Conventional and Non conventional Sources of Energy

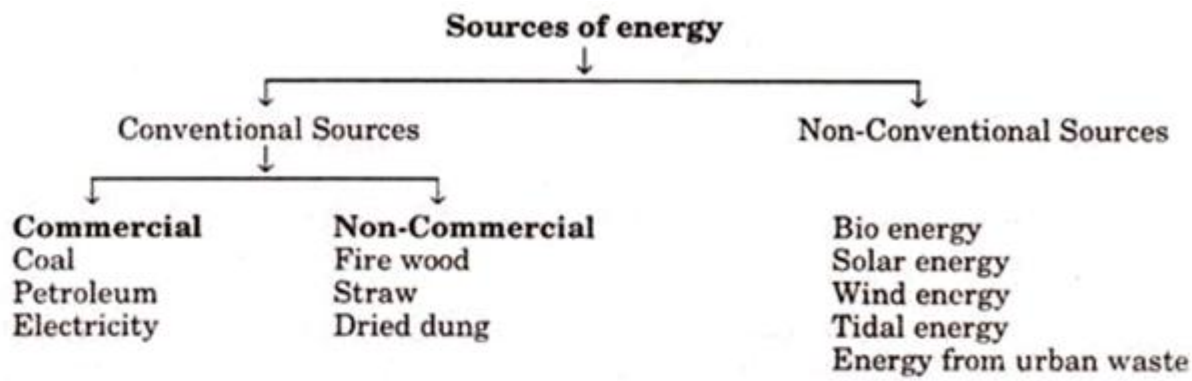
Energy is one of the major parts of the economic infrastructure, being the basic input needed to sustain the economic growth. There exists a strong relationship between economic development and energy consumption.

The more developed is a country; higher is the per capita of energy consumption and vice-versa. Human civilization relies on different sources of energy.

The two major sources of energy can be classified under:

1. **Conventional Sources**
2. **Non-Conventional Sources**

Below you could see the difference between conventional and non-conventional sources of energy.



What are Conventional Sources of Energy?

These sources of energy are also known as non-renewable sources of energy and are available in limited quantity apart from hydro-electric power. Further it can be classified under commercial and non-commercial energy.

Commercial Energy Sources

The coal, electricity and petroleum are known as commercial energy since the consumer needs to pay its price to buy them.

a) Coal

Coal is the most important source of energy. There are more than 148790 Coal deposits in India. In between 2005-2006, the annual production went up to 343 million tons. India is the fourth largest coal-producing country and the deposits are mostly found in Bihar, Orissa, Madhya Pradesh and Bengal.

b) Oil and Natural Gas:

Today oil is considered to be the liquid gold and one of the crucial sources of energy in India and the world. Oil is mostly used in planes, automobiles, trains and ships. It is mainly found in Assam, Gujarat and Mumbai.

The total production of oil in India was 0.3 million tons in 1950-51, which increased up to 32.4 million tons in 2000-01.

c) Electricity:

Electricity is a common source of energy and used for domestic and commercial purposes. The electricity is mainly utilized in electrical appliances like Fridge, T.V, washing machine and air conditioning.

The major sources of power generation are mentioned below:

1. Nuclear Power
2. Thermal Power
3. Hydro-electric power

1. Thermal Power:

Thermal power is generated at various power stations by means of oil and coal. It is a vital source of electric current and its share in total capacity of the nation in 2004-05 was 70 percent.

2. Hydroelectric Power:

The hydroelectric power is produced by constructing dams above flowing rivers like Damodar Valley Project and Bhakra Nangal Project. The installed capacity of hydroelectric power was 587.4 mW in 1950-51 and went up to 19600 mW in 2004-05.

3. Nuclear Power:

The fuel used in nuclear power plants is Uranium, which costs less than coal. Nuclear power plants can be found in Kota(Rajasthan), Naroura (UP) and Kalapakam(Chennai).

Non-commercial energy sources

Generally, the energy sources that are freely available are considered as the non-commercial energy sources. The examples of non-commercial energy sources are, Straw, dried dung, firewood.

What are Non-Conventional Sources of Energy?

These non-conventional sources are also known as renewable sources of energy. The examples include solar energy, bioenergy, tidal energy and wind energy.

1. **Solar Energy**

This is the energy that is produced by the sunlight. The photovoltaic cells are exposed to sunlight based on the form of electricity that needs to be produced. The energy is utilized for cooking and distillation of water.

2. **Wind Energy**

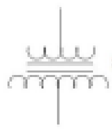
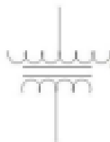
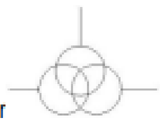
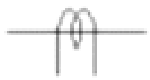
This kind of energy is generated by harnessing the power of wind and mostly used in operating water pumps for irrigation purposes. India stands as the second largest country in the generation of wind power.

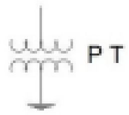
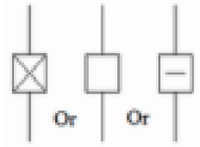
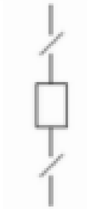
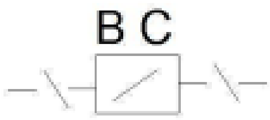
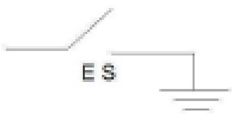
3. **Tidal Energy**

The energy that is generated by exploiting the tidal waves of the sea is known as tidal energy. This source is yet to be tapped due to the lack of cost-effective technology.

Symbols for Equipment in Sub-Stations

It is a usual practice to show the various elements (e.g.transformer, circuit breaker, isolator, instrument transformers etc.) of a sub-station by their graphic symbols in the connection schemes. Symbols of important equipment in sub-station are given below.

