SWAMI VIVEKANANDA SCHOOL OF ENGG. AND TECHNOLOGY

LECTURE NAME - SONALI SUSMITA TRIPATHY

SUB. NAME - GENERATION TRANSMISSION AND DISTRIBUTION

Ch- Generation of Electricity

Electrical energy is generated by conversion of energy available in different forms from different natural sources such as kinetic energy of blowing winds, Pressure head of water, chemical energy of fuels and Nuclear energy etc.

Some Main Generating station

The plant where bulk power energy is produced are known as generating power station.

Some main generating station are

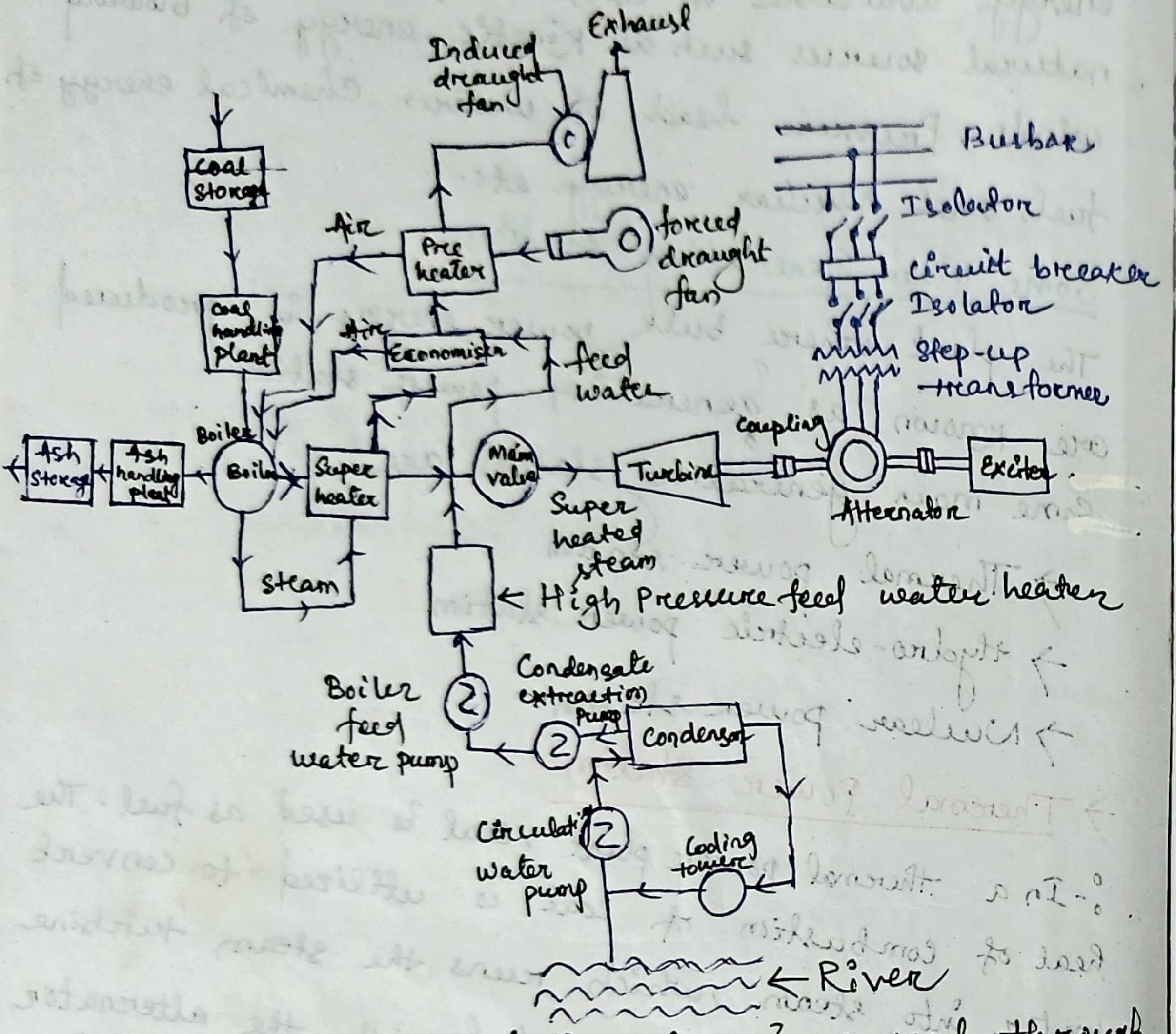
- → Thermal power station
- → Hydro-electric power station
- → Nuclear power station

