

FUNDAMENTAL

CHARGE:-

- The most basic quantity in an electric circuit is the electric charge.
- Charge is an electric property of the atomic particles of which matter consists, measured in coulombs (c). Charge, positive or negative, is denoted by the letter q or Q .
- All matter is made of fundamental building blocks known as atoms and that each atom consists of electron, proton & neutrons. We also know that the charge 'e' on an electron is negative and equal in magnitude to $1.602 \times 10^{-19} c$, while a proton carries a positive charge to the same magnitude as the electron and the neutron has no charge. The presence of equal numbers of protons and electrons leaves an atom neutrally charged.

CURRENT :-

- Current can be defined as the motion of charge through a conducting material, measured in Amperes (A). Electric current, is denoted by the letter i or I .
- The unit of current is the ampere abbreviated as (A) and corresponds to the quantity of total charge that passes through an arbitrary cross section of a conducting material per unit second.

Mathematically,

$$I = \frac{Q}{t} \text{ or } Q = It$$

where Q is the symbol of charge measured in coulombs (c), I is the current in amperes (A) and t is the time in second (s).

→ The current can also be defined as the rate of charge passing through a point in an electric circuit,

Mathematically,

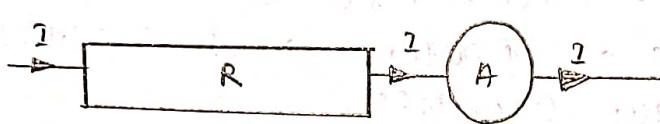
$$i = \frac{dq}{dt}$$

The charge transferred between time t_1 and t_2 is obtained as

$$q = \int_{t_1}^{t_2} i dt$$

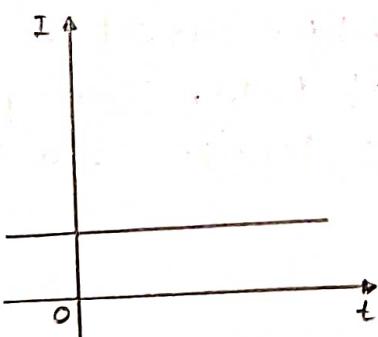
A constant current also known as a direct current or DC is denoted by symbol i whereas a time varying current is represented by the symbol or $i(t)$.

→ Current is always measured through a circuit element in ammeter as shown in fig.

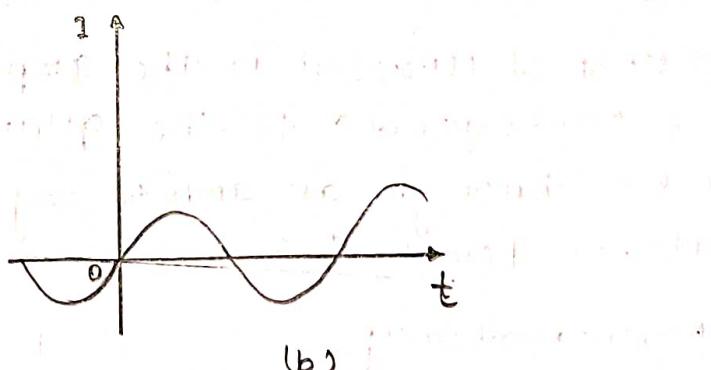


Two types of currents.

- 1) A direct current is a current that remains constant with time.
- 2) An alternating current is a current that varies with time.



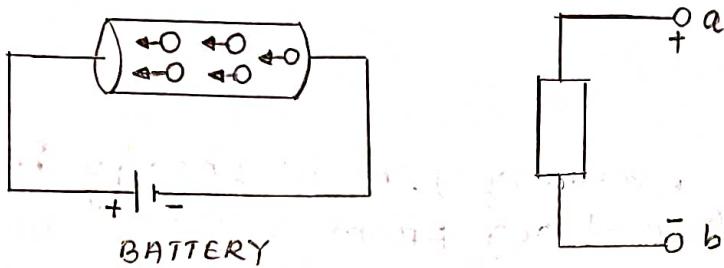
(a)
DIRECT CURRENT



(b)
ALTERNATING CURRENT

VOLTAGE (OR) POTENTIAL DIFFERENCE :-

To move the electron in a conductor in a particular direction requires some work or energy transfer. This work is performed by an external electromotive force (emf), typically represented by the battery in Fig 1.3(a). This emf is also known as voltage or Potential difference. The voltage V_{ab} between two points a and b in an electric circuit is the energy needed to move a unit charge from a to b.



Voltage is the energy required to move charge from one point to the other, measured in volts (V), voltage is denoted by the letter v or V.

Mathematically,

$$V_{ab} = \frac{dw}{dt}$$

where w is energy in joules and q is charge in coulomb (C). The voltage V_{ab} or simply v is measured in volts (V).

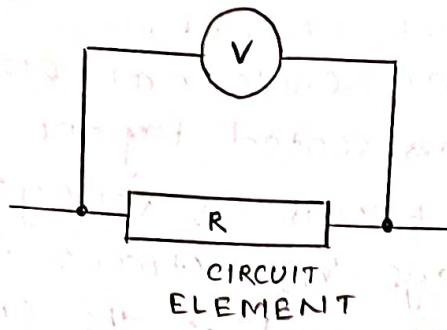
$$1 \text{ volt} = 1 \text{ joule/coulomb} = 1 \text{ newton meter/coulomb}$$

Fig. 1. shows the voltage across an element connected to points a and b. The plus (+) and minus (-) signs are used to define reference direction or voltage polarity.

→ The V_{ab} can be interpreted in two ways

- (1) point a is at a potential of V_{ab} Volts higher than point b. or
- (2) The potential at point a with respect to point b is V_{ab} . It follows logically that in general.

$$V_{ab} = -V_{ba}$$



POWER :-

Power is the time rate of expending or absorbing energy, measured in watts (W). Power, is denoted by the letter p or P .

$$P = \frac{dw}{dt}$$

where p is power in watts (W), w is energy in joules (J) and t is time in second (s). From voltage and current equations, it follows that.

$$P = \frac{dw}{dt} = \frac{dw}{dq} \times \frac{dq}{dt}$$

$$= V \times I$$

Thus, if magnitude of current I and voltage are given, then power can be evaluated as the product of the two quantities and is measured in watts (W).

SIGN OF POWER :-

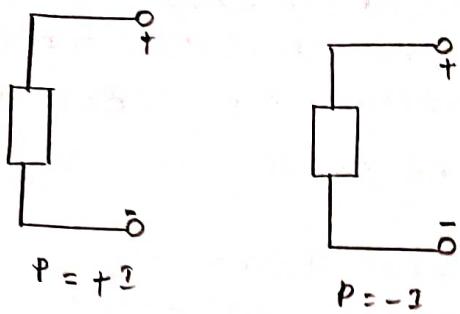
PLUS :- Power is absorbed by element (Resistor, inductor)

MINUS :- Power is supplied by the element (Battery, generator)

PASSIVE SIGN CONVENTION :-

If the current enters through the positive polarity of the voltage, $P = +VI$

If the current enters through the negative polarity of the voltage, $P = -VI$



ENERGY :-

- Energy is the capacity to do work, and is measured in joules (J)
- The energy absorbed or supplied by an element from time 0 to t is given by

$$\begin{aligned} W &= \int_0^t pdt \\ &= \int_0^t VIdt \end{aligned}$$

- The electric power utility companies measure energy in watt-hours (WH) or kilowatt-hours (kWh)

$$1\text{WH} = 3600\text{J}$$

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.

There are two kinds of sources

- Independent sources
- 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.