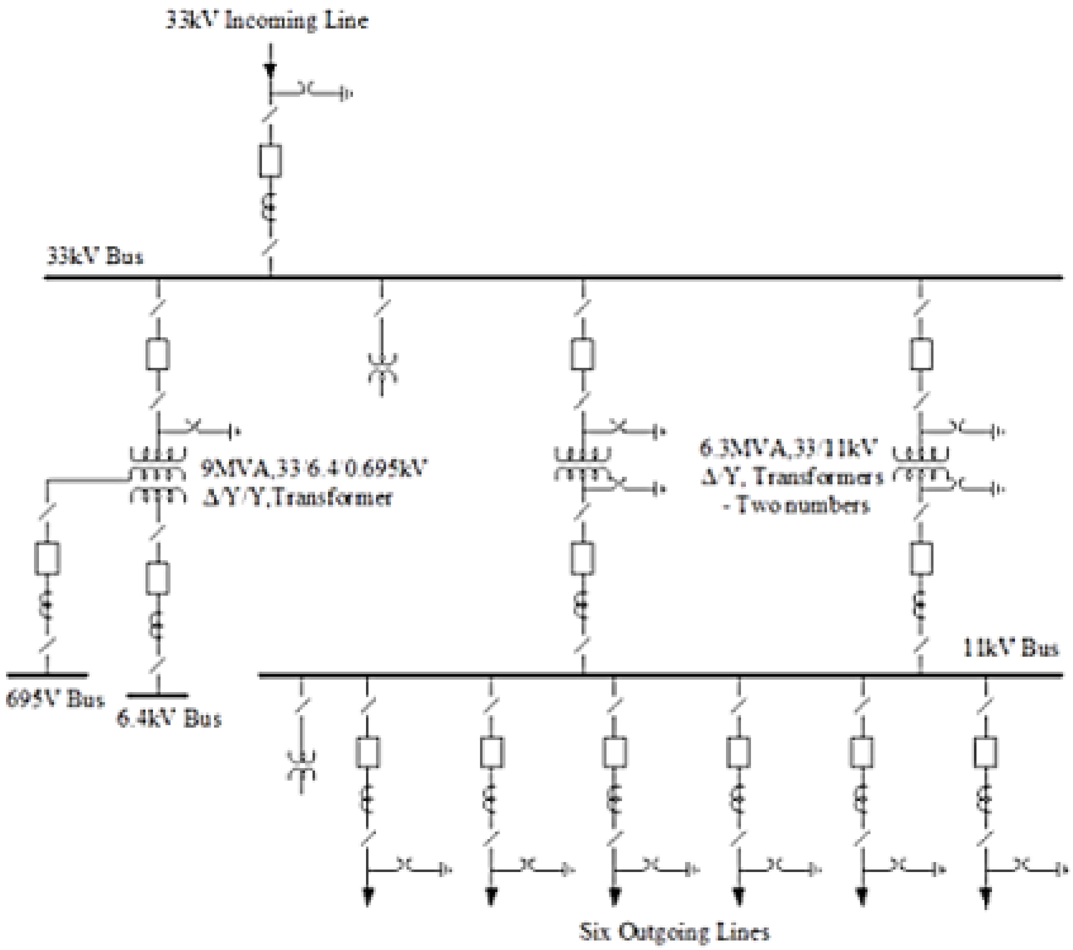
Sl No.	Circuit Element	Symbol
1.	Bus-bar	
2.	Isolator	 ISO
3.	AC Generator or Alternator	
4.	Power Transformer –Step Up	 STEP UP TRF.
5.	Power Transformer –Step Down	 STEP DOWN TRF.
6.	Three Winding Transformer	 or 
7.	Current Transformer (CT)	 CT

8.	Potential or Voltage Transformer(PT)	
9.	Circuit Breaker(CB)	
10.	Circuit breaker with isolator	
11.	Oil Circuit Breaker (OCB)	
12.	Lighting Arrestor (LA)	
13.	Bus Coupler	
14.	Earthing Switch	

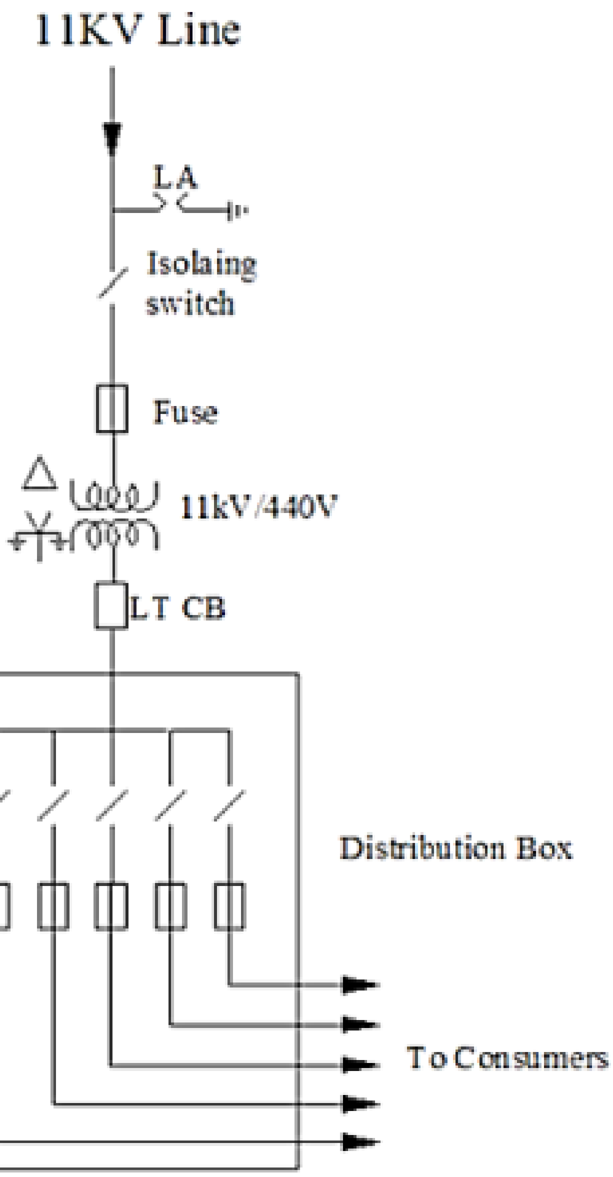
Q4. Draw the single line diagram of a 33/11kV substation having the following equipments

i) Incoming line: One, 33kV
ii) Outgoing lines: Six, 11kV
iii) Transformers- (a) One, 9MVA, 33/6.4/0.695kV, Δ/Y/Y
(b) Two, 6.3MVA, 33/11kV, Δ/Y

