. (S-18,19)

Q.7 Explain a.c through R-C series circuit. (S-18)

CHAPTER-3

GENERATION OF ELECTRICAL POWER

Learning Objectives:

3.1 Give elementary idea on generation of electricity from thermal , hydro & nuclear power station with block diagram.

Power plant :

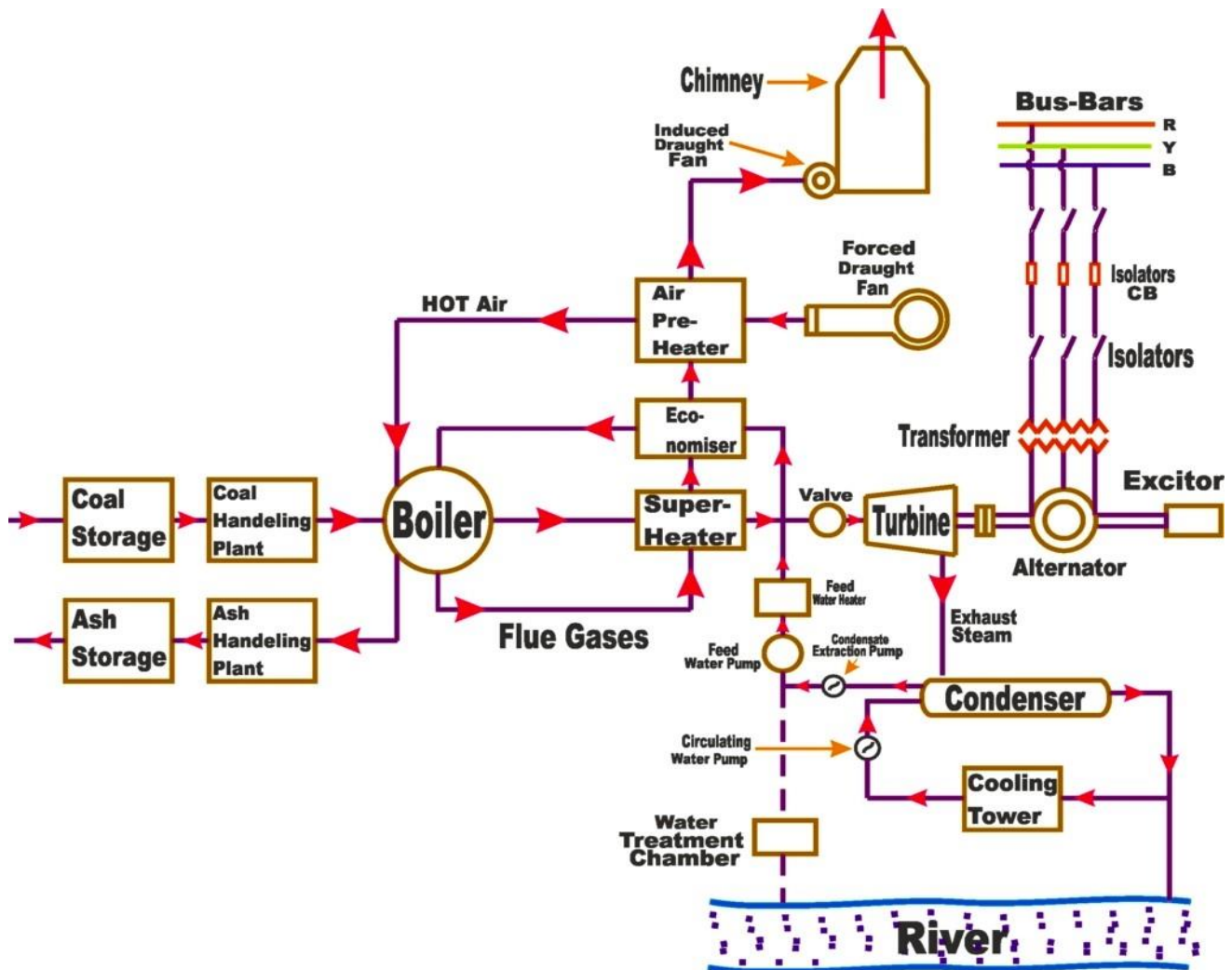
Bulk electric power is produced by special plants known as generating stations or power plants.

1. Steam power station (thermal station)
2. Hydro-electric power station
3. Nuclear power station

3.1 Generation of electricity from thermal power station:

A generating station which converts heat energy of coal combustion into electrical energy is known as a steam power station .

SCHMATIC ARRANGEMENT OF STEAM POWER STATION



Working of Thermal power Plant :

In thermal power plant ,coal, hot air, hot water taken into boiler. The coal are burnt in the boiler which converts hot water into high pressure steam. This high pressure steam, super heated in the super heater by flue gases. Now superheated high pressure steam passed through valve into the turbine blade ,so steam turbine blade rotate .Then turbine able to rotate the alternator ,because turbine shaft and alternator shaft coupled with each other .So the electrical power /energy produced in the alternator .The alternator energy is supplied to bus bar through circuit breaker.

ADVANTAGES :

- The Fuel (i.e. Coal) used is quite cheap.
- Less initial cost as compared to other generating stations.
- It can be installed at any place & the coal can be transported by Rail /Road.
- It requires less space as compared to hydro-electric PowerStation.

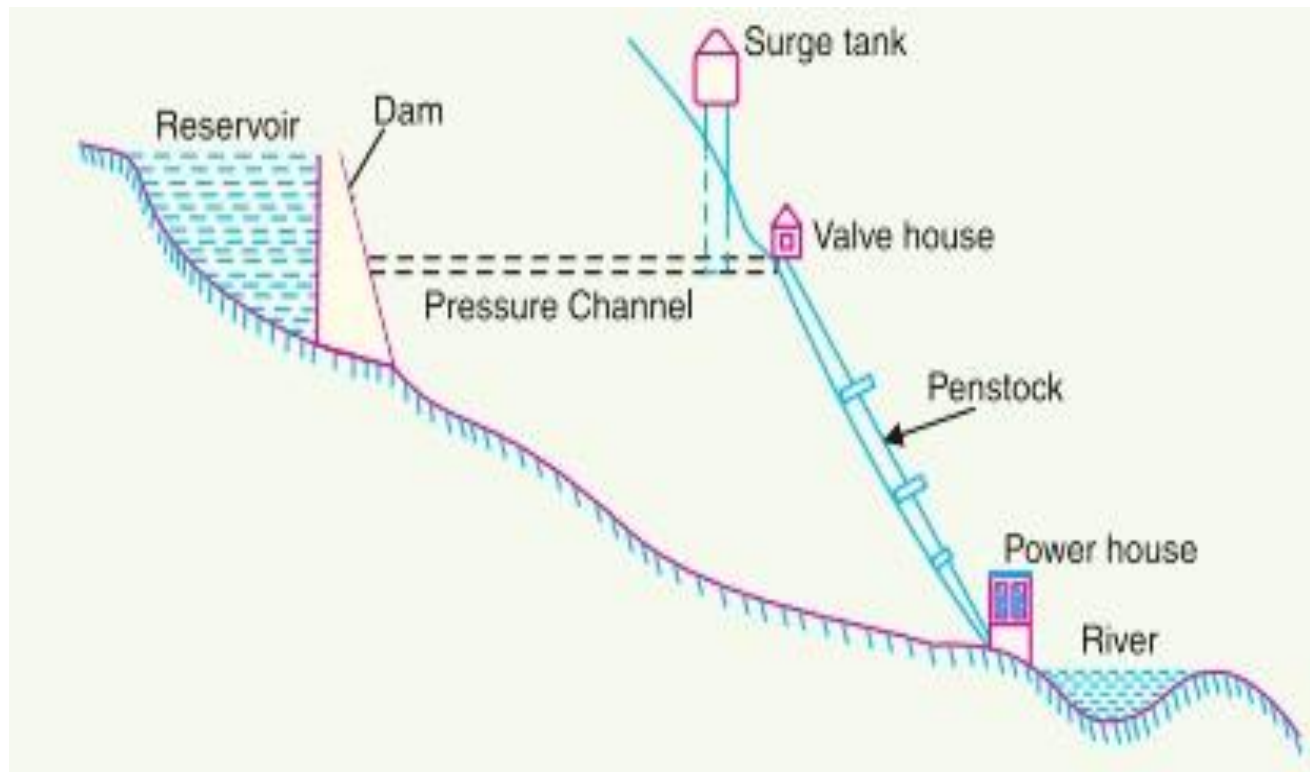
DISADVANTAGES

- It pollutes air / atmosphere due to smoke /fumes.
- Running cost is higher than hydro power plant.