IDEAL INDEPENDENT VOLTAGE SOURCE :-

An ideal independent voltage source is an active element that gives a constant voltage across its terminals irrespective of the current drawn through its terminals.

IDEAL INDEPENDENT CURRENT SOURCE :-

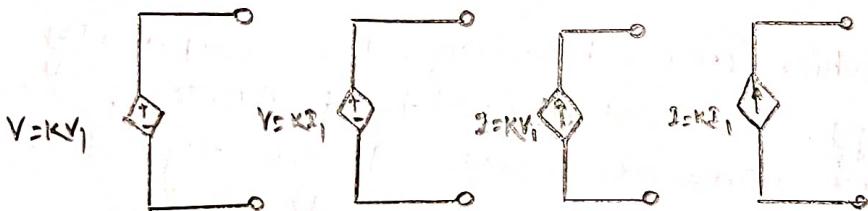
An ideal independent current source is an active element that gives a constant current through its terminal irrespective of the voltage appearing across its terminals.

DEPENDENT (CONTROLLED) SOURCES :-

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

→ Dependent sources are usually designated by diamond shaped symbols, as shown in fig. Since the control of the dependent source is achieved by a voltage or current of some other element in the circuit, and the source can be voltage or current, it follows that there are four possible types of dependent sources, namely:

1. A voltage-controlled voltage sources (Vcvs)
2. A current-controlled voltage sources (Ccvs)
3. A voltage-controlled current source (Vccs)
4. A current-controlled current sources (Cccs)



(a) Vcvs (b) Ccvs (c) Vccs (d) Cccs

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.

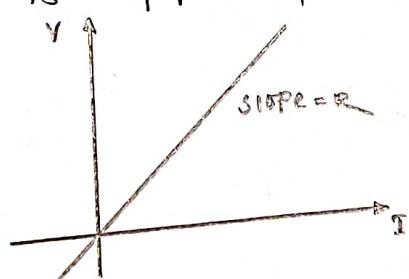
OHM'S LAW :-
→ Georg Simon Ohm (1789-1854), a German physical, is credited with finding the relationship between current and voltage across a resistor. This relationship is known as Ohm's law.
→ Ohm's law states that at constant temperature, the voltage (V) across a conducting material is directly proportional to the current (I) flowing through the material.

Mathematically,

$$V \propto I$$

$$V = RI$$

Where the constant of proportionality R called the resistance of the material. The $V-I$ relation for resistor according to Ohm's law is depicted in fig.



Limitations of law :-

1. Ohm's law is not applicable to non-linear elements like diode, transistor etc.
2. Ohm's law is not applicable for non-metallic conductors like silicon carbide.

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

$$\text{Sol} :- R = \frac{V}{I} = \frac{120}{2} = 60 \Omega$$

Example - 1.2 The essential component of a toaster is an electrical element that convey electrical energy to heat energy. How much current is drawn by a toaster with resistance 12Ω at 110V?

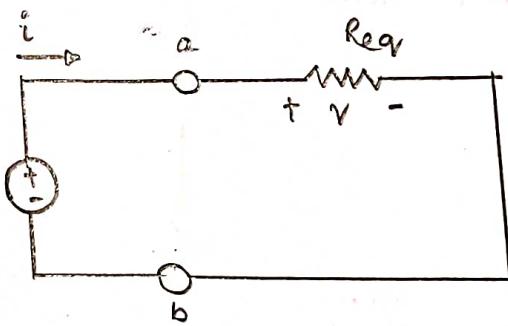
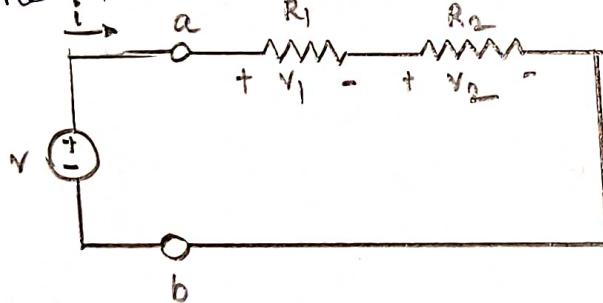
$$\text{Sol} :- I = \frac{V}{R} = \frac{110}{12} = 9.167 \text{ Amp.}$$

RESISTOR :-

material in general have a characteristic behavior of resisting the flow of electric charge. This physical property, or ability to resist the flow of current, is known as resistance and is represented by the symbol R . The resistance is measured in ohms (Ω).

RELATION OF V, I AND R IN SERIES CIRCUIT :-

Two or more resistors are said to be in series if the same current flows through all of them. The process of combining the resistors is facilitated by combining two or them at a time. with this in :



The two resistors are in series, since the same current i flows in both of them. Applying Ohm's law to each of the resistors, we obtain

$$V_1 = iR_1 \quad V_2 = iR_2 \quad (1.11)$$

If we apply KVL in the loop, we have

$$V = V_1 + V_2 = 0 \quad (1.12)$$

Combining equation (1.11) & (1.12) we get

$$\begin{aligned} V &= V_1 + V_2 \\ &= iR_1 + iR_2 \\ &= i(R_1 + R_2) \end{aligned} \quad (1.13)$$

Equation (1.13) can be written as

$$V = i R_{\text{eq}} \quad (1.14)$$

where $R_{\text{eq}} = R_1 + R_2$

i.e. the summation of two resistors.

From eq. (1.13) we get.

$$i = \frac{V}{R_1 + R_2} \quad (1.15)$$

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

For N resistors in series then,

$$\begin{aligned} R_{\text{eq}} &= R_1 + R_2 + \dots + R_N \\ &= \sum_{n=1}^N R_n \end{aligned} \quad (1.16)$$

VOLTAGE DIVISION :-

To determine the voltage across each resistor in fig.

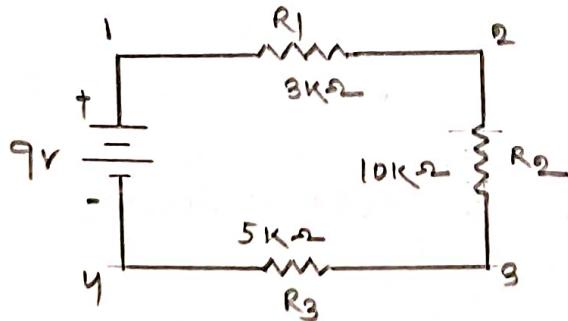
1.8. We substitute eq. (1.15) into eq. (1.11) and obtain.

$$V_1 = \frac{V}{R_1 + R_2} R_1$$

$$V_2 = \frac{V}{R_1 + R_2} R_2$$

Note that the source voltage is divided among the resistors in direct proportion to their resistances. The larger the resistance, the larger the voltage drop. This is called the principle of voltage division.