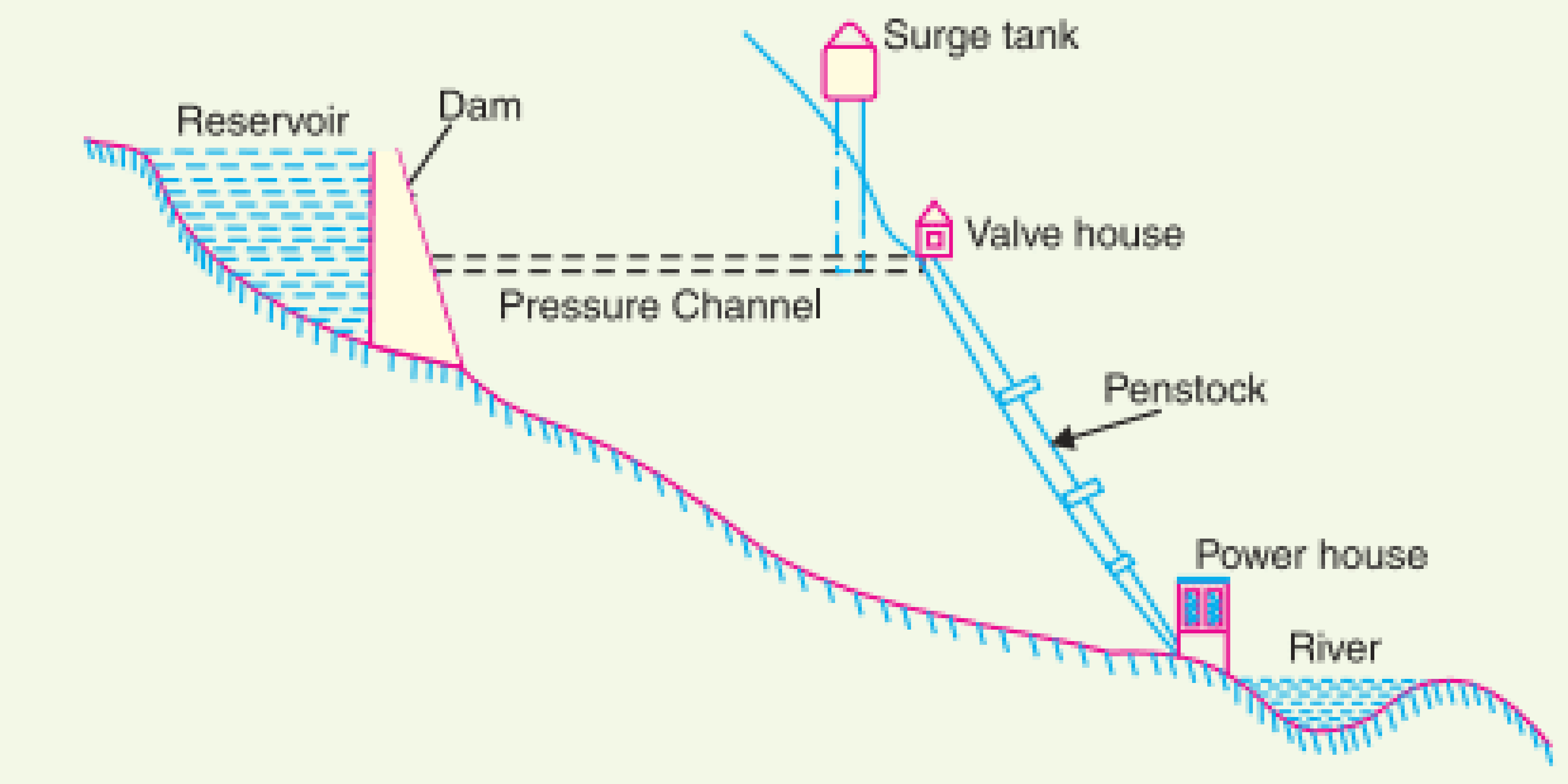
Show the positions of CTs, PTs, isolators, lightning arresters, circuit breakers.



Q7. Draw the single line diagram of a Pole Mounted Substation.



Hydel Power Generation



Schematic arrangement of a Hydro-electric plant

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

Dams are built of concrete or stone masonry, earth or rock fill.

The type and arrangement depends upon the topography of the site.

A masonry dam may be built in a narrow canyon.

An earth dam may be best suited for a wide valley.

The type of dam also depends upon the foundation conditions, local materials and transportation available, occurrence of earthquakes and other hazards.

At most of sites, more than one type of dam may be suitable and the one which is most economical is chosen.

Surge tank : A surge tank is located near the beginning of the conduit.

When the turbine is running at a steady load, there are no surges in the flow of water through the conduit. However, when the load on the turbine decreases, the governor closes the gates of turbine, reducing water supply to the turbine.

The excess water at the lower end of the conduit rushes back to the surge tank and increases its water level.

Valve House: The valve house contains main sluice valves and automatic isolating valves.

The former controls the water flow to the power house and the latter cuts off the supply of water when the penstock bursts.

From the valve house, water is taken to water turbine through a huge steel pipe known as penstock.

The water turbine converts hydraulic energy into mechanical energy.

The turbine drives the alternator which converts mechanical energy into electrical energy.

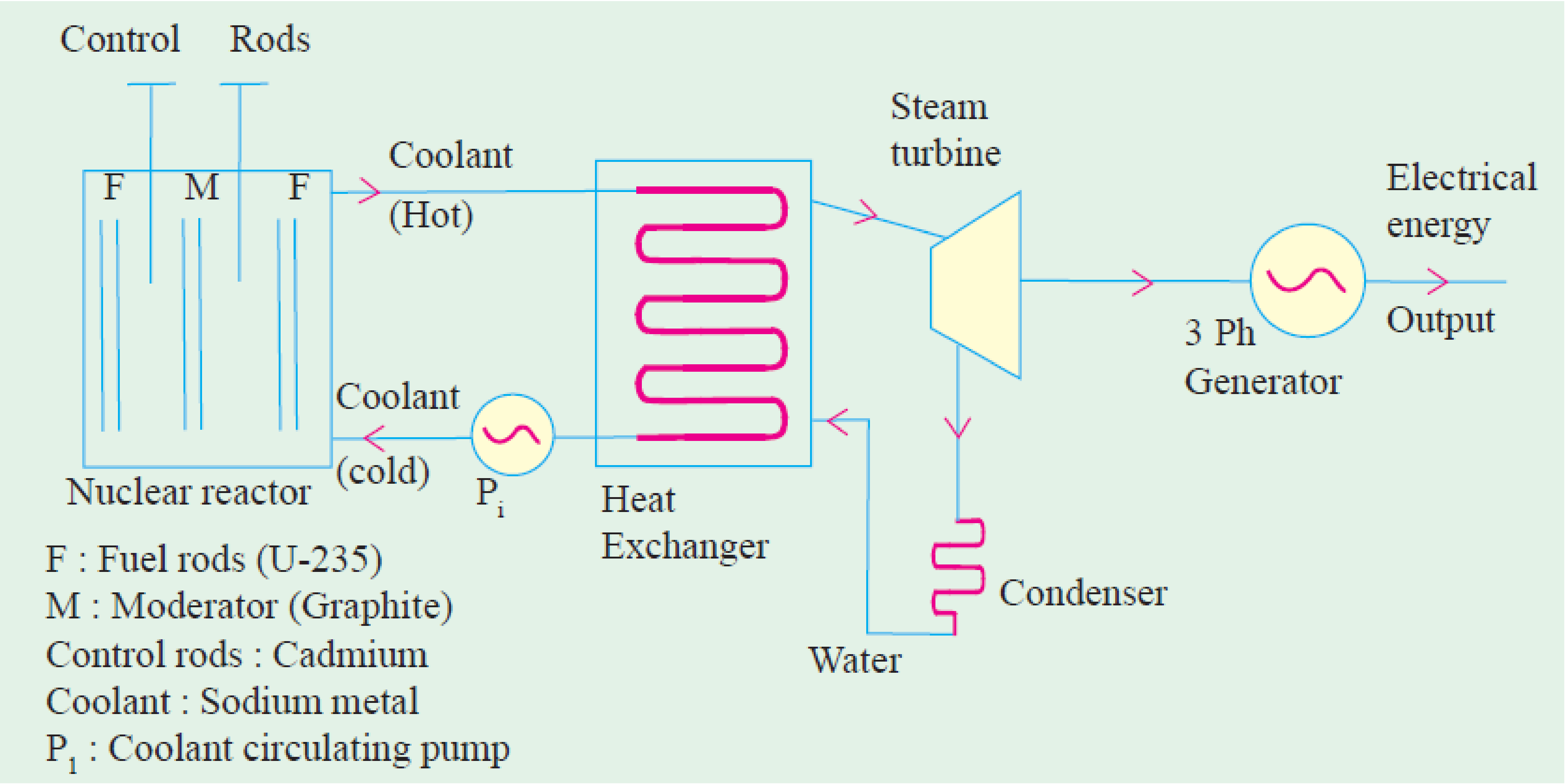
Penstocks : Penstocks are open or closed conduits which carry water to the turbines.