3.1 Generation of electricity from Hydro-electric power station:

A generating station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as a hydro-electric power station.

SCHMATIC ARRANGEMENT OF HYDROELECTRIC POWER PLANT:



Working of Hydro-Electric Power Plant :

In hydroelectric power plant ,water stores in a reservoir by constructed a dam across a river or lake. Then water passed through surge tank and valve house by pressure channel to the penstock. From penstock water strikes water turbine blade ,hence turbine rotate .Once water turbine, alternator rotate. So the electrical energy produced in the alternator.

ADVANTAGES :

- It requires no fuel as water is used for the generation of Electrical Energy.
- It is quite neat & clean as no smoke or ash is produced.
- Running cost is very less as water is used.
- It is simple in construction & requires less maintenance.
- It can be started quickly as compared to Thermal Power Station.
- In addition to generation of Electrical Energy these plants are also helpful in irrigation & control of floods.

DISADVANTAGES

- It involves high capital cost due to construction of dams.
- Generation depends on average rainfall round the year.
- High cost of transmission as these plants are located in hilly areas quite far from localities.

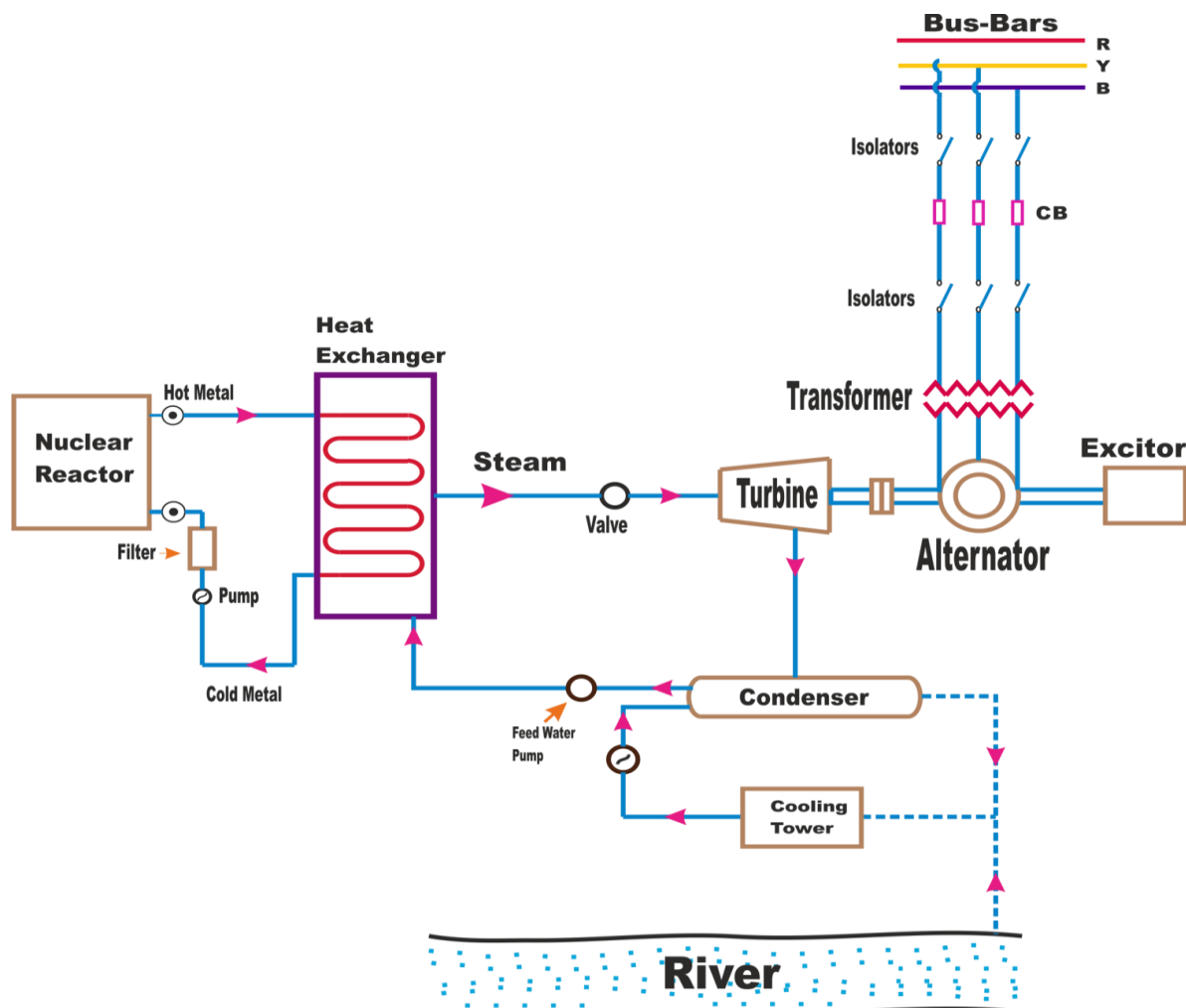
3.1 Generation of electricity from Nuclear power station:

A generating station in which nuclear energy is converted into electrical energy is known as a nuclear power station.

NUCLEAR FUEL

- I. URANIUM(U^{235})
- II. PLUTONIUM(Pu^{239})
- III. THORIUM(Th^{232})

SCHEMATIC ARRANGEMENT OF NUCLEAR POWER STATION :



Working of Nuclear PowerPlant:

In nuclear power station ,radio active elements such as Uranium (U) or Thorium (Th) are subjected to nuclear fission in a special apparatus known as a reactor. The heat energy thus released in nuclear reactor utilized in producing steam ,by heat exchanger at high pressure steam strikes the stem turbine blade which converts steam energy into mechanical energy. The turbine drives the alternator ,which converts mechanical energy into electrical energy.

ADVANTAGES :

- There is saving in fuel transportation as amount of fuel required is less.
- A Nuclear Power Plant requires less space as compared to other plants.
- This type of plant is economical for producing bulk Electrical Energy.

DISADVANTAGES :

- Fuel is expensive and difficult to recover.
- Capital lost is higher than other plants.
- Experienced workman ship is required for plant erection &commissioning.
- The Fission by-products are radio active & can cause dangerous radio-active pollution. The disposal of by-product is big problem.

Short questions with answer:

Q-1 Write down the function of superheater.

Ans- Overall efficiency is increased.

Too much condensation in the last stage of turbine is avoided.

Q-2 Write the function of economizer.(W-17)

Ans: It is a feed water heater to the boiler.

It increases the feed water temperature.

Q-3 Write down the function of air preheater. (S-19)

Ans: It increases the temperature of the air supplied for coal burning by deriving heat from flue gases.

It increases the thermal efficiency.

It increases the steam capacity per square metre of boiler surface.

Q-4 Write down the function of penstocks.

Ans: Penstocks are open or closed conduits which carry water to the turbine.

Q-5 Write the function of surge tank . (W-20)

Ans: It protects the penstocks from over load and low load condition.

Q-6 Write the function of spillways .

Ans: In order to discharge the surplus water from the storage reservoir into the river on the down stream side of the dam ,spillways are used.

Q-7 Write down the function of dam.

Ans: A dam is a barrier which stores water and creates water head.

Q-8 Write down the fuel name of nuclear power station .

Ans: Uranium (U^{235}) and Thorium (Th^{232}).

Q-9 Write down the function of condensers .

Ans: A condenser is a device which condenses the steam at the exhaust of turbine.

It creates low pressure at the exhaust of turbine thus permitting expansion of the steam in the prime mover to a very low pressure.

Condensed steam can be used as feed water to the boiler .

Q-10 Write down the types of steam turbines used as prime mover in steam power station.

Ans: There are two types of steam turbine used in a power station that is impulse turbine and reaction turbine.

Q-11 Write down the name of control rod used in a nuclear power plant.

Ans: The name of control rod used in a nuclear power plant is cadmium.

Q-12 Write down the function of control rod .

Ans: Cadmium is strong neutron absorber and thus regulates the supply of neutrons for fission.

Q-13 Write down the name of coolant used in a nuclear power plant.

Ans: The name of coolant used in a nuclear power plant is sodium metal.

Q-14 Write down the name of moderator used in a nuclear power plant.

Ans: The moderator used in a nuclear power plant is graphite.