Example - 1.3 - Find the current I passing through and the voltage across each of the resistors in the circuit



$$R_{\text{total}} = R_1 + R_2 + R_3$$

$$= 3 \text{k}\Omega + 10 \text{k}\Omega + 5 \text{k}\Omega$$

$$= 18 \text{k}\Omega$$

$$I = \frac{V}{R_{\text{total}}} = \frac{9}{18 \times 10^3} = 0.5 \text{ mA}$$

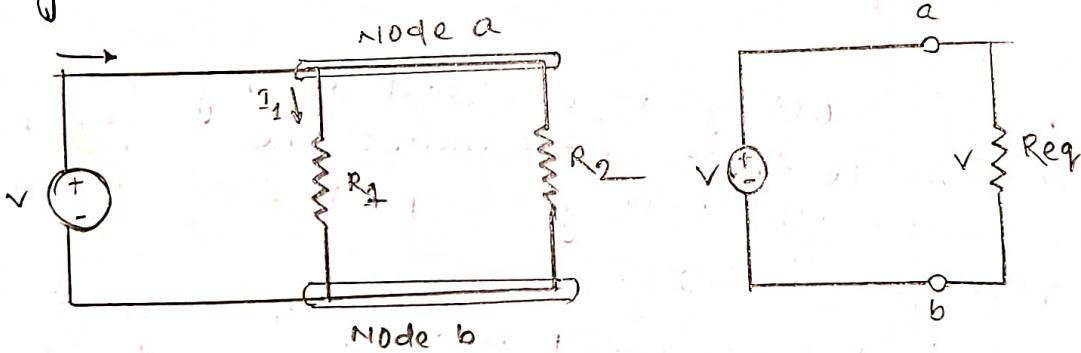
$$V_{R_1} = \frac{VRI}{R_1 + R_2 + R_3} = \frac{9}{18 \times 10^3 + 3 \times 10^3} = 1.5 \text{ V}$$

$$V_{R_2} = \frac{V}{R_1 + R_2 + R_3} R_2 = \frac{9}{18 \times 10^3 + 10 \times 10^3} = 5 \text{ V}$$

$$V_{R_3} = \frac{V}{R_1 + R_2 + R_3} R_3 = 2.5 \text{ V}$$

RELATION OF V, I & R IN PARALLEL CIRCUIT :-

Two or more resistors are said to be in parallel if the same voltage appears across each element. Consider the circuit in Fig. where two resistors are connected in parallel and therefore have the same voltage across them.



$$V = I_1 R_1 = I_2 R_2 \quad \text{--- 1.18}$$

$$I_1 = \frac{V}{R_1}$$

$$I_2 = \frac{V}{R_2} \quad \text{--- 1.19}$$

Applying KCL at node a gives the total current is

$$I = I_1 + I_2 \quad \text{--- 1.20}$$

Substituting equation 1.19 into 1.20 we get

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$$\begin{aligned} I &= \frac{V}{R_1} + \frac{V}{R_2} \\ &= V \left(\frac{1}{R_1} + \frac{1}{R_2} \right) \\ &= \frac{V}{R_{eq}} \quad (1.21) \end{aligned}$$

Thus the equivalent resistance of parallel connected resistors is the reciprocal of the sum of the reciprocals of the individual resistances.

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

$$\begin{aligned} \frac{1}{R_{eq}} &= \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_N} \\ &= \sum_{n=1}^N \frac{1}{R_n} \quad (1.23) \end{aligned}$$

DIVISION OF CURRENT IN PARALLEL CIRCUIT :-

We know that the equivalent resistor has the same voltage, or

$$V = i R_{eq} = \frac{i R_1 R_2}{R_1 + R_2} \quad (1.24)$$

Substituting eq. (1.24) into (1.19)

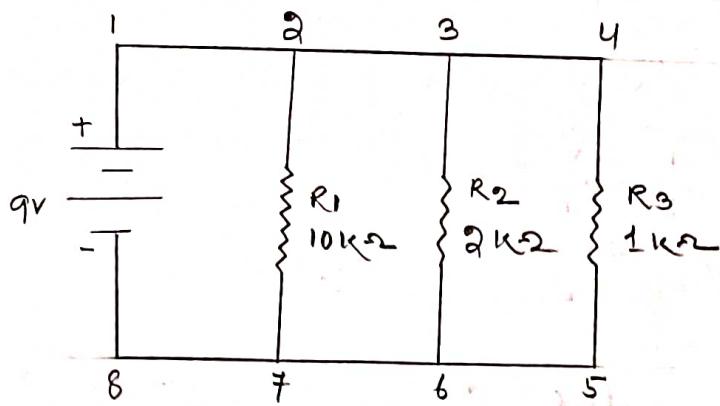
$$i_1 = \frac{i R_2}{R_1 + R_2}$$

$$i_2 = \frac{i R_1}{R_1 + R_2}$$

This shows that the total current is shared by the resistors in inverse proportion to their resistances. This is known as the principle of current division, and the circuit is known as a current divider.

Example 1.4 —

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



$$\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{10 \times 10^3} + \frac{1}{2 \times 10^3} + \frac{1}{1 \times 10^3} = 0.0016$$

$$R_{\text{total}} = 625 \Omega$$

$$I = \frac{V}{R_{\text{total}}} = \frac{9}{625} = 0.0144 \text{ Amp} = 14.4 \text{ mA}$$

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

$$I_{R2} = \frac{V}{R_2} = \frac{9}{2 \times 10^3} = 4.5 \text{ mA}$$

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

POWER IN SERIES AND PARALLEL CIRCUIT :-

(a) Series combinations :- If the electrical appliances of power P_1 & P_2 are connected in series with main voltage V having resistance R_1 & R_2 , then

$$R_1 = \frac{V^2}{P_1} \quad R_2 = \frac{V^2}{P_2} \quad \left[\because P = \frac{V^2}{R} \right] \quad (1.26)$$

With connected in series, then their effective resistance is $R = R_1 + R_2$

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

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

(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

$$\begin{aligned} R_1 &= \frac{V^2}{P_1} \\ R_2 &= \frac{V^2}{P_2} \end{aligned} \quad \left[\because P = \frac{V^2}{R} \right] \quad (1.28)$$

when connected in parallel, then their effective resistance is

$$\begin{aligned} \frac{1}{R} &= \frac{1}{R_1} + \frac{1}{R_2} \\ \frac{P}{V^2} &= \frac{P_1}{V^2} + \frac{P_2}{V^2} \end{aligned} \quad (1.29)$$

KIRCHHOFF'S LAWS :-

The most common and useful set of laws for solving electric circuits are the Kirchhoff's voltage and current laws. Several other useful relationships can be derived based on these laws. These laws are commonly known as Kirchhoff's current law and Kirchhoff's voltage law.

KIRCHHOFF'S CURRENT LAW (KCL) :-

This is also called as Kirchhoff's first law or Kirchhoff's nodal law. Kirchhoff's first law is based on the law of conservation of charge, which requires that the algebraic sum of charges within a system cannot change.

Statement :- Algebraic sum of the current meeting at any junction or node is zero. The term "algebraic" means the value of the quantity along with its sign, positive or negative.

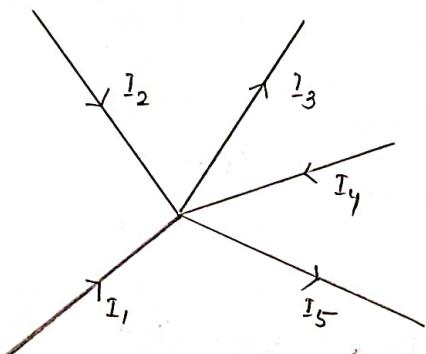
Mathematically, KCL implies that

$$\sum_{n=1}^N = 0$$

where N is the number of branches connected to the node and i is the n th current entering the node. By this law, currents entering a node may be regarded as positive, while currents leaving the node may be taken as negative or vice versa.

ALTERNATE STATEMENT :-

Sum of the currents flowing towards a junction is equal to the sum of the currents flowing away from the junction.



Explanation:-

Consider where five branches of a circuit are connected together at the junction or node A. Currents I_1 , I_2 and I_4 are flowing towards the junction whereas currents I_3 & I_5 are flowing away from junction A. It is a positive sign is assigned to the currents I_2 and I_4 that are flowing into the junction then the current I_3 and I_5 flowing away from the junction should be assigned with the opposite sign i.e. the negative sign.