They are generally made of reinforced concrete or steel.

Concrete penstocks are suitable for low heads (< 30 m) as greater pressure causes rapid deterioration of concrete.

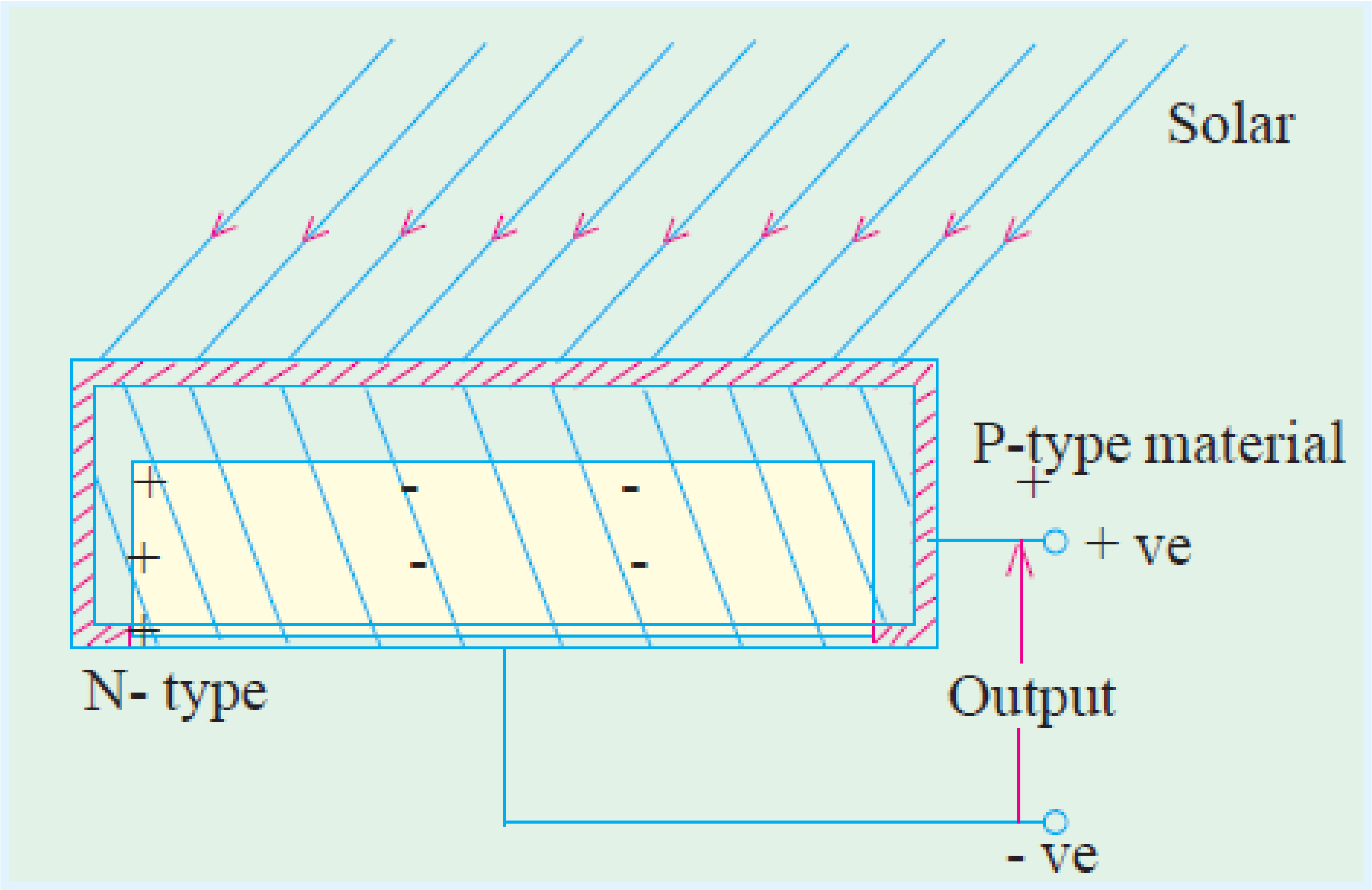
The steel penstocks can be designed for any head; the thickness of the penstock increases with the head or working pressure.