Long questions:

Q-1 Explain with neat sketch about Thermal power plant.(S-18)

Q-2 Explain with neat sketch about Hydroelectric power plant. (W-17, S-19)

Q-3 Explain with neat sketch about nuclear power plant.(S-18, W-19, S-19)

CHAPTER 4.0

CONVERSION OF ELECTRICAL ENERGY

Learning Resources:

4.1 Introduction of DC machines.

4.2 Main parts of DC machines.

4.3 Classification of DC generator

4.4 Classification of DC motor.

4.5 Uses of different types of DC generators & motors.

4.6 Types and uses of single phase induction motors.

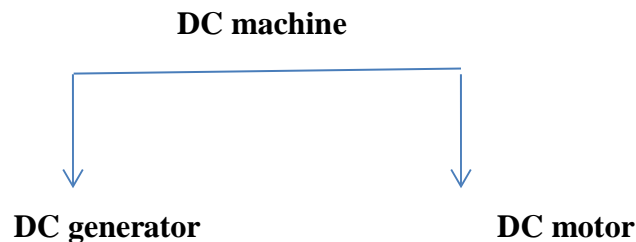
4.7 Concept of Lumen

4.8 Different types of Lamps (Filament, Fluorescent, LED bulb) its Construction and Principle.

4.9 Star rating of home appliances (Terminology, Energy efficiency, Star rating Concept)

4.1 Introduction of DC machines.

The electromagnetic system is an essential element of all rotating electrical machines and electrochemical devices as well as static devices like the transformer. Practically all electric motors and generators, ranging in size from fractional kilowatt power units found in domestic appliances to the several thousand kW motors used in heavy industries and several hundred MW generators installed in generating stations.



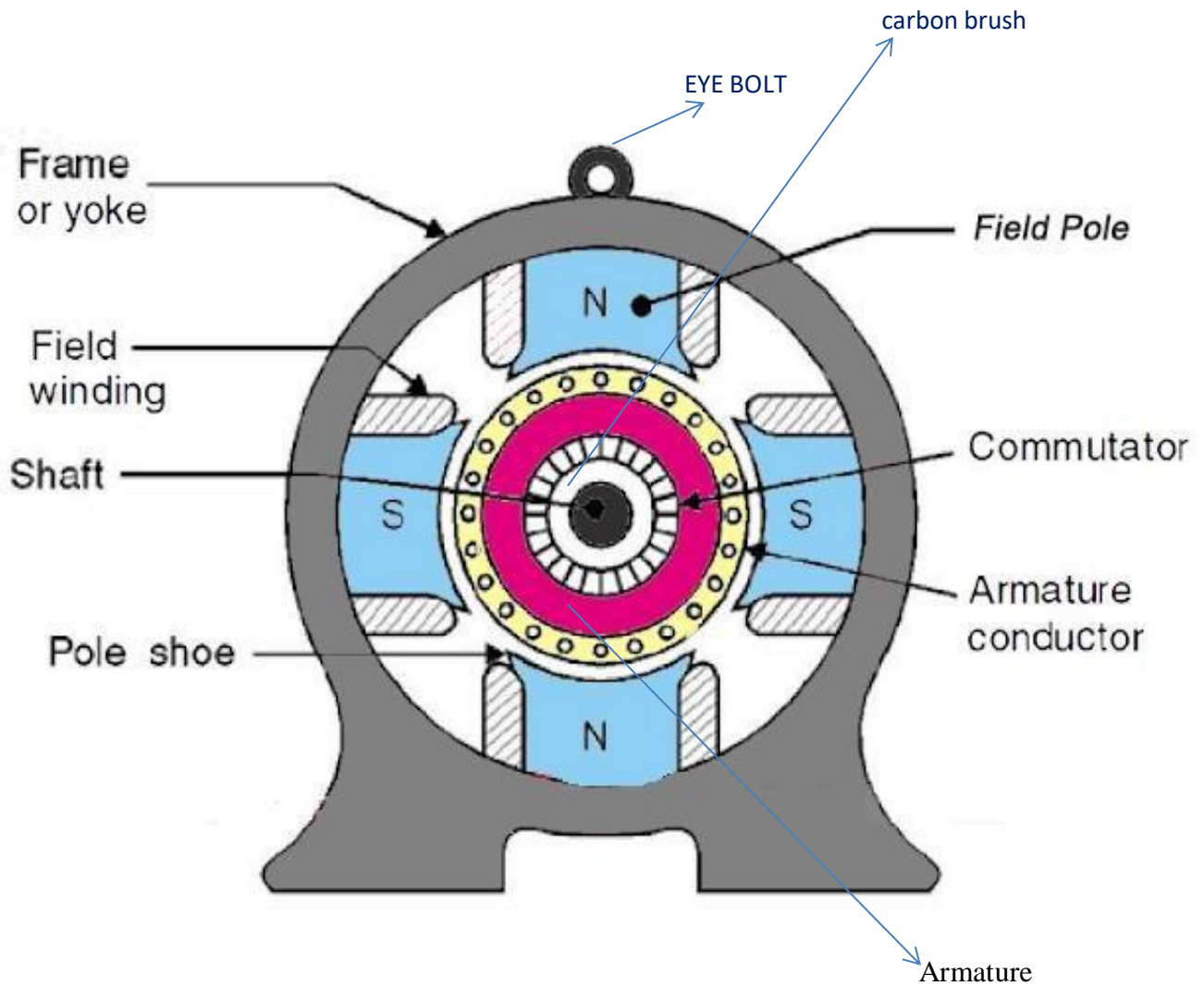
DC generator : It is defined as a DC electrical machine which converts mechanical energy into electrical energy .

DC generator principle: It based on the principle of dynamically induced emf.

DC motor: It is defined as DC electrical machine which converts electrical energy into mechanical energy .

DC motor principle: It works under the principle that “ Whenever a current carrying conductor is placed in a magnetic field then a mechanical force is experienced by the conductor “.

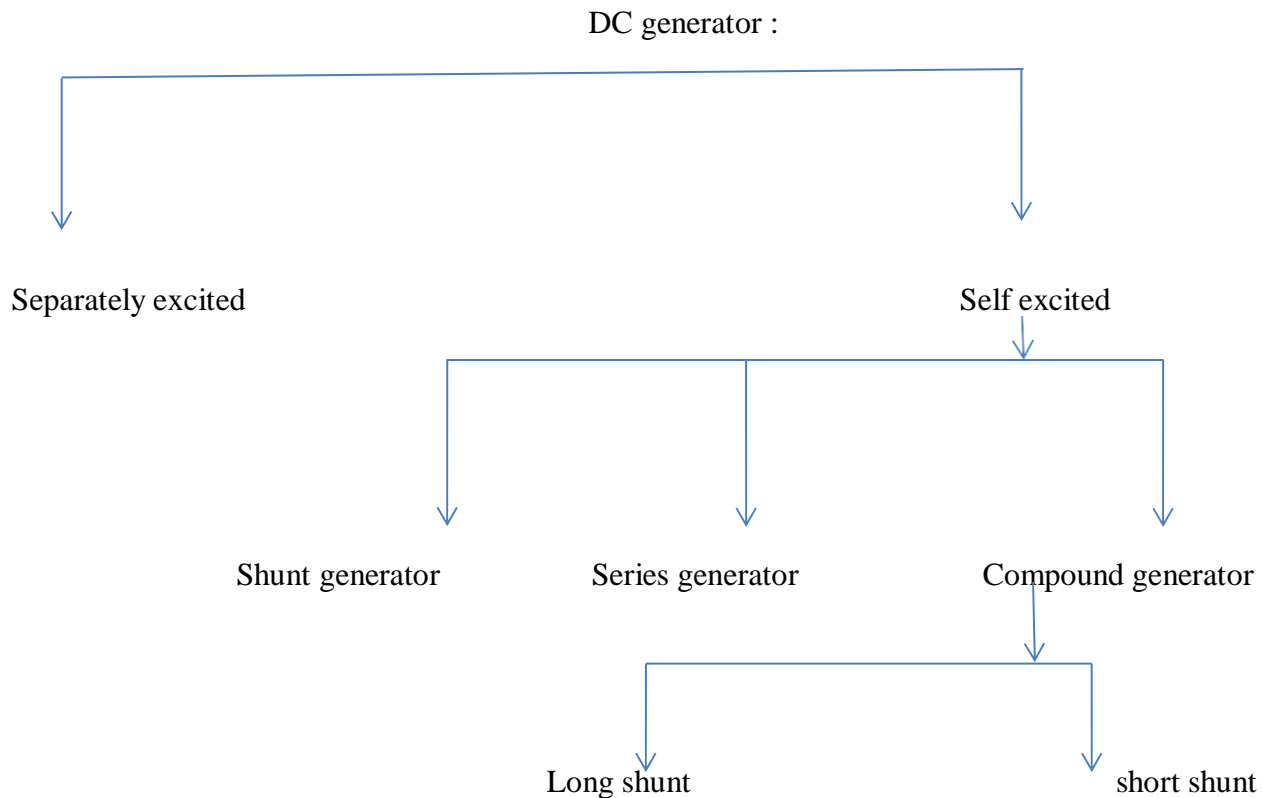
4.2 Main parts of DC machines:



Following are the important parts of a DC machine,

- Eye bolt
- Yoke
- Field winding
- Pole shoes
- Field pole
- Armature conductors and windings
- Armature
- Commutator
- Carbon brush

4.3 Classification of DC generator:



Separately excited DC Generator: If field windings of a DC generator are excited by some external DC source then it is called as separately excited DC generator.