→ Thermal Power Station

:- In a thermal power plant, coal is used as fuel. The heat of combustion of coal is utilized to convert water into steam, which runs the steam turbine. The steam turbine is coupled with the alternator from which electrical energy is obtained.

Elements of ~~Hydroelectric~~ Thermal power plant

1. **Boiler** :- The heat of combustion produced by burning coal in the boiler is used to heat up water and to convert it into steam.
2. **Super Heater** :- The wet steam from the boiler is passed through super heater where it is dried. The dry and superheated steam from the super heater is allowed to be injected into the steam turbine blade, through main steam valve



3. <u>Economiser</u> :- The feed water is passed through the economiser before supplying it to the boiler. The function of Economiser is to preheat the feed water by utilizing the heat of flue gas.

4. <u>Air Preheater</u> :- The air is drawn from the atmosphere by a forced draught fan and is passed through the air pre heater and it is heated by utilizing the heat.

5. <u>Steam turbine</u> :- The dry and super heated steam from the super heater is fed to the steam turbine through the main steam valve. Here

heat energy of steam is converted into mechanical energy. The used steam is exhausted to the condenser where it is convered to water which is again fed to the boiler.

6. Electrical plant :- The alternator and turbine are coupled to each other. The mechanical power of turbine is converted to electrical power by alternator.

7. Exciter :- The exciter for exciting the field coils of the alternator is a permanent DC compound generator and it is mounted on the same shaft.

8. Water treatment chamber :- Clean and soft water is required for the boiler for their long life.

→ The water taken from the river is stored in the storage tank and chemical treatment is done to make it soft and clean.

9. Control room :- The control room houses all the measuring instruments for each pannel of alternator, synchronizing gear, protective gears automatic voltage regulator etc.

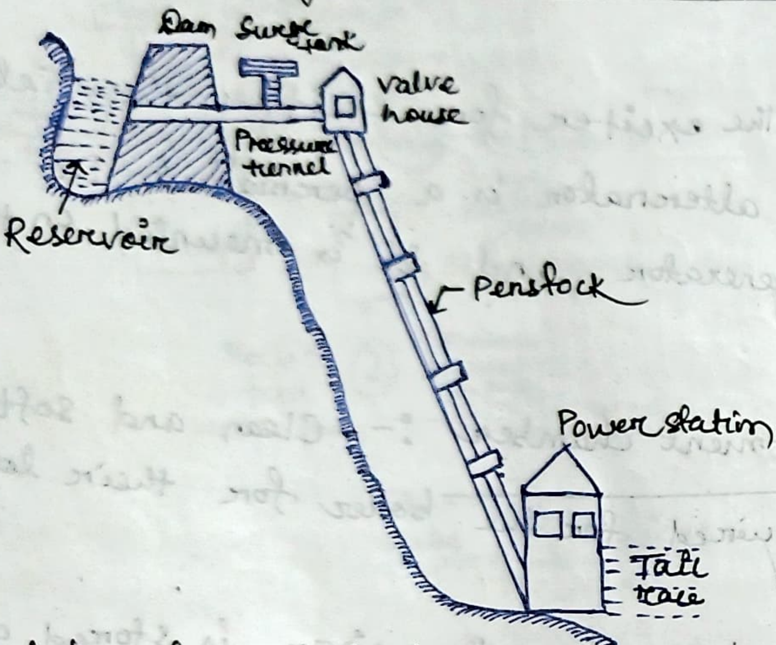
10. Switch Yard :- The switch yard houses transformer, circuit breaker and switches for connecting and disconnecting.