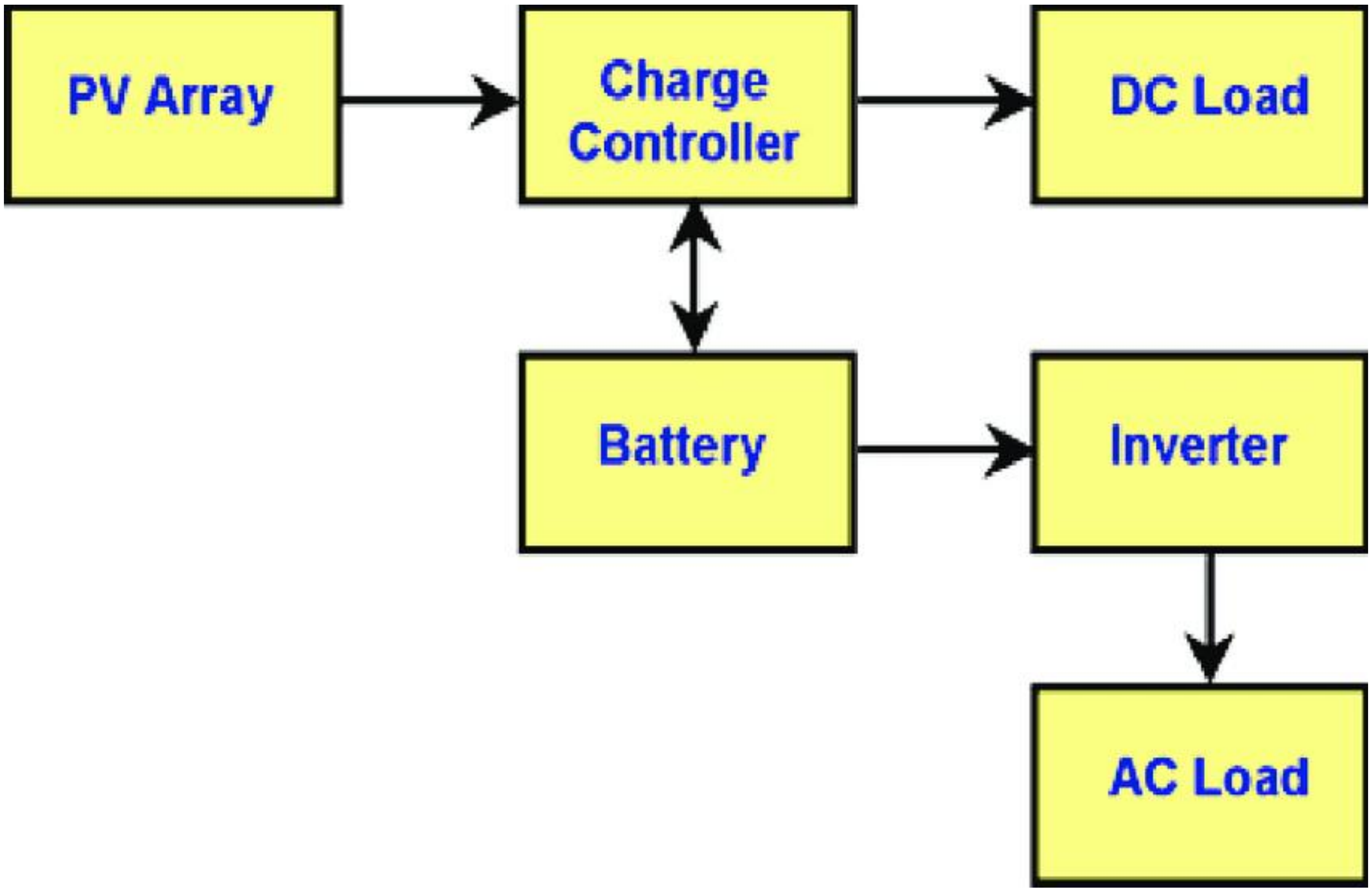
Schematic Diagram of a Nuclear Power Station indicating Main Components



- Nuclear energy is available as a result of fission reaction.
- In a typical system, Uranium 235 is bombarded with neutrons and Heat energy is released.
- In chain-reaction, these release more neutrons, since more Uranium 235 atoms are fissioned. Speeds of Neutrons must be reduced to critical speeds for the chain reaction to take place.
- Moderators (= speed-reducing agents like graphite, heavy water, etc). are used for this purpose. Nuclear fuel rods (of Uranium 235) must be embedded in speed reducing agents.
- Further, control rods (made of cadmium) are required since they are strong neutron absorbers and help in finely regulating this reaction so that power control of the generator is precisely obtainable. When control rods are pulled out and are away from fuel rods, intensity of chain reaction increases, which increases the power output of the system. While if they are pushed in and closer to the fuel rods, the power-output decreases. Thus, the electrical load demand on the generator decides (automatically) the control-rod positions through a very sophisticated control system.

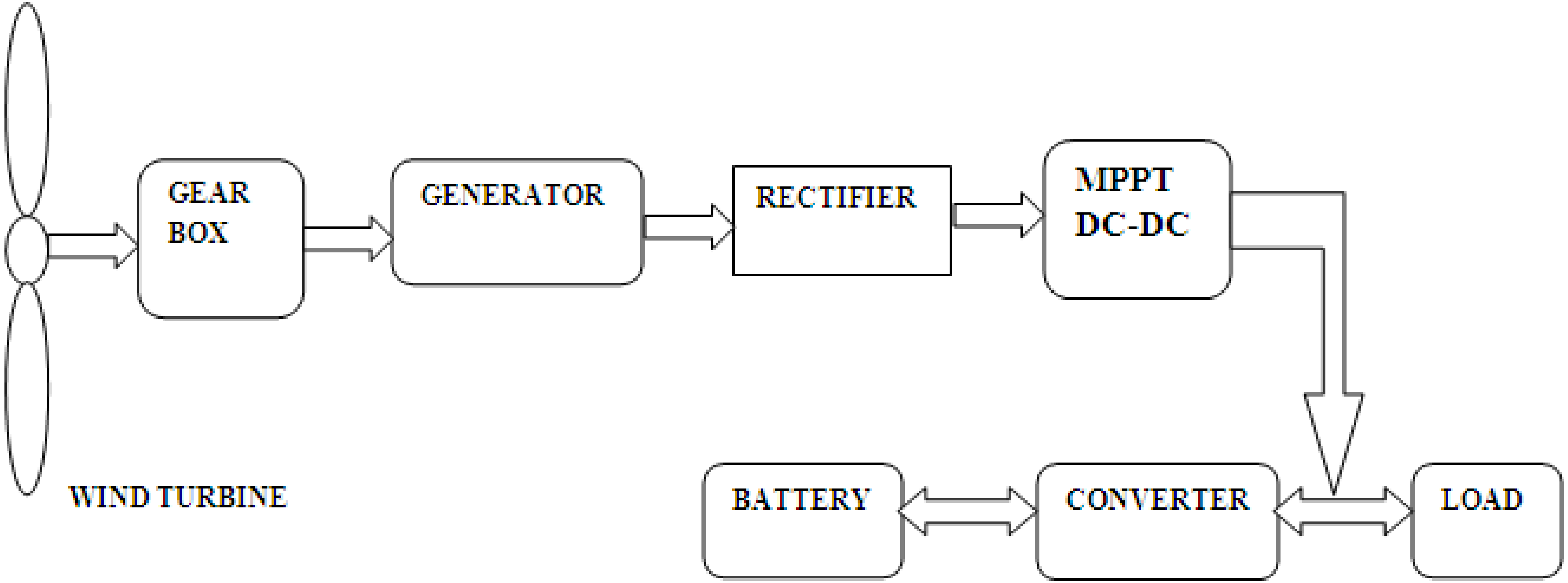
Photo Voltaic Cells (P.V. Cells or SOLAR Cells)




PV Array
Charge Controller
DC Load
Battery
Inverter
AC Load

- When ionized solar radiation is incident on a semi-conductor diode, energy conversion can take place with a voltage of 0.5 to 1 volt (d.c.) and a current density of 20-40 mA/cm2, depending on the materials used and the conditions of Sunlight.
- Area of these solar cells decides the current output. An array of large number of such diodes (i.e. Solar cells) results into higher d.c. output voltage.
- Since, the final form of electrical energy required is generally an alternating current, it is realized from d.c. using inverters.
- At quite a few locations in India, for realizing few hundred kilowatts of power-rating, huge arrays are accommodated in horizontal as well as vertical stacks, so that land area required is not too vast. Electrically, they are connected in series and in parallel combinations of cells so that rated voltage and current are realized.
- Just to understand the principle of operation of solar cells, let a semi-conductor diode receive ionized radiation from Sun, as in fig.1
- Best material may lead to the efficiency being typically 15%. Since solar energy is available free of cost, this low-efficiency does not matter.