Self excited DC generator: If the field windings of a DC generator are excited or energized by the current produced of its own then it is said to be self excited DC generator.

DC shunt generator: If field windings of a self excited DC generator are connected in parallel then it is called as DC shunt generator .

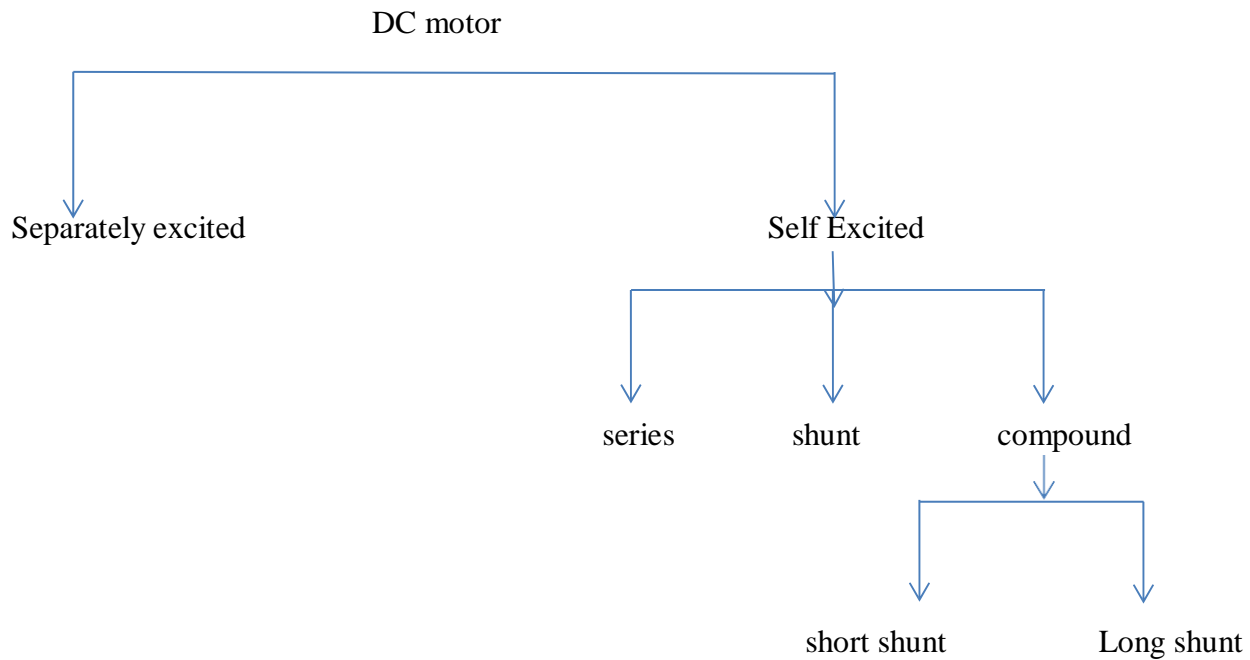
DC series generator: If the field windings of a self excited DC generator are connected in series then it is called as DC series generator .

DC compound generator : In a self excited DC generator ,if shunt field windings are simultaneously used then it is called as DC compound generator .

Long shunt compound generator: In a compound generator if shunt field winding is connected across both the series field and armature winding then it is called as long shunt compound generator .

Short shunt compound generator: If shunt field winding of a compound generator is connected across the armature only leaving the series field then it is called as short shunt compound generator.

4.4 Classification of DC motor:



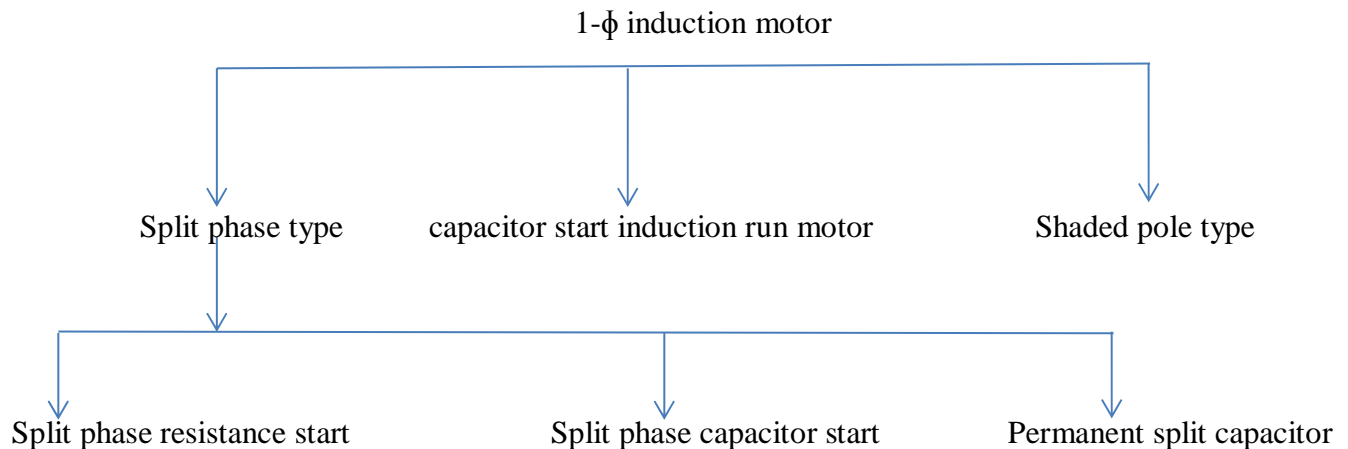
4.5 Uses of different types of DC generators:

Name of DC generator	Applications
Series generator	<ul style="list-style-type: none">➤ Ordinary lighting and power supply purposes.➤ Charging batteries.
Shunt generator	<ul style="list-style-type: none">➤ Booster➤ Railway distribution systems
Compound generator	<ul style="list-style-type: none">➤ Electric railways.➤ Motor drives.➤ Arc weldings

4.5 Uses of different types DC motors:

Name of DC motor	Applications
Shunt motor	<ul style="list-style-type: none">➤ Centrifugal pumps.➤ Machine tools.➤ Blowers and fans.➤ Reciprocating pumps.
Series motor	<ul style="list-style-type: none">➤ Electric locomotives.➤ Rapid transit system.➤ Cranes and hoists.➤ Trolley cars.➤ Conveyors
Compound motor	<ul style="list-style-type: none">➤ Shears and punches.➤ Elevators.➤ Rolling mills.➤ Ice machines.➤ Air compressors.➤ Printing press.

4.6 Types of single phase (1- ϕ) induction motors:



4.6 Uses of single phase (1- ϕ) induction motor:

Name of single phase induction motor	Uses
Split phase resistance start induction motor.	<ul style="list-style-type: none">➤ Blower➤ Centrifugal pumps➤ Washing machine➤ Small machine tools➤ Small domestic refrigerator
Split phase capacitor start induction motor	<ul style="list-style-type: none">➤ Compressor➤ Washing machine➤ Air conditioner➤ Refrigerator
Permanent split capacitor induction motor	<ul style="list-style-type: none">➤ Ceiling fan➤ Table fan➤ Pedestal fan➤ Exhaust fan➤ Water pumps

4.7 Concept of Lumen: It is the product of candle power and solid angle.

$$\text{lumens} = \text{candle power} \times \text{solid angle}$$

$$= C.P \times \omega$$

Candle power: Candle power of a source is the number of lumens emitted in a unit solid angle in a given direction.

or

It is defined as the number of lumens per unit solid angle.

$$C.P = \text{Lumens} / \omega$$

Solid angle(ω): A solid angle(ω) is subtended at a point in space by an area and is the angle enclosed in the volume formed by an infinite number of lines lying on the surface of the volume and meeting at a point.

$$\text{Solid angle, } \omega = \text{Area} / (\text{Radius})^2 = A/R^2$$

Solid angle is represented in steradian.