Applying Kirchhoff's current law to the junction A

$$I_1 + I_2 - I_3 + I_4 - I_5 = 0 \quad (\text{Algebraic sum is zero})$$

The above equation can be modified as $I_1 + I_2 + I_4 = I_3 + I_5$

KIRCHHOFF'S VOLTAGE LAW:-

This is also called as Kirchhoff's second law or Kirchhoff's loop or mesh law. Kirchhoff's second law is based on the principle of conservation of energy.

Statement :-

Algebraic sum of all the voltages around a closed path or closed loop at any instant is zero. Algebraic sum of the voltages means the magnitude and direction of the voltages;

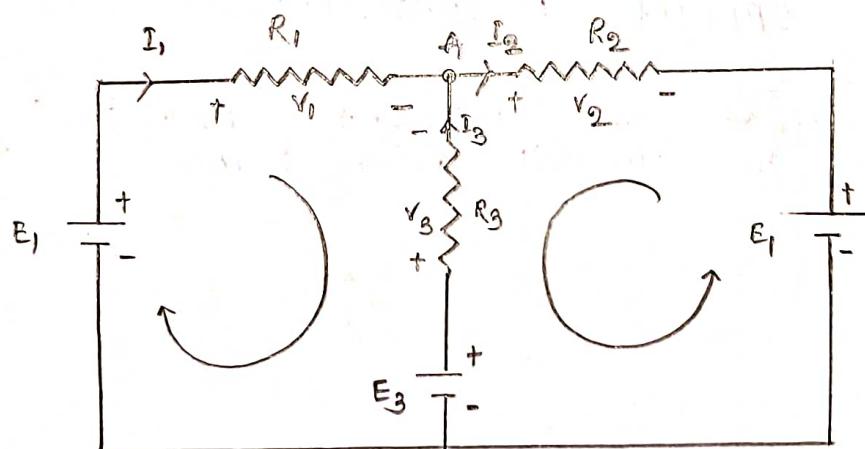
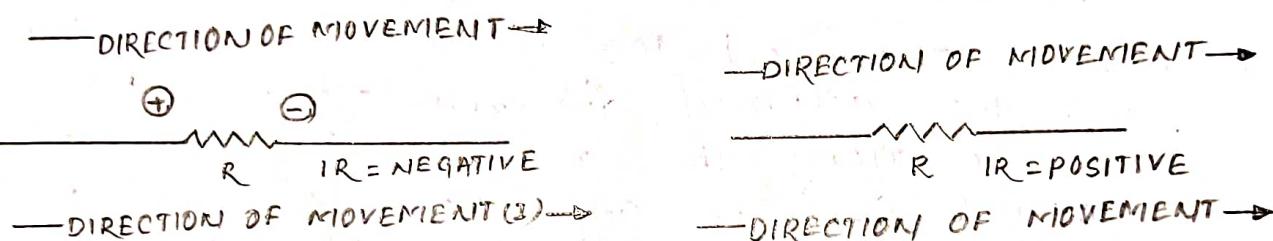
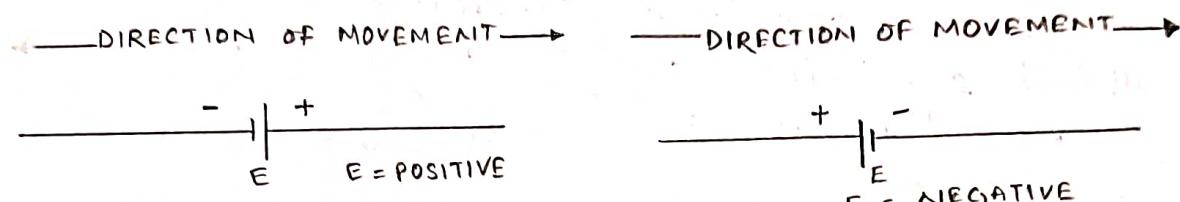
Care should be taken in assigning proper signs or polarities to voltages in different sections of the circuit.

Mathematically, KVL implies that

$$\sum_{n=1}^N V_n = 0$$

Where N is the number of voltages in the loop and is the voltage in a loop.

Sign Rules of KVL : If we give positive sign to all rise in potential then we must give negative sign for all fall in potential and vice versa.



The circuit has three active elements with voltage E_1, E_2 and E_3 . The polarity of each of them is fixed. R_1, R_2, R_3 are three passive elements present in the circuit. Currents I_1 and I_3 are marked flowing into the junction A and current I_2 marked away from the junction A with known information or assumed directions. With reference to the direction of these currents, the polarity of voltage drops V_1, V_2 , and V_3 are marked.

For loop 1 it is considered around clockwise

$$+E_1 - V_1 + V_3 - E_3 = 0$$

$$+E_1 - I_1 R_1 + I_3 R_3 - E_3 = 0$$

$$E_1 - E_3 = I_1 R_1 - I_3 R_3$$

For loop 2 it is considered anticlockwise

$$+E_2 + V_2 + V_3 - E_3 = 0$$

$$+E_2 + I_2 R_2 + I_3 R_3 - E_3 = 0$$

$$E_2 - E_3 = -I_2 R_2 - I_3 R_3$$

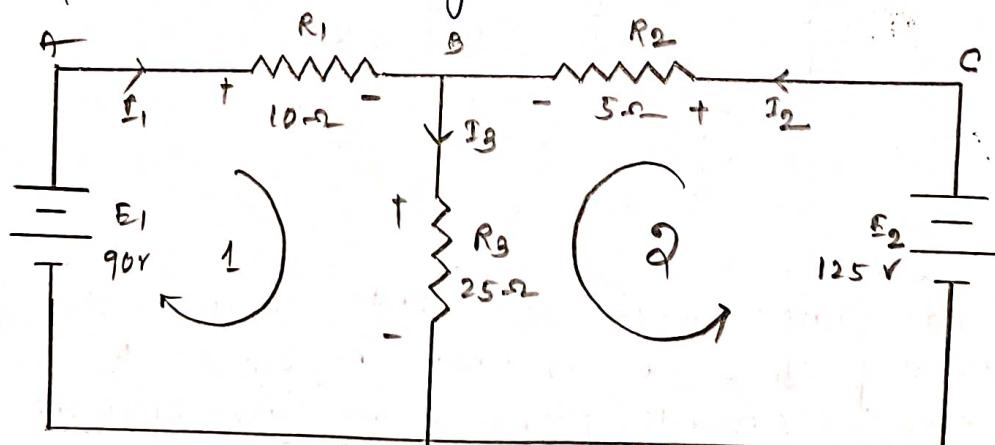
Two equations are obtained following Kirchhoff's voltage law. The third equation can be written based on Kirchhoff's current law as

$$I_1 - I_2 + I_3 = 0$$

With the three equations, can solve for the three currents I_1 , I_2 and I_3 .

If the results obtained for I_1 , I_2 and I_3 are all positive, then the assumed direction of the currents are said to be along the actual directions. A negative result for one of more currents will indicate that the assumed direction of the respective current is opposite to the actual direction.

Example 1.5 — calculate the current supplied by two batteries in the circuit given below.