Wind energy system block diagram



BASIC ELECTRICAL ENGINEERING

Material Prepared

by

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Ohm's Law:

Ohm's Law states that the current flowing through the conductor is directly proportional to the potential difference across a conductor, the temperature of the conductor remaining constant. The constant of proportionality is R, the resistance

$$V = I \times R \text{ Volts}$$

where R is the resistance of the conductor between the two points considered.

Limitations of Ohm's law:

- It does not apply to linear relationship between V and I does not apply to all non-metallic conductors. For example, for silicon carbide, the relationship is given by $V = KI^m$ where K and m are constants and m is less than unity.
- It does not apply to non-linear devices such as Zener diodes and voltage-regulator (VR) tubes.

ELECTRICAL POWER:

Power is the rate at which, the work is done and is expressed in Joules per second / Watt (W).

Ex. When one coulomb of electrical charge moves through a potential difference of one volt in one second the work done is one Joule/sec and in electrical engineering it is expressed as one Watt and is denoted by the symbol P.

So Power supplied, $P = E \times I$ Watts

Applying Ohm's Law for V, $P = (I \times R) \times I$ Watts

$$P = I^2 \times R \text{ Watts}$$

or Applying Ohm's Law for I, $P = V \times \frac{V}{R}$

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

ELECTRICAL ENERGY:

Electrical Energy is the total amount work done in a given time. The energy supplied for a time t seconds is given as,

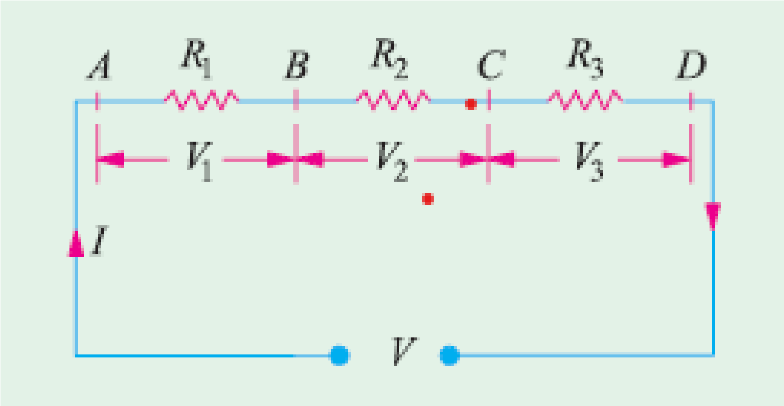
$$W = P \times t$$

$$= E \times I \times t \text{ Watt-sec}$$

$$= I^2 \times R \text{ x } t$$

$$= \frac{V^2}{R} \text{ x } t$$

Resistance in Series : Consider three resistances *R*1, *R*2 and *R*3 etc. are joined end-on-end as in Fig. below, they are said to be connected in series. It can be proved that the equivalent resistance or total resistance between points *A* and *D* is equal to the sum of the three individual resistances.



Being a series circuit, it should be remembered that

(*i*) current is the same through all the three conductors (*ii*) but voltage drop across each is different due to its different resistance and is given by Ohm's Law and (*iii*) sum of the three voltage drops is equal to the voltage applied across the three conductors.

$$V = V_1 + V_2 + V_3 = IR_1 + IR_2 + IR_3$$
$$V = IR$$

where *R* is the equivalent resistance of the series combination.

As seen from above, the main characteristics of a series circuit are :

1. same current flows through all parts of the circuit.
2. different resistors have their individual voltage drops.
3. voltage drops are additive.
4. applied voltage equals the sum of different voltage drops.
5. resistances are additive.
6. powers are additive.

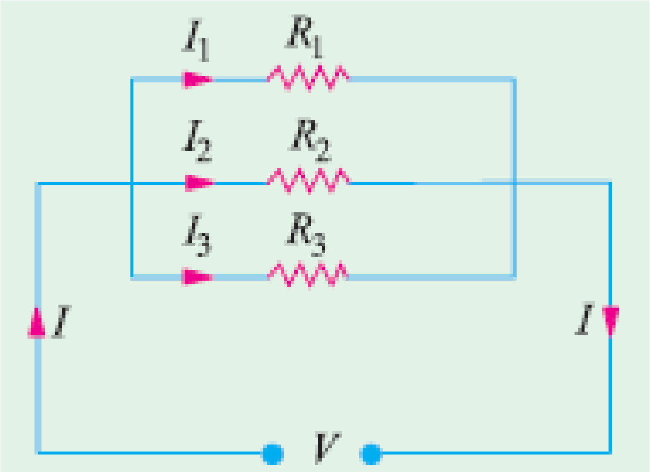
Resistances in Parallel :

Three resistances, are said to be connected in parallel.

Case ***(i)*** potential difference (p.d) across all resistances is the same

(ii) current in each resistor is different

(iii) the total current is the sum of the three separate currents.



$$I = I_1 + I_2 + I_3 = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$I = \frac{V}{R}$$ where V is the applied voltage.

R = equivalent resistance of the parallel combination.

The main characteristics of a parallel circuit are :

1. same voltage acts across all parts of the circuit

2. different resistors have their individual current.

3. branch currents are additive.

4. conductance's are additive.

5. powers are additive.

Voltage Divider

Consider the circuit as shown in the diagram below, where two resistance are connected in series with a voltage source "V"

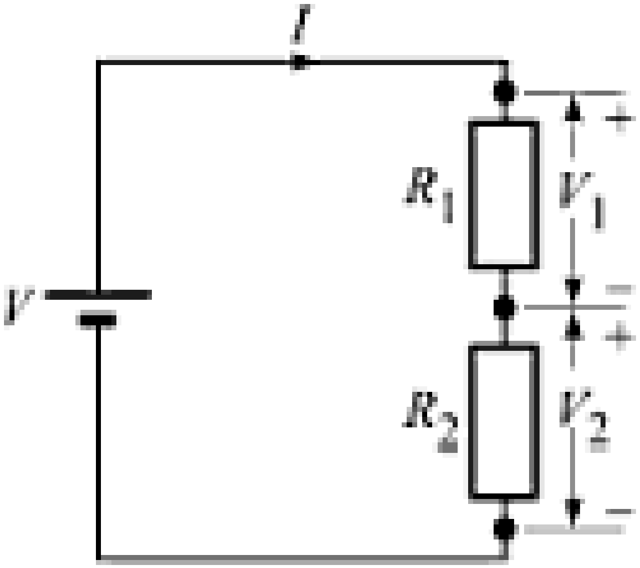


Illustration of voltage divider.