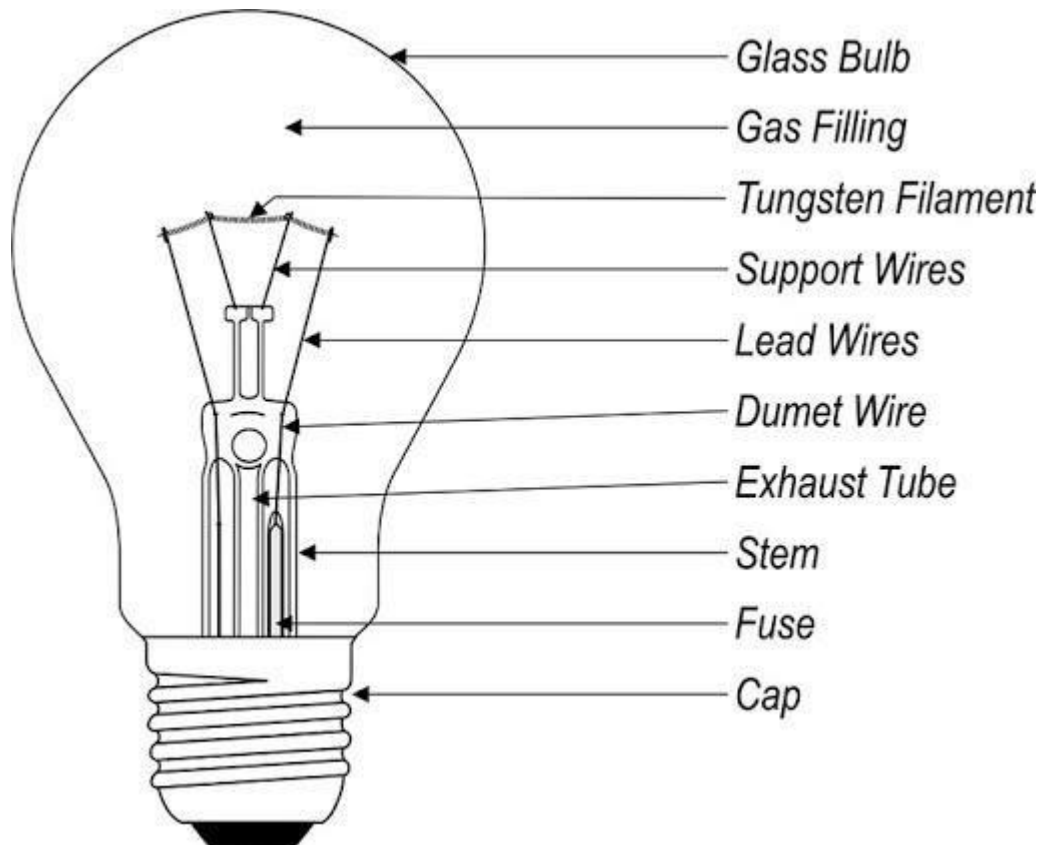
4.8 Different types of lamps:

- Filament lamps
- Florescent lamp
- LED bulb

Filament lamp:

Principle: Filament lamp work on the principle of incandescence.

Construction:

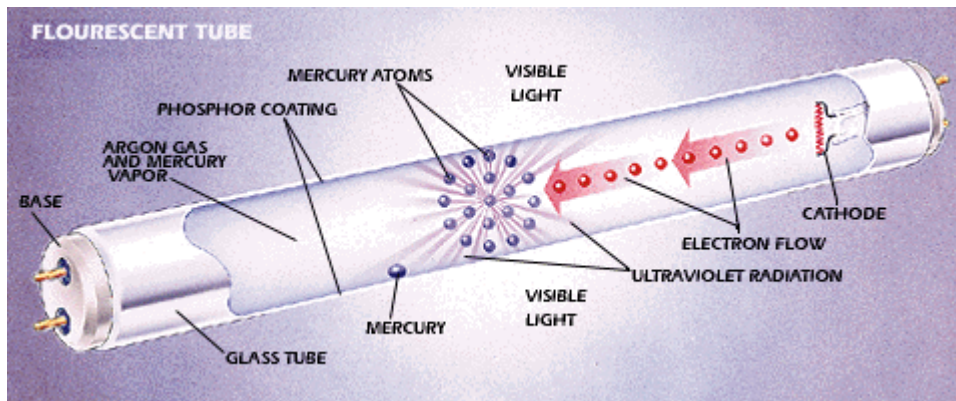


One glass bulb holds the filament inside it. The lamp has a metal cap. This metal cap provides the electrical connectivity to the filament from an external electrical circuit. This cap also helps the holder to hold the lamp. In the vacuum type variant, the air is sucked out from the bulb. But in the gas-filled variant we fill the bulb with argon or nitrogen like inert gases.

Florescent lamp:

principle: Florescent lamp work on the principle of florescence.

Construction:



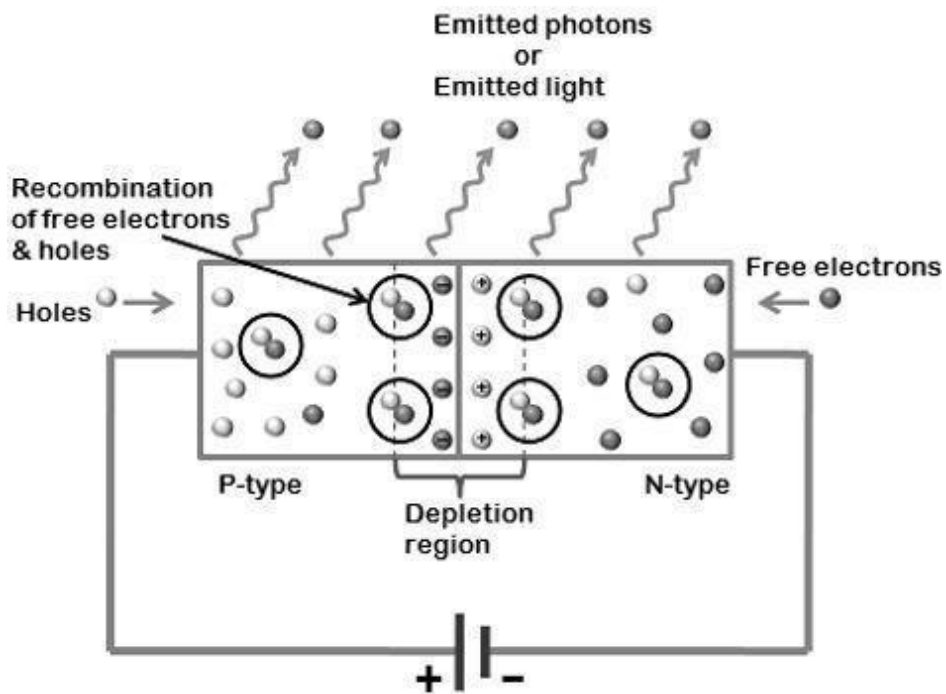
A fluorescent tube light consists of

1. a lime glass tube
2. drop of mercury
3. argon gas
4. phosphor coating
5. electrode coils(cathode)
6. mounting assemblies
7. aluminum cap(base)

LED(Light emitting diode):

Principle: It works under the principle of P-N junction diode.

Construction:



The semiconductor material used in LED is Gallium Arsenide (GaAs), Gallium Phosphide (GaP) or Gallium Arsenide Phosphide (GaAsP). Any of the above-mentioned compounds can be used for the construction of LED, but the colour of radiated light changes with the change in material. Below are some of the material and their respective colour of light which they emit. In addition to it, the ranges of typical forward voltage are also given below.

4.9 Star rating of Home appliances:

A home appliance, domestic appliance or household appliance, is a machine which assists in household functions such as cooking, cleaning and food preservation.