Hydroelectric Power Station

:- In hydroelectric plant the energy contained in water is utilized to rotate hydraulic turbines to which are coupled electrical generators.

:- Water laying at height contains potential energy where as fast moving rivers contain kinetic energy.

Elements of hydroelectric Power Plant



1. Catchment Area :- It is the area over which rainfall is collected and led to the reservoir.
2. Water Reservoir :- Water is stored in the catchment area in large quantity from where it is led to the water reservoir.
3. Dam :- The function of dam is to create water head.
   :- the water from the resorevoir is brought to surge tank through the pressure channel.
4. Valve house :- Valve house which contains main valve for controlling the water flow.
5. Penstock :- The huge steel or concrete pipe that conveys the water from valve house to water turbine.

6. Hydraulic Turbine :- The turbine converts the water energy into mechanical energy.

7. Surge tank :- It act as the storage of water which is sufficient for one day or for specific period of time.

8. Pressure channel :- It is constructed between reservoir and valve house to carry water from reservoir to valve house.

9. Alternator :- The turbine is coupled with the alternator which converts the mechanical energy to electrical energy.

10. Exciter :- The exciter for exciting the field coil of alternator is a permanent magnet dc compound generator.

11. Tail race :- After water is done its useful work it is discharged to the tail race.

12. Control room :- All controlling equipment, protective devices, indicating instruments are placed on the panel.

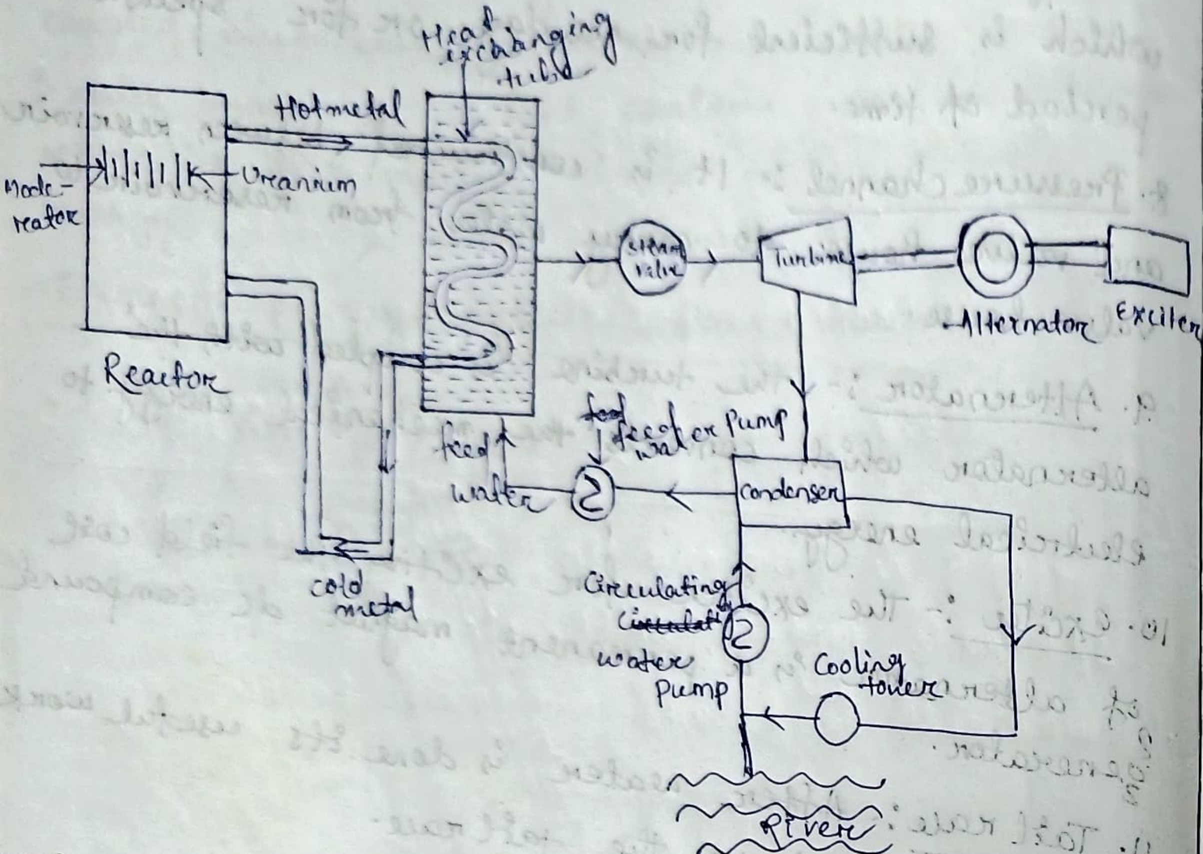
Nuclear Power Station

:- In this power station there is a ~~heat~~ nuclear reactor which is used as the source of heat.

:- Uranium, Thorium, and ~~platinu~~ plutonium are the main nuclear fuel.