The current is given by

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

$$V_1 = IR_1 = \frac{V}{R_1 + R_2} R_1$$

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

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

Current Divider

Consider the circuit as shown in the diagram below, where two resistance are connected in parallel with a voltage source "V"

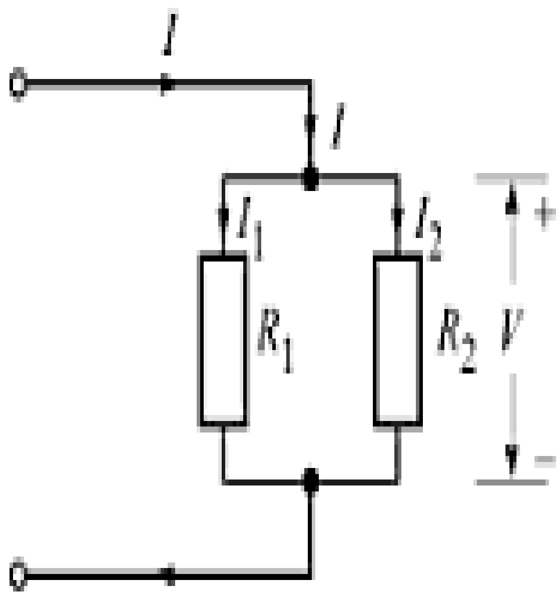


Illustration of current divider.

The voltage is given by

$$V = I_1 R_1 \quad \text{and} \quad V = I_2 R_2 \quad \text{or} \quad I_2 = \frac{I_1 R_1}{R_2}$$

$$I = I_1 + I_2 = I_1 + I_1 \frac{R_1}{R_2} = I_1 \left(\frac{R_1 + R_2}{R_2} \right)$$

$$I_1 = I \frac{R_2}{R_1 + R_2}$$

$$I_2 = I \frac{R_1}{R_1 + R_2}$$

Kirchhoff's Laws : The two-laws are :

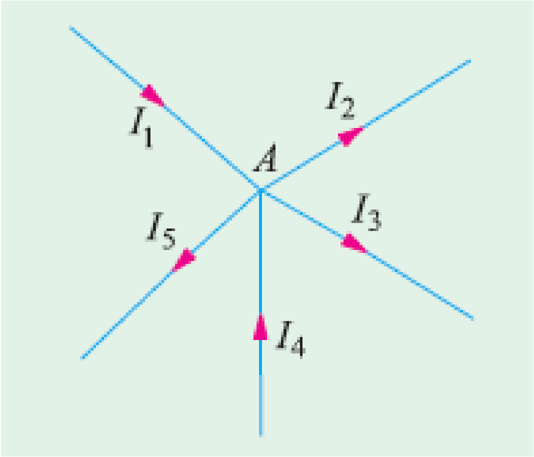
1. Kirchhoff's Current Law (KCL)

It states as follows : I***n any electrical network, the algebraic sum of the currents meeting at a point*** **(*or junction*) *is***

***zero*.**

$$\Sigma I = 0$$

In another way, it simply means that the total current *leaving* a junction is equal to the total current ***entering*** that junction.



I1 + I4 = I2 + I3 + I5

incoming currents = outgoing currents

2. Kirchhoff’s Voltage Law (KVL)

It states as follows : ***The algebraic sum of the products of currents and resistances in each of the conductors in any closed path (or mesh) in a network plus the algebraic sum of the e.m.fs. in that path is zero.***

In other words, $\Sigma\, IR + \Sigma\, e.m.f. = 0$

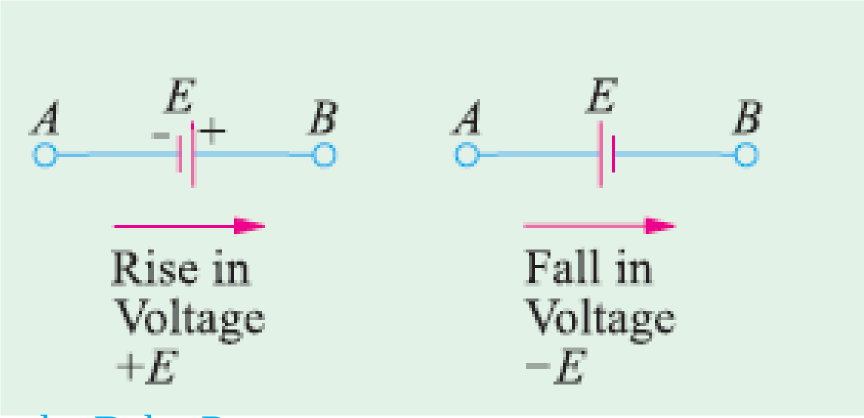
Determination of Voltage Sign :

In applying Kirchhoff’s laws to specific problems, particular attention should be paid to the algebraic signs of voltage drops and e.m.f’s., otherwise results will come out to be wrong. Following sign conventions is suggested :

(*a*) Sign of Battery E.M.F.

A *rise* in voltage should be given as + ve sign and a ***fall*** in voltage is given as –ve sign.

Keeping this in mind, it is clear that as we go from the –ve terminal of a battery to its +ve terminal (Shown in Fig.), there is a *rise* in potential, hence this voltage should be given a + ve sign. If, on the other hand, we go from +ve terminal to –ve terminal, then there is a *fall* in potential, hence this voltage should be preceded by a –ve sign. ***It is important to note that the sign of the battery e.m.f. is independent of the direction of the current through that branch.***

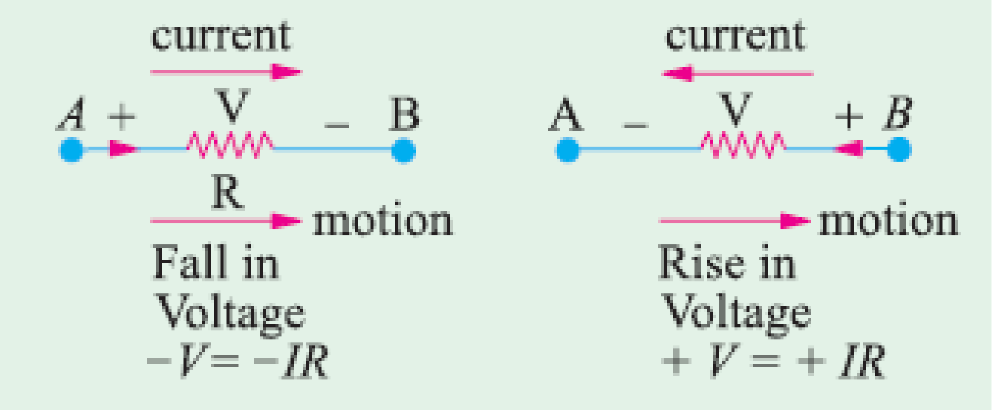


(b) Sign of IR Drop

Now, take the case of a resistor (Shown in Fig.). If we go through a resistor in the same direction as the current, then there is a fall in potential because current flows from a higher to a lower potential.