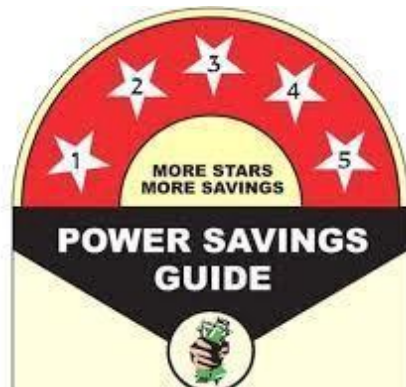
Examples: Refrigerator, toaster, kettle, microwave, air conditioner, washing machine, cloth washers etc.

Energy efficiency:

- It is defined as energy service per unit of energy consumption.
- Energy efficiency simply means using less energy to perform the same task – that is, eliminating energy waste.
- Energy efficiency brings a variety of benefits: reducing greenhouse gas emissions, reducing demand for energy imports, and lowering our costs on a household and economy-wide level.

Star rating concept:

- An energy efficiency rating scheme for Electrical appliances is known as Star labeling.
- Star Rating is the average amount of electricity used by the equipment in a year i.e kWh/year or unit/year under standard test conditions.
- Star ratings are provided to all the major kind of appliances in the form of labels. These star ratings are given out of 5 and they provide a basic sense of how energy efficient each product is.
- The star rating system was devised by the Bureau of Energy Efficiency (BEE) India, with a range of 1 to 5 stars. This system ensured that the energy efficiency of appliances was easily understood by the common man.



Short questions with answer:

Q-1 Write down the various parts of dc machines. (W-16,17,18)

Ans: The various parts of dc machines are :

- Eye bolt
- Yoke
- Field winding
- Pole shoes
- Field pole
- Armature conductors and windings
- Armature
- Commutator
- Carbon brush

Q-2 Write down the name of DC generator which is used as charging of batteries.

Ans: DC series generator.

Q-3 Write down the name of DC generator which is used as booster.

Ans: DC shunt generator.

Q-4 Write down the DC motor which is used as a reciprocating pumps.

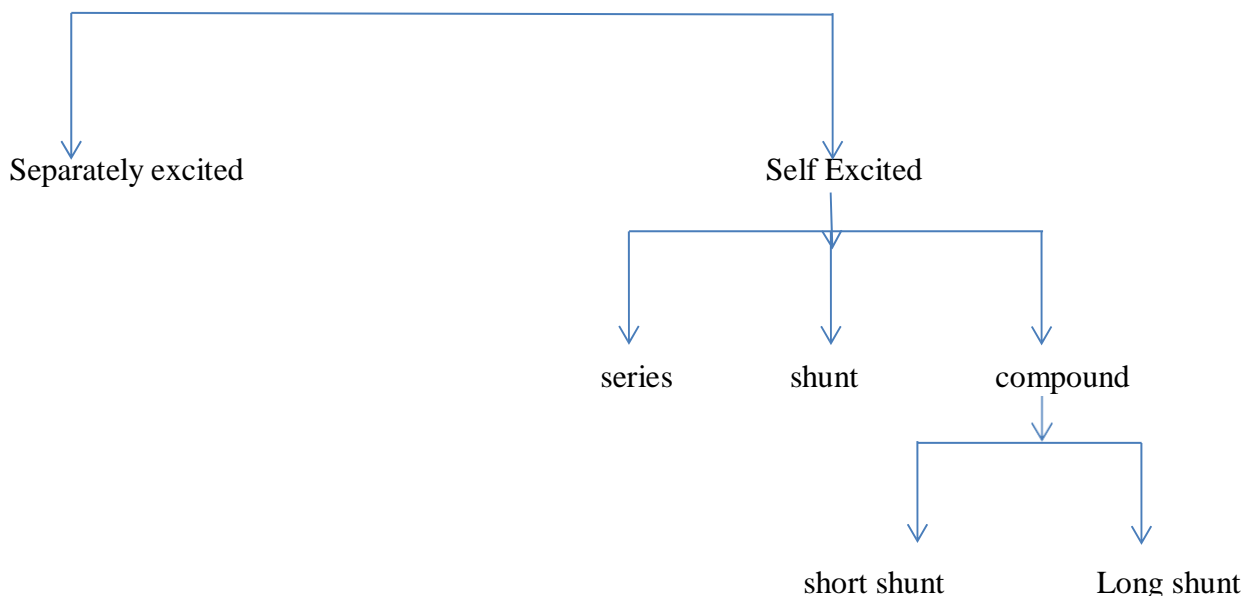
Ans: DC shunt motor.

Q-5 Write down the name of single phase induction motor which is used as a ceiling fan.

Ans: Permanent split capacitor induction motor.

Q.6 State different types of D.C motor. (S-18)

DC motor



Q.7 Why Commutator is used in D.C machines? (S-18)

Ans: Commutator is used in D.C machines because it converts a.c to d.c in d.c generator and d.c to a.c in d.c motor.

LONG QUESTIONS:

Q-1 Write down the classification of dc generator.

Q-2 Write down the types and uses of single phase induction motor.

Q-3 Draw the constructional features of Fluorescent lamps.

Q-4 Write the classification of DC motor with circuit diagram .(W-17)

CHAPTER - 5

WIRING AND POWER BILLING

Learning Resources:

5.1 Types of wiring for domestic installations.

5.2 Layout of household electrical wiring (single line diagram showing all the important component in the system).

5.3 List out the basic protective devices used in house hold wiring.

5.4 Calculate energy consumed in a small electrical installation.

Electrical wiring:

Electrical wiring is an electrical installation of cabling and associated devices such as switches, distribution boards, sockets, and light fittings in a structure.

5.1 Types of wiring for domestic installations.

Following are the types of internal wiring usually employed in industries and house wiring:

1. Cleat wiring
2. Wooden casing and capping wiring
3. T.R.S or Batten wiring
4. Conduit wiring

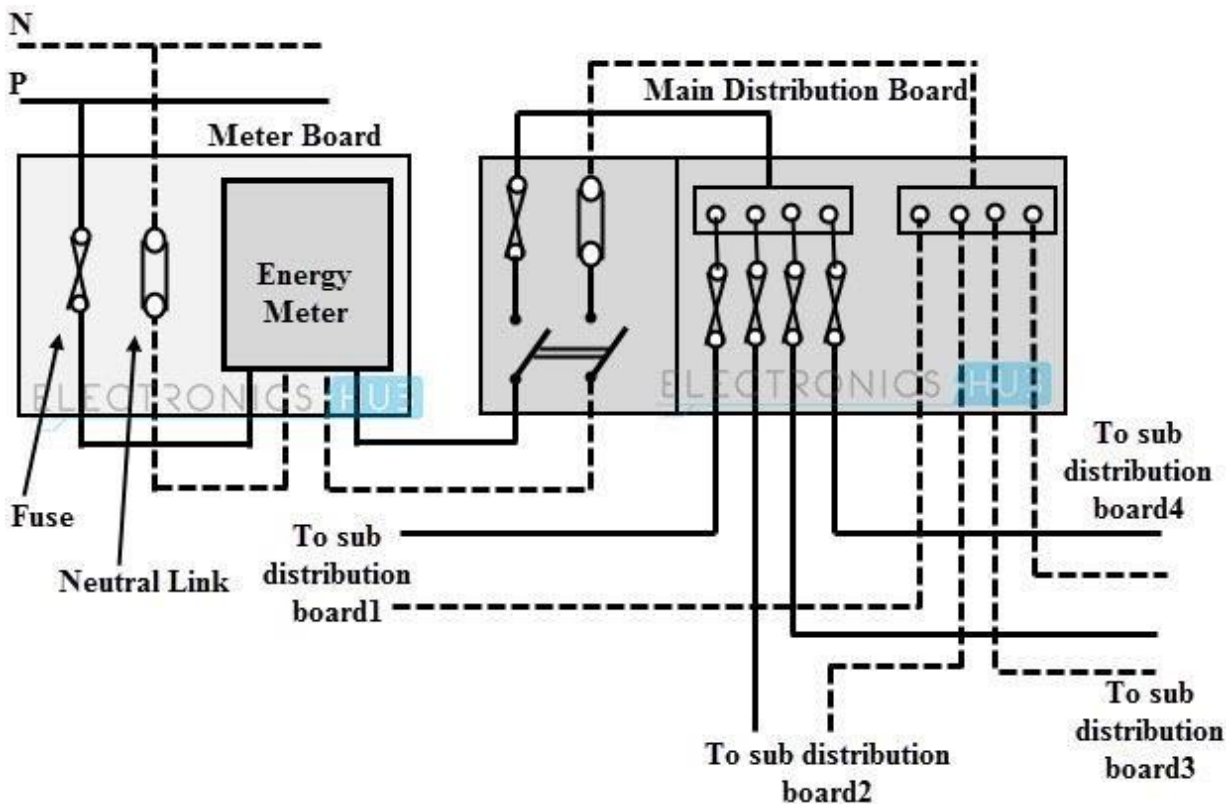
Again conduit wiring divided into 3 types:

1. Surface conduit wiring
2. Concealed conduit wiring
3. Flexible conduit wiring

Comparison between various systems of wiring:

Sl no.	Particulars	Cleat wiring	Wooden casing and capping wiring	TRS wiring	Concealed wiring
01	Cost	Very low	Medium	Low	Very costly
02	Voltage	Up to 250v	Up to 250v	Up to 250v	Up to 660v
03	Life	Very short	Fairly long	Long	Very long
04	Protection against fire	Poor	No	Fair	Very good
05	Appearance	Not good	Fair	Good	Very good
06	Field of application	For temporary wiring e.g functions, building under construction	For residential ,commercial ,office building.	For residential ,commercial ,office building.	For residential ,commercial ,office building, godowns, private building etc.