Solution :

The four junctions are marked as A, B, C and D. The current through R_1 is assumed to flow from A to B and through R_2 from C to B and finally through R_3 from B to D, with reference to current directions. properties of the voltage drop in R_1 , R_2 and R_3 are then marked as shown in figure. Applying KCL to junction B.

$$I_3 = I_1 + I_2 \quad \dots \dots \quad (1)$$

Applying KVL to loop 1

$$E_1 = I_1 R_1 - I_3 R_3 = 0$$

$$E_1 = I_1 R_1 + I_3 R_3$$

$$90 = 10I_1 + 25I_3 \quad \dots \dots \quad (2)$$

Substituting eq. (1) in eq. (2)

$$90 = 10I_1 + 25(I_1 + I_2)$$

$$90 = 35I_1 + 25I_2 \quad \dots \dots \quad (3)$$

Applying KVL to loop 2

$$E_2 - I_2 R_2 - I_3 R_3 = 0$$

$$E_2 = I_2 R_2 + I_3 R_3 \quad \dots \dots \quad (4)$$

$$125 = 5I_2 + 25I_3$$

Substituting eq. (1) in eq. (4)

$$125 = 5I_2 + 25(I_1 + I_2) \quad \dots \dots \quad (5)$$

$$125 = 25I_1 + 30I_2$$

After solving eq.(3) and (5) we get

$$I_1 = -1A$$

$$I_2 = 5A$$

As the sign of the current I_1 is found to be negative from the solution, the actual direction of I_1 is from B to A to D i.e. 90V battery gets a charging current of 1A.

AC CIRCUIT

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A.C. FUNDAMENTAL:

A.c → the current which changes its direction and magnitude period that current is called alternating current.

D.C →

The current which changes its magnitude only that current is called direct current.

ADVANTAGES:

i) DC generation is low - 1500V

ii) But AC generation - 11KV

TRANSMISSION:

11KV, 33KV, 66KV, 132KV, 220KV, 400KV same rating = 5

Traction line - 18KV to 25KV

D.C - Large size

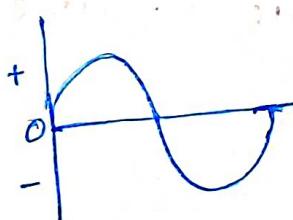
A.C - Smaller size

D.C required more maintenance.

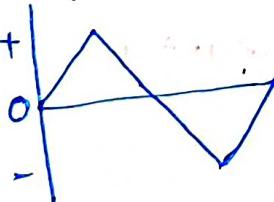
THE SINEWAVE:

The shape of line voltage have form generated by a coil rotating in a magnetic field is called a sine wave.

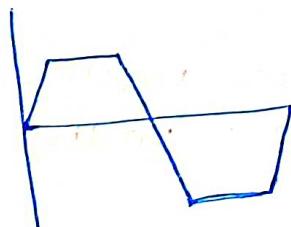
Sinusoidal waves
sine waves



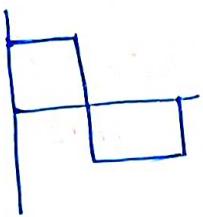
Triangular wave



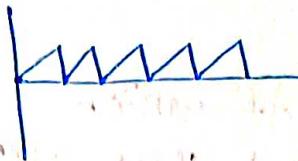
Trapezium wave



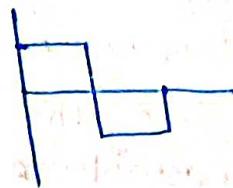
Rectangular wave



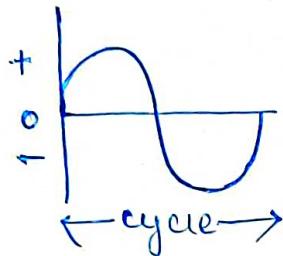
Saw teeth wave



Square wave



CYCLE :- The complete change in value or and direction of alternating quantity is called cycle.

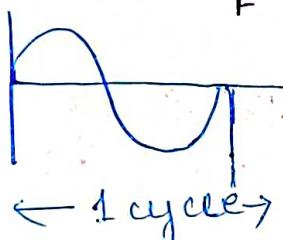


FREQUENCY :-

The number of cycles per second is called frequency. It's denoted symbol 'f' and unit is Hertz. The standard frequency of India is 50 Hertz.

PERIOD :- Time taken to complete one cycle is called Period. It's denoted by T.

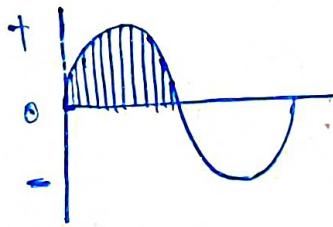
$$T = \frac{1}{f}$$



The period (T) of the sine wave is 0.02 second.

INSTANTANEOUS VALUE :-

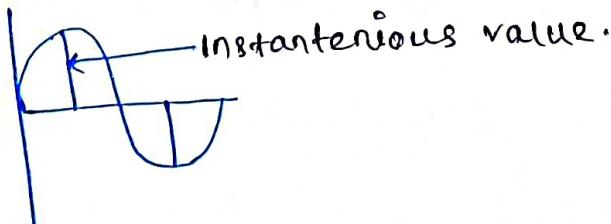
The value of alternating quantity at any particular instant is called instantaneous value.



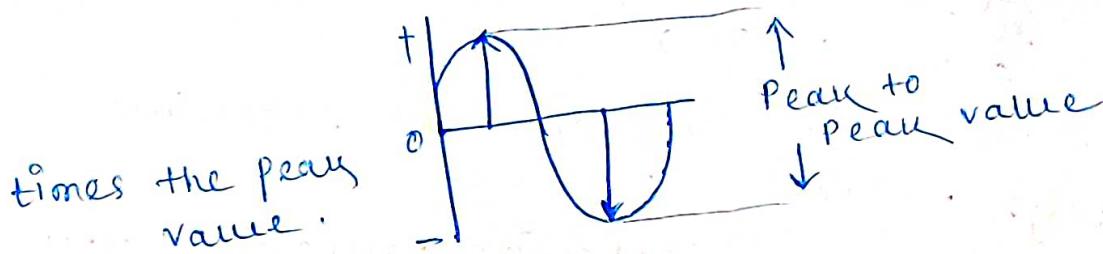
AMPLITUDE :-

It is the highest value of the instantaneous value.

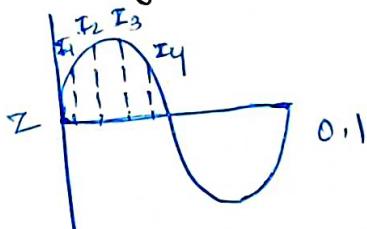
It is also called peak value.



Peak to Peak \rightarrow peak to peak value of sine wave
 is the total overall value from one peak to the other. It is equal to two.



AVERAGE VALUE -
 It is the average of the instantaneous value
 of half cycle.

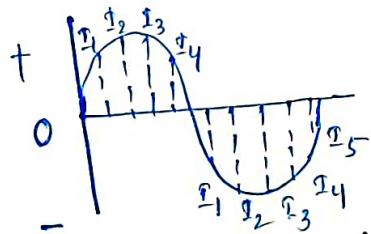


$$\text{Average value} = \frac{I_1 + I_2 + I_3 + I_4}{4}$$

for voltage, $V_{av} = 0.687 V_{max}$.

For current, $I_{av} = 0.637 I_{max}$.

RMS VALUE (Root mean square):
 It is also called effective value or virtual value.
 It is value of an alternating current that value
 which will produce the same heating effect as a specific
 value of a steady dc.