:- The nuclear fuel are a highly concentrated forms of energy and are high atomic weight metals.

:- By fission process in a nuclear reactor, the above substance become unstable and become metals of lower atomic weight like silicon, nickel etc.



∴ The whole arrangement of nuclear power plant can be divided into following stages.

1. Nuclear reactor
2. Heat exchanger
3. Steam turbine
4. Alternator

:- High atomic weight substance (U_{235}) undergoes the process of nuclear fission in the nuclear reactor. In this process heat is produced.

:- The produced heat is given to liquid sodium metal which carries the heat to the heat exchanger. The liquid sodium metal is called working substance.

:- In the heat exchanger the heat of working substance is utilized to heat-up the water and convert it into steam.

:- After giving up heat the working substance is again fed to the reactor.

:- The steam produced in the heat exchanger is fed to the steam turbine through steam valve. Here the heat energy is converted into mechanical energy.

:- The steam turbine is coupled with the alternator which convert the mechanical energy to electrical energy.

:- The electrical energy is carried on to the busbars through a step up transformers, isolator and circuit breaker.

Introduction to Solar Plant

Solar cells :-

:- Solar cells are device, which directly convert incident solar radiation to electric current.

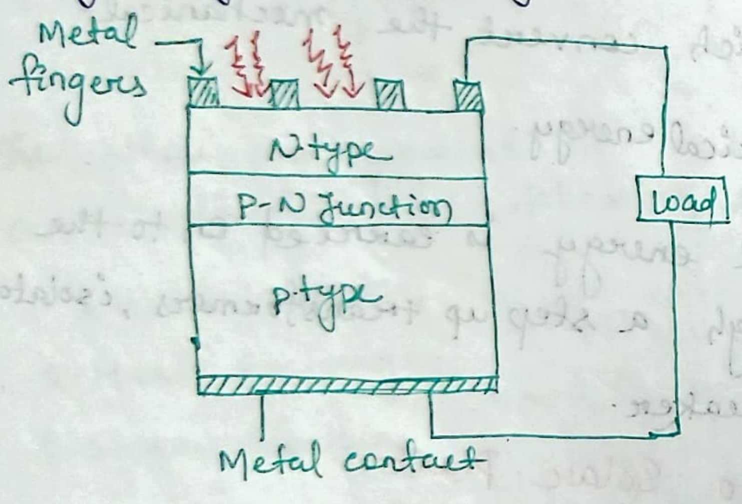
:- It works on the principle of photoelectric effect. So this is called photovoltaic cells.

:- It works on the principle of photoelectric effect. Thats why this is called photovoltaic cell.

:- photo electric effect is the phenomenon in which electrons are ejected from the surface of a metal when light is incident on it. These ejected electrons are called photoelectrons.