5.2 Layout of household electrical wiring (single line diagram showing all the important component in the system) :



5.3 List out the basic protective devices used in house hold wiring :

The basic protective devices used in house hold wiring are :

- DPIC (Double pole iron clad) main switch of 5,15,30 A rating 220V.
- TPIC (Tripole pole iron clad) main switch of 30,60,100,200 A rating 440V.
- DPMCB (Double pole miniature circuit breaker) of 5,10,16,32,45 and 63 A rating 250V.
- TPMCB (Tripole pole miniature circuit breaker) of 16,32,45 and 63A rating 500V.
- MCCB (Mouled case circuit breaker) of 100,200,300,500A rating 660V.
- TPNMCB (Tripole pole with neutral miniature circuit breaker) of 16,32,45 and 63 A rating 500V.
- Flush switches
- Kit-kat fuse units
- ELCB (Earth leakage circuit breaker) or RCCB (Residential current circuit breaker)

5.4 Calculate energy consumed in a small electrical installation.

Q -1 A residential house of a farmer has the following loads used in average :

Bed room 1 no.

2 light points for 6 hours /day

1 fan point for 12 hours/day

Drawing room 1 no.

2 light points for 8 hours/day

1 fan point for 16 hours/day

Kitchen room 1 no.

1 light point for 10 hours/day

1 heater 1000W for 7 hours/day

Store room 1 no.

2 light points for 6 hours/day

Verandah

1 light point for 8 hours/day

1 fan light point for 8 hours/day

Find out the energy bill for the month of January 2021 when the unit price of the energy is RS 2.00/unit.

ANS: Energy consumed /day by various loads:

Sl no	Place	Loads	Number	Wattage	Working hours/day	Energy consumed/day
01	BED ROOM 1 NO.	Light	2	60	6	$2 \times 60 \times 6 = 720\text{WH}$
		Fan	1	80	12	$1 \times 80 \times 12 = 960\text{WH}$
02	DRAWING ROOM 1 NO.	Light	2	60	8	$2 \times 60 \times 8 = 960\text{WH}$
		Fan	1	80	16	$1 \times 80 \times 16 = 1280\text{WH}$
03	KITCHEN ROOM 1 NO.	Light	1	60	10	$1 \times 60 \times 10 = 600\text{WH}$
		Heater	1	1000	7	$1 \times 1000 \times 7 = 7000\text{WH}$
04	STORE ROOM 1 NO.	Light	2	60	6	$2 \times 60 \times 6 = 720\text{WH}$
05	VERANDAH	Light	1	60	8	$1 \times 60 \times 8 = 480\text{WH}$
		Fan	1	80	8	$1 \times 80 \times 8 = 640\text{WH}$
						Total energy consumed /day = $13360\text{Wh} = 13.36\text{KWH}$

Hence total monthly consumption (Jan 2021) = $13.36 \times 31 = 414.16\text{ KWH}$

We know 1 unit = 1KWH

So total unit consumption = 414.16 unit.

The energy bill for month of jan 2021 = 414.16×2 (given 1 unit = Rs 2) = Rs 828.32/ (Ans)

Short questions with answer:

Q-1 Write the full form of DPIC.

Ans: The full form of DPIC is double pole iron clad main switch.

Q-2 Write the full form of ELCB .

Ans: The full form of ELCB is earth leakage circuit breaker.

Q-3 Which wiring is very costly ?

Ans: concealed wiring is very costly.

Q-4 How much watt hour is one unit for electrical energy calculation ?

Ans: 1000 watt hour is one unit for electrical energy calculation.

Q-5 What are the protective device used in house hold wiring. (W-17), (S-18)

Ans: The protective device used in house hold wiring are fuse, MCB, ELCB, earthing or grounding.

Q-6 Name types of wiring ? (S-18), (W-19)

Ans: Following are the types of internal wiring usually employed in industries and house wiring:

- Cleat wiring
- Wooden casing and capping wiring
- T.R.S or Batten wiring
- Conduit wiring

Again conduit wiring divided into 3 types:

- Surface conduit wiring
- Concealed conduit wiring
- Flexible conduit wiring

LONG QUESTIONS:

Q-1 Write down the protective devices used in house hold wiring.

Q-2 Explain about types of internal wiring .(W-17,S-18,S-19)

CHAPTER - 6

MEASURING INSTRUMENTS

Learning Resources:

6.1 Introduction to measuring instruments.

6.2 Torques in instruments.

6.3 Different uses of PMMC type of instruments (Ammeter & Voltmeter).

6.4 Different uses of MI type of instruments (Ammeter & Voltmeter).

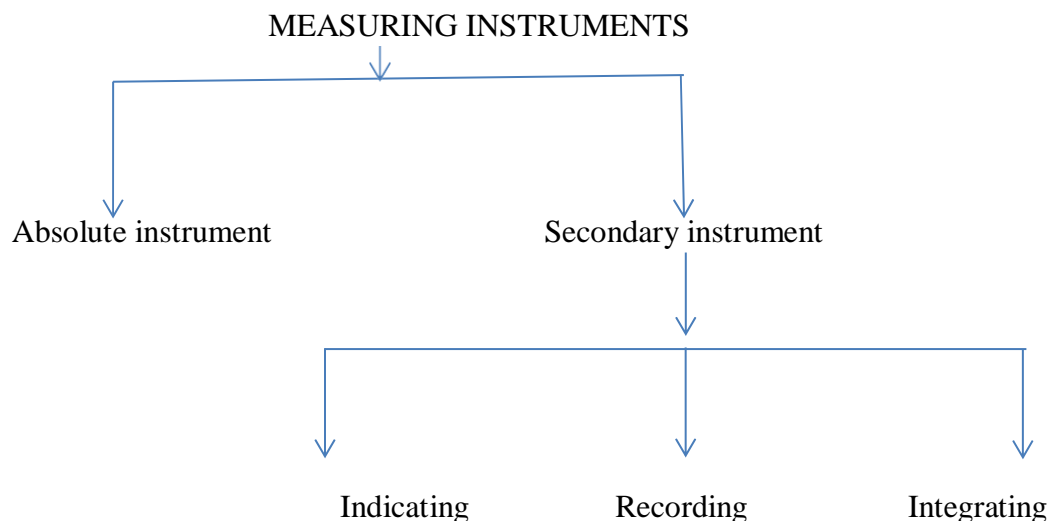
6.5 Draw the connection diagram of A.C/ D.C Ammeter, voltmeter, energy meter and wattmeter. (Single phase only).

6.1 Introduction to measuring instrument:

The measurement of a given quantity is the result of comparison between the quantity to be measured and a definite standard. The instruments which are used for such measurements are called measuring instruments.

The three basic quantities in the electrical measurement are current, voltage and power.

Classifications of electrical measuring instruments:-



6.2 Torques in instruments

There are three types of torques,

- I. Deflection torque(T_d)/operating torque
- II. Controlling torque (T_c)/restoring/balancing torque
- III. Damping torque

Deflection torque: It is the torque which deflects the point on a calibrated scale according to the electrical quantity passing through the instrument .

Controlling torque: It is the torque which controls the movement of the pointer on a particular scale according to the quantity of electricity passing through it.

Damping torque: It is the torque which avoids the vibration of the pointer on a particular range of scale.