Average of square of instantaneous value \rightarrow

$$\frac{I_1^2 + I_2^2 + I_3^2 + \dots + I_{18}^2 + I_{19}^2 + I_{20}^2}{20}$$

For voltage, $V = 0.707 V_{max}$

For current, $I = 0.707 I_{max}$

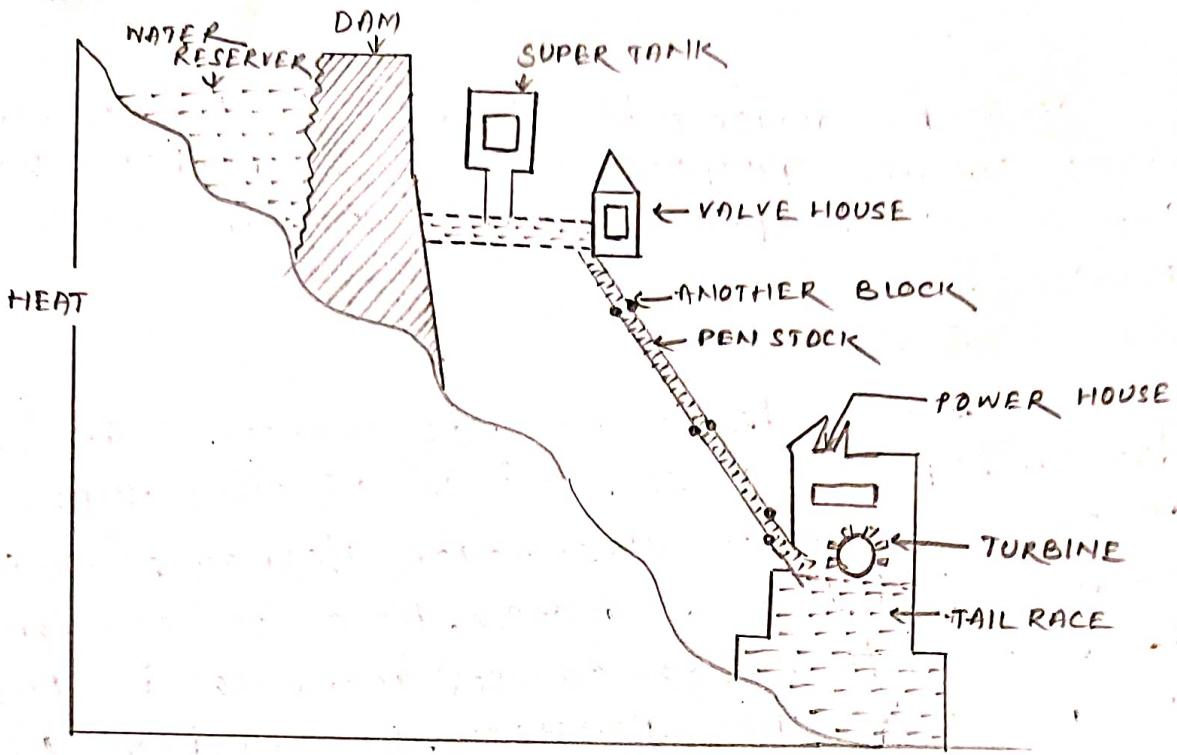
Standard a.c. meters indicate effective value only.
voltmeter indicate - 280V, Rms val.
 $280 = 0.707 V_{max}$

$$V_{max} = \frac{280}{0.707} = 395 \text{ V.}$$

FORM FACTOR or it is the ratio of effective value of average value.

$$\text{Form factor} = \frac{\text{effective value}}{\text{Average value}} = \frac{0.707}{0.636} = 1.11$$

SCHEMATIC ARRANGEMENT OF HYDRO-ELECTRIC POWER PLANT



(BLOCK DIAGRAM OF HYDRO POWER PLANT)

1. CATCHMENT AREA:-

In hydro electric power plant collect the rain water through surrounding hilly area, the surrounding all water collect & stored area to those place is known as catchment area.

2. RESERVOIR:-

The function of reservoir is to store the water near dam; this water is useful to drive the water turbines. The reservoir is useful to provide a head of stored water.

3. HEAD-RACE LEVEL:-

The water surface in the reservoir up to the dam is known as head-race level.

4. DAM:-

The dam is used hydro-electric power plant to store the water. Whenever the dam stored the power, it provides suitable head to this stored water. This stored water is useful throughout the year to run the hydro-electric power plant. Dam is made up of cement, concrete and sand materials.

5. SPILL WAY :-

The excess water from dam is discharged through spillway at a permissible level.

b. PENSTOCK :-

It is the device which is used in hydro-electric power plant for the purpose of flow of water. The water flow of from dam towards turbine with the help of Penstock.

7. SURGE TANK :-

It is a device which is connected in between dam and power house. It is of vertical type. When load on power plant or alternator decreases then Governor reduces discharge of water. Due to sudden reduction in water discharge causes increase in pressure of the water in the Penstock. Due to high pressure Penstock may damage. At that time surge tank helps by storing this rejected water immediately.

8. GENERATOR :-

It is used to convert the mechanical energy into electrical energy. For that purpose that turbine and generator are mechanically coupled.

ADVANTAGES :-

- i) It requires no fuel as water is used for the generation of electrical energy.
- (ii) It is quite neat and clean as no smoke or ash is produced.
- (iii) Running cost is very less as water is used.
- (iv) It is simple in construction and requires less maintenance.
- (v) It can be started quickly as compared to thermal power station.
- (vi) In addition to generation of electrical energy these plants are also helpful in irrigation & control of floods.

DISADVANTAGES :-

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

NUCLEAR POWER PLANT :-

The power plant which uses nuclear energy of radioactive material (Uranium or Thorium) converted into electrical energy is known as nuclear plant.

As we know that, the freely moving neutrons bombarded with radioactive material (U_{92}^{235} or Th_{90}^{232}) the heat energy produced, with the help of this heat energy water a steam produced at high pressure & temperature. High pressure steam passes towards turbine where KE is converted to ME we know that, turbine and generator are mechanically coupled through this combination an electrical energy is produced in nuclear power plant.

SELECTION OF SITE FOR NUCLEAR POWER PLANT :-

1. AVAILABILITY OF WATER :-

Sufficient supply of water is obvious for generating steam & cooling purposes in nuclear power station.

2. DISPOSAL OF WASTE :-

The wastes of nuclear power station are radioactive and may cause severe health hazards. Because of this, special care to be taken during disposal of wastes of nuclear power plant.