Construction and working of P-V cell

:- For construction all we need is P type and N type materials. Here P-type should be large layered and N-type should be thin layered.



:- The N type should be thin layer because thin layer make easy to penetrate the sunlight to the junction or depletion layer.

:- On N type metal finger is placed and the P type is made in contact to the metal.

:- the metal finger is covered with a transparent sheet or non-reflectable material.

:- when the sun light is incident on N layer it is reached to the depletion layer.

:- when light falls on junction e's are ejected according to intensity of light.

:- Now it is form a potential accross the P~N junction.

:- The e's will flow from n layer to p-layer by an external circuit and current will flow opposite to the flow of electron.

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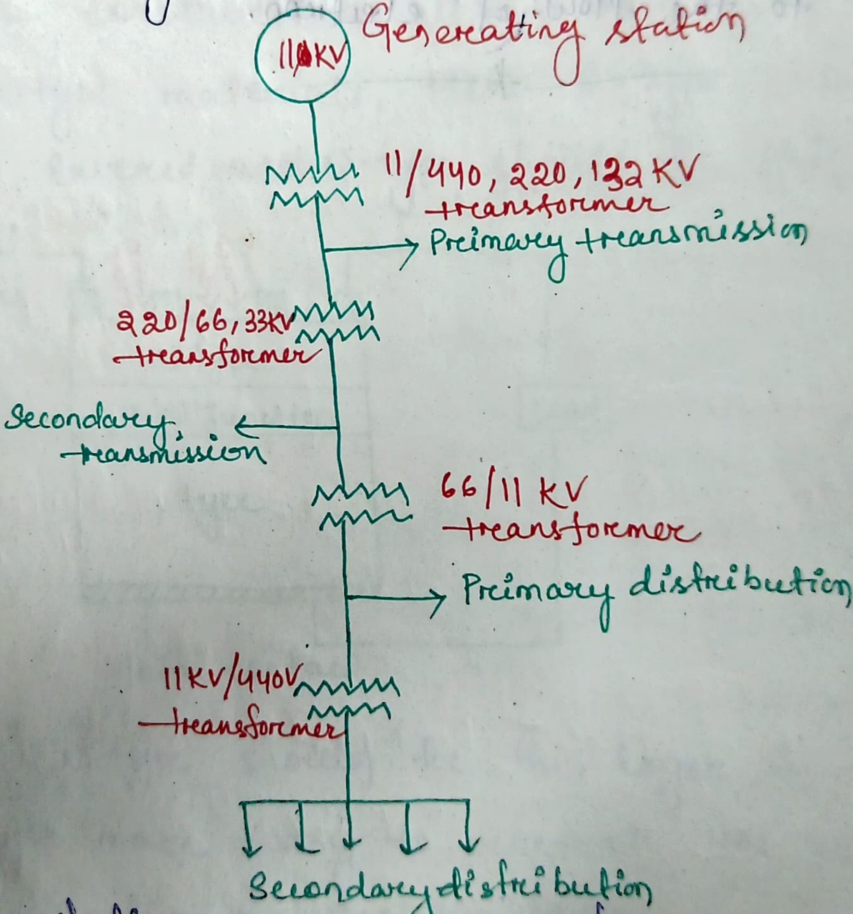
Ch- Transmission of Electric Power

Layout of transmission and distribution scheme

The transmission and distribution of power system consisting of the following stages.

1. Power station or generating station
2. Primary transmission
3. Secondary transmission
4. Primary distribution
5. Secondary distribution



1. **Power station** :- It is also called generating station. Here the power is generated at 11KV, which is further stepped up to 400KV or 200KV or 132KV for primary transmission.