6.3 Different uses of PMMC type of instruments (Ammeter & Voltmeter) :

PMMC type instruments:

- PMMC (Permanent magnet moving coil)
- It uses only for DC

PMMC type ammeter:

- It uses only DC circuit.
- PMMC type ammeter measure current in DC circuit only.

PMMC type voltmeter:

- It uses only in DC circuit.
- PMMC type voltmeter measures voltage in DC circuit only.

6.4 Different uses of MI type instruments (Ammeter and Voltmeter) :

MI type type instrument:

- Movng iron type used both in AC and DC circuit.

MI type ammeter:

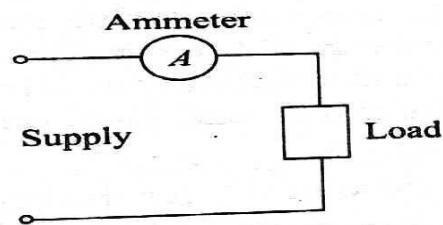
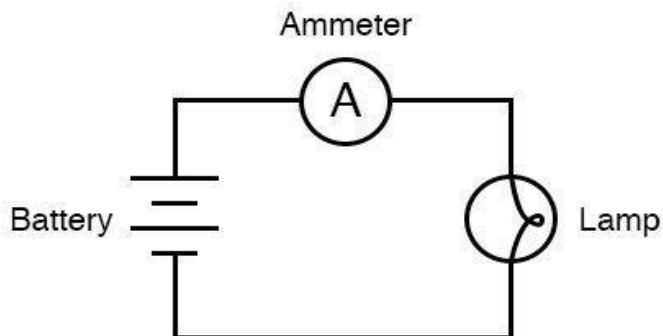
- MI type ammeter measure current in both AC and DC circuit.

MI type voltmeter:

- MI type voltmeter measure voltage in both AC and DC circuit.

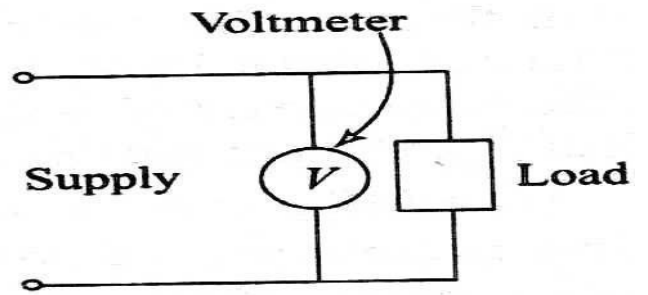
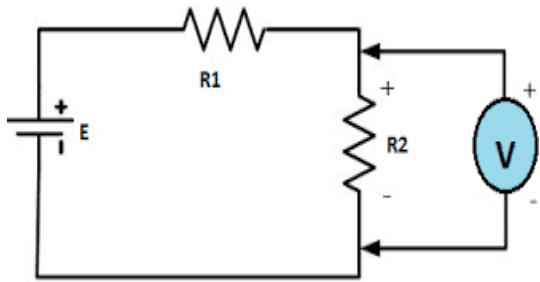
6.5 Draw the connection diagram of A.C/ D.C Ammeter, voltmeter, energy meter and wattmeter. (Single phase only) :

Connection diagram of ammeter:



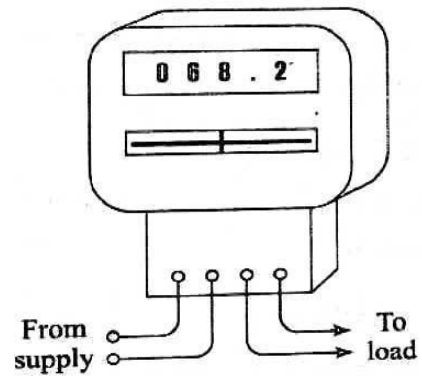
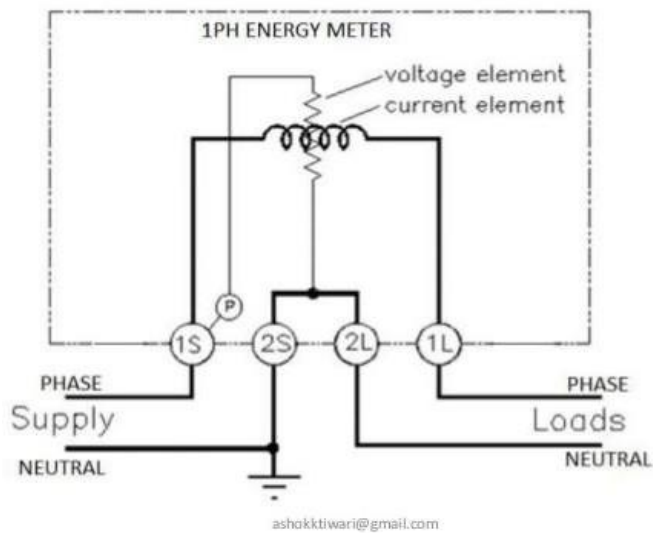
- Ammeters are always connected in series with the circuit.

Connection diagram of voltmeter:

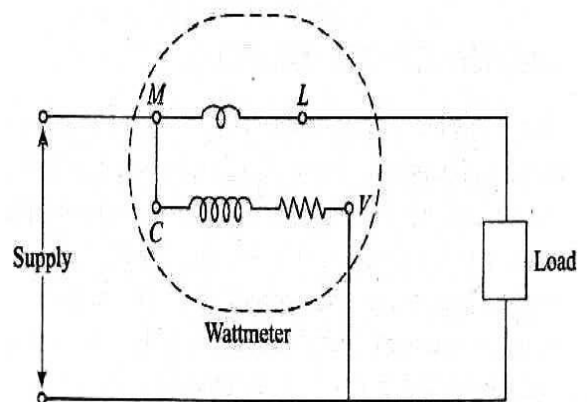
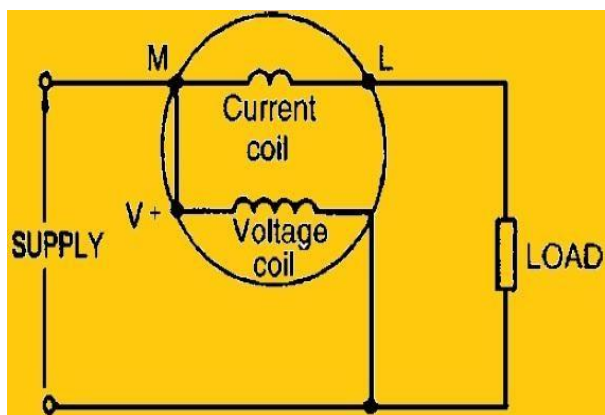


- Voltmeters are always connected in parallel.

Connection diagram of energy meter:



Connection diagram of single phase wattmeter:



Short questions with answer:

Q-1 Write a example of integrating type instruments.

Ans: Single phase energy meter is a example of integrating type instruments.

Q-2 Which type of instrument used to measure both AC and DC ?

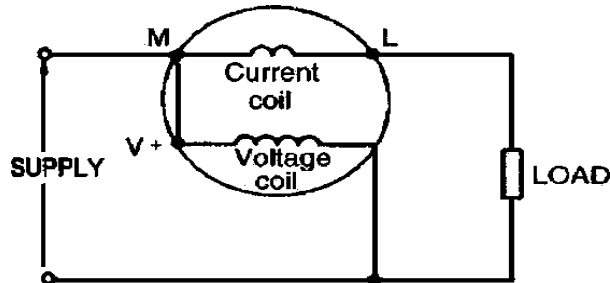
Ans: MI type instrument used to measure both AC and DC.

Q-3 Which type of instruments are used to measure only DC ?

Ans: PMMC type instrument used to measure only DC.

Q-4 Draw the connection diagram of single phase wattmeter . (W-16)

Ans:



Q-4 What are the different torque in measuring instruments ? (S-19)

Ans: The different torque torque in measuring instruments are :

- I. Deflecting torque.
- II. Controlling torque
- III. Damping torque.

Long questions :

Q-1 Draw the connection diagram of single phase energy meter.

Q-2 Draw the connection diagram of wattmeter.

Q-3 Draw the connection diagram of voltmeter and ammeter.

Q-4 State uses of MI type ammeter and voltmeter with connection diagram. (S-18)

Q-5 State different uses of MI type instruments instruments briefly. (S-19)

Q-6 State different uses of PMMC type instrument. (S-18)