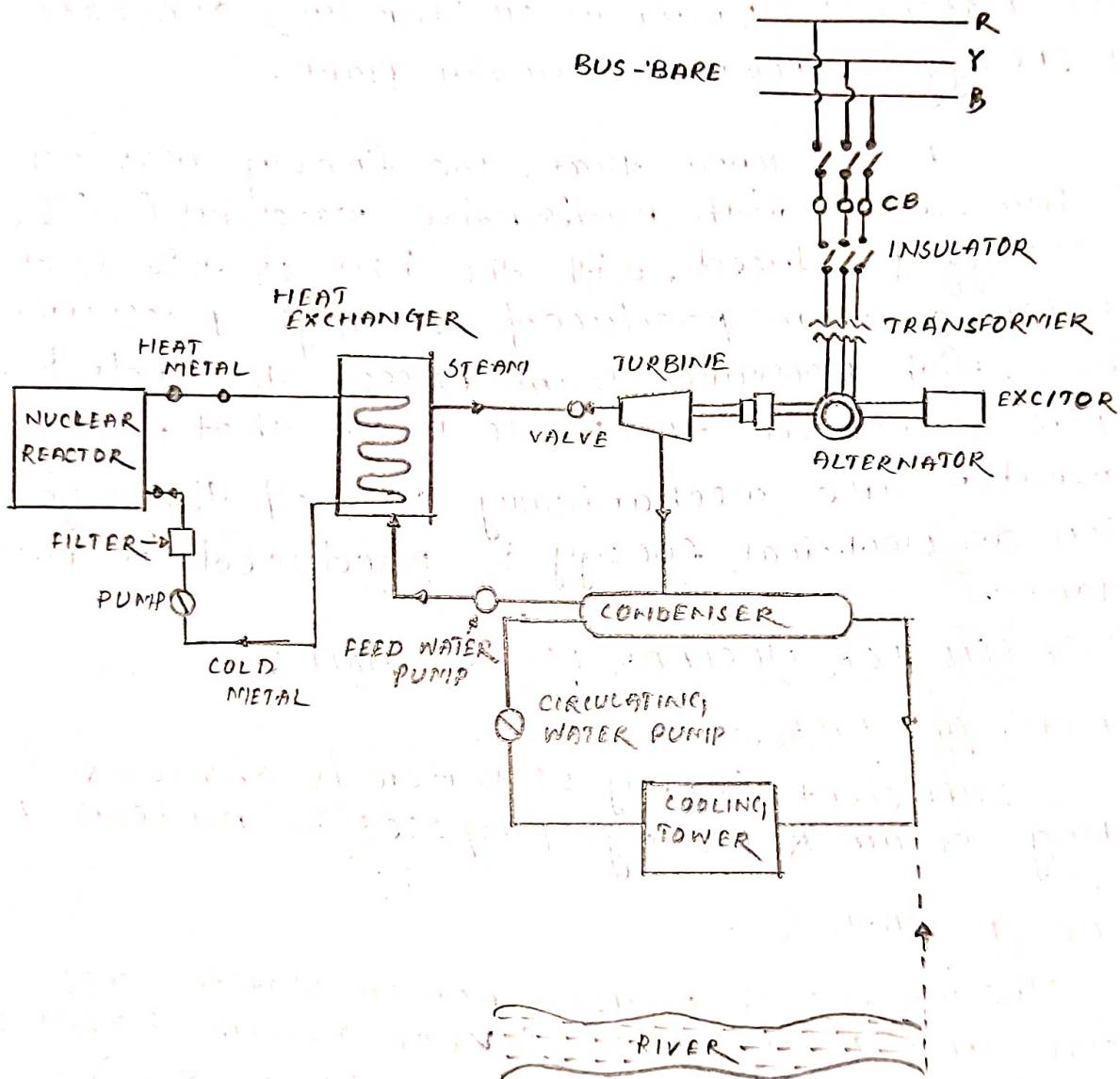
3. DISTANCE FROM POPULATED AREA :-

As there is always a probability of radioactivity it is always preferable to locate a nuclear station sufficiently away from populated area.

4. TRANSPORTATION FACILITIES :-

During commissioning period, heavy equipment to be erected, which to be transported from manufacturer site. So good railways and road ways availabilities are required.

SCHEMATIC ARRANGEMENT OF NUCLEAR POWER PLANT :-



(BLOCK DIAGRAM OF NUCLEAR POWER PLANT)

1. NUCLEAR FUEL :-

In nuclear power plant the fuels used are U^{235} or U^{238} . Out of these there fuel any one of the fuel used in nuclear power plant. The fuel is required in nuclear power plant to produce a huge amount of heat energy. The fuel are inserted in fuel rod. These fuel rods are bombarded with slow moving neutrons. Separate provision provided for bombardment or hits the neutrons to the fuel rod, this device is known as neutron bombardment device.

2. MODERATOR :-

In nuclear power plant, moderator is a device, of rod shaped. Moderator is placed near the nuclear fuel rod. The main function of moderator in nuclear power plant is reduce the speed of neutrons and increases the fission process. moderator rod is made up of graphite or heavy water or beryllium material.

3. CONTROL RODS :-

In nuclear power plant, the control rods are placed in between nuclear fuel rod, moderator and then control rod. In nuclear power plant the main function of control rod is to control the chain reaction. If the control rod is inserted then it absorbs the freely moving neutrons & stop the chain reaction, It is no inserted chain reaction is in process, means chain reaction continued. The steady rate or to stop the reaction maintained rods. The control rods are made up of cadmium, boron.

4. NUCLEAR REACTOR :-

It is an apparatus in which the nuclear fuel (U^{235}) is subjected to nuclear reactor.

5. HEAT EXCHANGER :-

The main function of heat exchanger is nuclear power plant is to boil the cold water and produce steam at high temperature & pressure.

b. TURBINE :-

Turbine receives steam from heat exchanger at high pressure, and it rotates at high speed then alternator also rotates, this way electrical power produced. The exhaust steam from turbine passes to condenser for further use.

ADVANTAGES :-

- i) There is saving in fuel transportation as amount of fuel required is less.
- ii) A nuclear power plant requires less space as compared to other plants.
- iii) This type of plant is economical for producing bulk electrical energy.

DISADVANTAGES :-

- i) Fuel is expensive and difficult to recover.
- ii) Capital cost is higher than other plants.
- iii) Experienced workmanship is required for plant erection & commissioning.
- iv) The fission by-products are radioactive & can cause dangerous radio-active pollution.