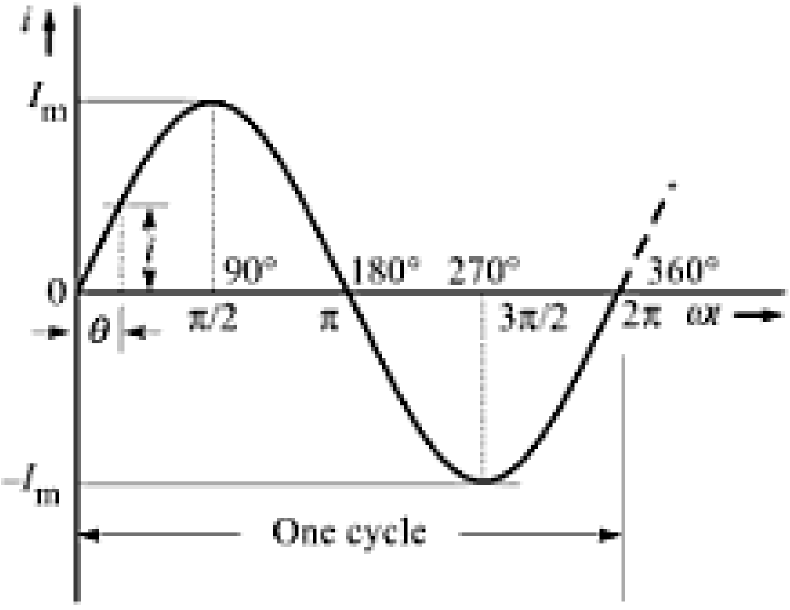
Hence, this voltage fall should be taken as −ve. However, if we go in a direction opposite to that of the current, then there is a rise in voltage. Hence, this voltage rise should be given a positive sign.

It is clear that the sign of voltage drop across a resistor depends on the direction of current through that resistor but is independent of the polarity of any other source of e.m.f. in the circuit under consideration.

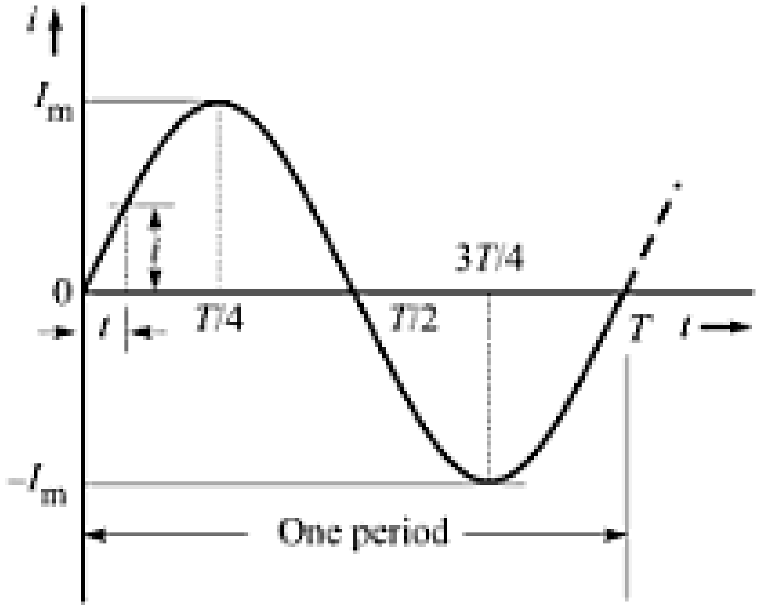


MODULE – 1 AC Fundamentals

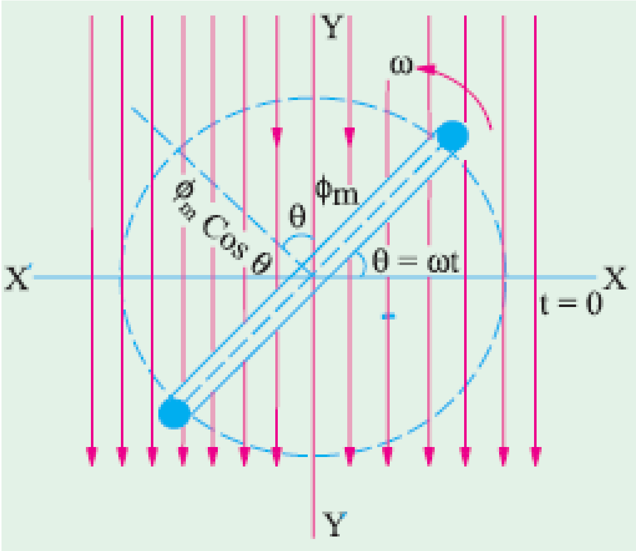
In AC power the voltage and current vary with time sinusoidaly. Such a variation is shown in figure below and is mathematically expressed as $I = I_m \sin \omega t$



(a) Current i versus angle ωt.



(b) Current i versus time t.



Consider a rectangular coil, having *N* turns and rotating in a uniform magnetic field, with an angular velocity of ω radian/second, as shown in Fig.

Let time be measured from the *X*-axis. Maximum flux Φm is linked with the coil, when its plane coincides with the *X*-axis. In time *t* seconds, this coil rotates through an angle $\theta = \omega t$.

In this deflected position, the component of the flux which is perpendicular to the plane of the coil, is $\Phi = \Phi m \cos \omega t$.

Hence, ***flux linkages*** of the coil at any time is $N\,\Phi = N\,\Phi m \cos \omega t$.

According to Faraday's Laws of Electromagnetic Induction, the e.m.f. induced in the coil is given by the rate of change of flux-linkages of the coil.

Hence, the value of the induced e.m.f. at this instant is

$$e = -\frac{d\varphi}{dt} = -\frac{d(N\,\Phi m\cos\omega t)}{dt} = -N\Phi_m\,\omega\,(-\sin\omega t)\ \text{volt}$$

When the coil has turned through 90º *i.e.* when θ = 90º, then sin θ = 1, hence *e* has maximum value, say *Em*.

Then

$e = \omega N \Phi m \sin\theta$ volt $= Em \sin\omega t$

Where $E_m = \omega N \Phi_m = 2\pi f N \Phi_m = 2\pi f N B m A$

Where *Bm* = maximum flux density in Wb/m^2 ; *A* = area of the coil in m^2, *f* = frequency of rotation of the coil in rev/second

$e = E_m \sin\theta = E_m \sin\omega t$ and $i = I_m \sin\omega t$

Cycle : One complete set of positive and negative values of alternating quantity is known as cycle.

Time Period: The time taken by an alternating quantity to complete one cycle is called its time period T.
T = time-period of the alternating voltage or current = 1/f
For example, a 50-Hz alternating current has a time period of 1/50 second.

Frequency : The number of cycles/second is called the frequency of the alternating quantity. Its unit is hertz (Hz).

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