THERMAL POWER STATION

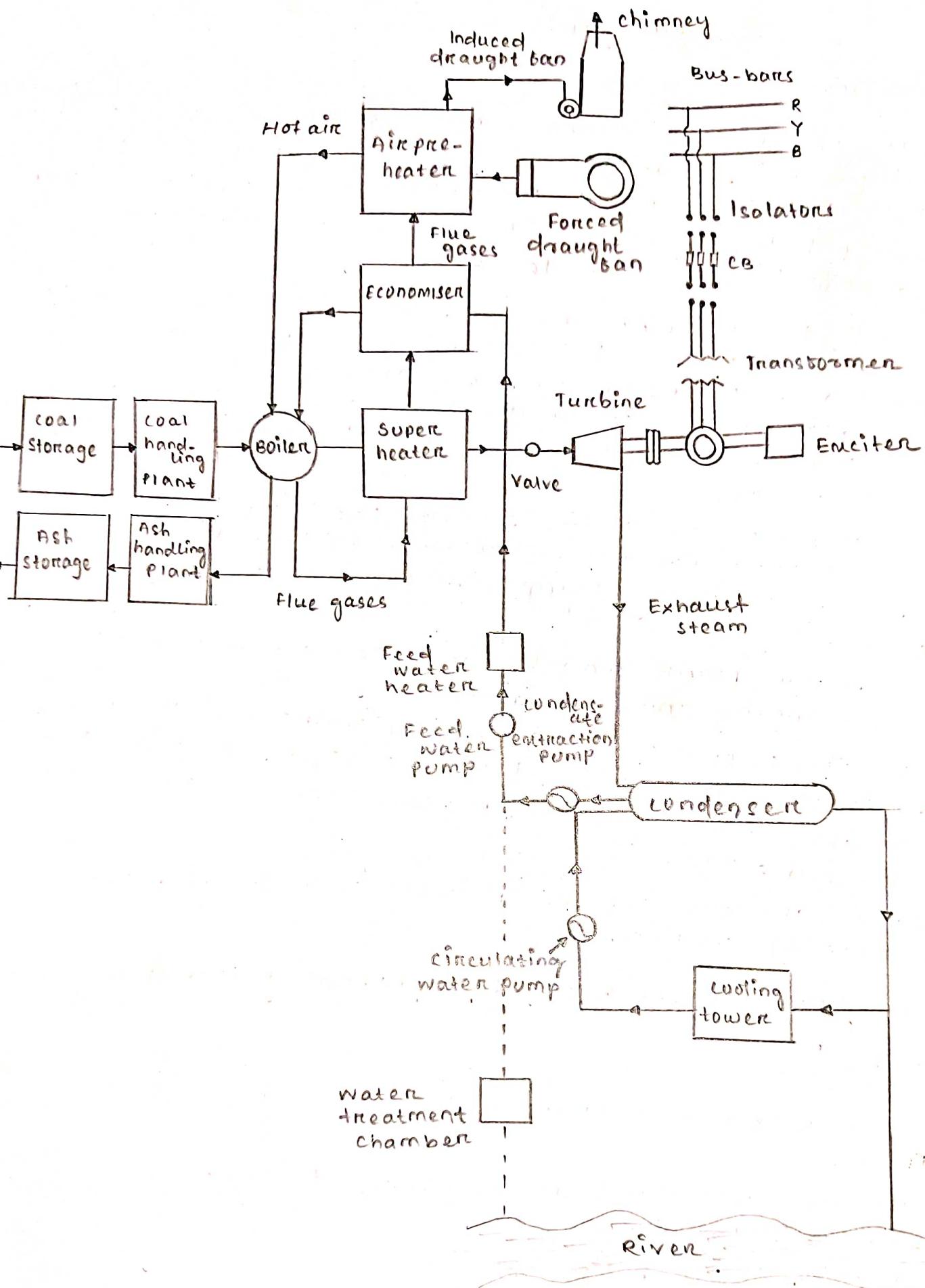
INTRODUCTION :-

- Thermal energy is the major source of power generation in India. More than 60% of electric power is produced by steam plants in India. India has large deposit of coal (about 170 billion tonnes), 5th largest in world. Indian coals are classified as A-G grade coals.
- In steam power plants, the heat of combustion of fossil fuels is utilized by the boilers to raise steam at high pressure and temperature. The steam so produced is used in driving the steam turbines or sometimes steam engines coupled to generators and thus in generating electrical energy.
- Steam turbines or steam engines used in steam power plants not only act as prime movers but also as drivers for auxiliary equipment, such as pumps, stokers, fans etc.
- Steam power plants may be installed either to generate electrical energy only or generate electrical energy along with generation of steam for industrial purposes such as in paper mills, textile mills, sugar mills and refineries, chemical works, plastic manufacture, food manufacture etc.
- Thermal stations can be private industrial plants and central station.

ADVANTAGES AND DISADVANTAGES OF A THERMAL POWER PLANT -

ADVANTAGES :-

- Less initial cost as compared to other generating stations.
- It requires less land as compared to hydro power plant.
- The fuel (i.e. coal) is cheaper.
- The cost of generation is lesser than that of diesel power plants.



(SCHEMATIC ARRANGEMENT OF STEAM POWER STATION)

- AVAILABILITY OF COAL :-

Huge amount of coal is required for carrying the steam. Since the government policy is to use the only low grade coal with 30 to 40% ash content for power generation purposes, the steam power plants should be located near the coal mines to avoid the transport of coal & ash.

- LAND REQUIREMENT :-

The land is required not only for setting up the plant but for other purposes also such as staff colony, coal storage, ash disposal etc.

Eg. For 2000mw plant, the land requirement may be of the order of 200-250 acres. As the cost of the land adds up to the final cost of the plant, it should be available at a reasonable price. Land should be available for future extension.

- TRANSPORTATION FACILITIES :-

The facilities must be available for transportation of heavy equipment and fuels eg. near railway station.

- LABOUR SUPPLIES :-

Skilled and unskilled labours should be available at reasonable rates near the site of the plant.

- ASH DISPOSAL :-

Ash is the main waste product of the steam power plant and with low grade coal. It may be 3.5 tones per day. Some suitable means for disposal of ash should be through ob. It may be purchased by building contractors.

- DISTANCE FROM POPULATED AREA :-

The continuous burning of coal at the power station produces smoke, fumes and ash which positive pollute the surrounding area.

DISADVANTAGES :-

- It pollutes the atmosphere due to the production of large amount of smoke. This is one of the causes of global warming.
- The overall efficiency of a thermal power station is low (less than 30%).
- Requires long time for erection and put into action.
- costlier in operating with that of hydro and nuclear power plants.
- Requirement of water in huge quantity.

SELECTION OF SITE FOR THERMAL POWER PLANT -

• NEARNESS TO LOAD CENTRE :-

The power plant should be as near as possible to the load centre to the centre of load. So that the transmission cost losses are minimum. This factor is most important when DC supply system is adopted. However in the case of AC supply when transformation of energy from lower voltage to higher voltage and vice versa is possible power plants can be created at places other than that of load provided other conditions are favorable.

• WATER RESOURCES :-

For the construction and operating of power plant large volumes of water are required for the following reasons:

- (i) To raise the steam in boiler
- (ii) For cooling purpose such as in condensers
- (iii) As a carrying medium such as disposal of ash.
- (iv) For drinking purposes.

→ This could be supplied from either rivers or underground water resources. Therefore having enough water supplies in defined vicinity can be a factor in the selection of site.

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MAJOR COMPONENTS OF A THERMAL POWER PLANT:-

- BOILER
- ASH HANDLING PLANT
- TURBINE
- CONDENSER
- ECONOMISER
- AIR PRE HEATER

BOILER:-

- A boiler is a closed vessel in which water, under pressure, is converted into steam. The heat is transferred to the boiler by all three modes of heat transfer i.e. conduction, convection and radiation.
- Major type of boilers are :
 - (i) Fire tube boiler and
 - (ii) Water tube boiler
- Generally, water tube boilers are used for electric power stations.

ECONOMIZER:-

- Boilers are provided with economizer and air pre-heater to recover heat from flue gases. An increase of about 20% in boiler efficiency is achieved by providing both economizer and air pre heaters.
- Economizer alone gives only 10-12% efficiency increase, causes saving in fuel consumption 5-15%. The feed water from the high pressure heaters enters the economizer and picks up heat from the flue gases after the low temperature super heater.
- Economizer can be classified as an inline or staggered arrangement based on the type of tube arrangement.
- For pressure of 70 kg/cm^2 or more economizer becomes a necessity.
- The tubes are arranged in parallel continuous loops.

AIR PREHEATERS :-

- After the flue gases leave economizer, some further heat can be extracted from them and is used to heat the incoming air for combustion.
- Air preheaters may be of following types:
 - Plate
 - Tubular
 - Regenerative
- Cooling of flue gases by 20° increase the efficiency of the plant by 1%.
- In order to avoid corrosion of the preheaters, the gases should not be cooled below the dew point.

STEAM TURBINES :-

- Steam entering from a small opening attains a very high velocity.
- The velocity attained during expansion depends on the initial and final content of the steam.
- The difference in initial and final heat content present the heat energy to be converted to kinetic energy.
- There are two types of steam turbines:-
 - 1) Impulse
 - 2) Reaction

CONDENSERS :-

- The function of the condenser is to condense the steam exiting the turbine. The condenser helps maintain low pressure at the exhaust.
- Two types of condensers are used.
 - 1) Jet condenser
 - 2) Surface condenser

ELECTROSTATIC PRECIPITATORS :-

04

- An electrostatic precipitator, or electrostatic air cleaner is a particular collection device that removes particles from a flowing gas using the force of an induced electrostatic charge.
- The basic idea of an ESP.
 - Charging
 - Collection
 - Removing
- Every particle either has or can be given a charge - Positive or negative.
- We impart a negative charge to all the particles in a gas stream in ESP
- Then a grounded plate having a positive charge is setup.