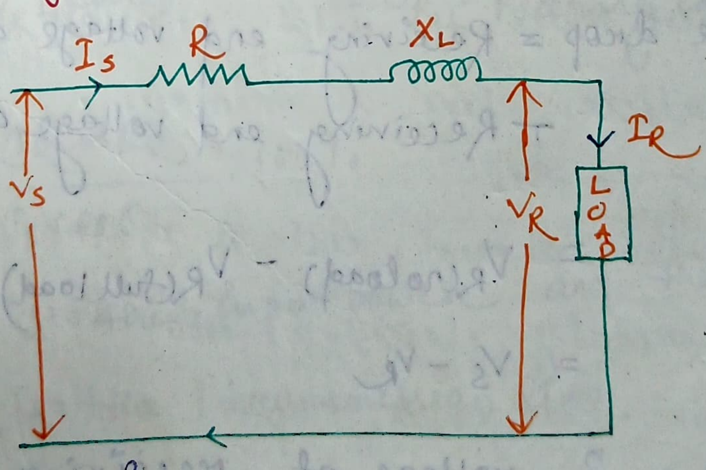
2. **Primary transmission** :- After stepping up power at 400KV, 220KV it is given to big consumers by 3 phase, 3 wire overhead system.

3. Secondary transmission :- Power is stepped down to ~~66 KV/33~~ 66 KV, 33 KV and is given to consumers.

4. Primary distribution :- Power is stepped down again to 11 KV and 3 phase 3 wire lines runs along important roads of the city. This is given to big industries.

5. Secondary distribution :- Now the 11 KV voltage is further stepped down to 400 V. The voltage between two phases is 400 V which is given to small industries. The voltage between phase and the neutral is 230 V and is given to domestic consumers.

Voltage Regulation of transmission line



V_s = Sending end voltage

V_R = Receiving end voltage

$I_s = I_R$ = Current through the line

Z = Line impedance = $R + jX$

:- When transmission line is carrying current there is a voltage drop across the impedance of the line.

:- Due to this voltage drop, normally receiving end voltage is less than the sending end voltage.

:- Suppose the line is unloaded, In this case the receiving end voltage and sending end voltage will be same as there is no current flowing through the transmission line.

:- But as soon as there is a flow of current, there will be a voltage drop.

Thus the voltage drop from no load to full load can be expressed as

voltage drop = Receiving end voltage at no load − Receiving end voltage at full load

$$= V_{R(no\ load)} - V_{R(full\ load)}$$

$$= V_S - V_R$$

this drop in voltage at receiving end when expressed as percentage of receiving end voltage V_R is known as voltage regulation of transmission line.

$$\%\ \text{Voltage regulation} = \frac{V_S - V_R}{V_R} \times 100$$

:- Thus the voltage regulation can be defined as "The drop in receiving end voltage from no load to full load expressed as percentage of receiving end voltage.

Transmission Efficiency

:- Transmission efficiency is a parameter which says how much percentage of input power at sending end is delivered to the receiving end.

:- Suppose sending end power = P_S MW

receiving end power = P_R MW

then % transmission efficiency, $\eta = \frac{P_R}{P_S} \times 100\ \%$

$P_S = V_S I_S \cos\theta_S$ $\qquad$ $\cos\theta_S$ = sending end power factor

$P_R = V_R I_R \cos\theta_R$ $\qquad$ $\cos\theta_R$ = Receiving end power factor

$$\eta = \frac{V_R I_R \cos\theta_R}{V_S I_S \cos\theta_S} \times 100\ \%$$

If P_S is the input power and there is some

transmission line

$$\eta = \left[1 - \frac{Loss}{P_s}\right] \times 100\%$$

If the resistance of line is R and current flowing through it is I then loss = I^2R

$$\eta = \left[1 - \frac{I^2R}{P_s}\right] \times 100$$

$$= \left[1 - \frac{I^2R}{V_s I_s \cos\phi_s}\right] \times 100$$

Kelvin's law of economical choice of conductor size

:> The cost of conductor material is very considerable part of the total ~~fo~~ cost of the transmission line.

:> The most economical area of conductor is that for which the total annual cost of the transmission line is minimum.

~~: According to the~~

:- The total annual cost of of transmission line is broadly classified into two parts.

(i) Annual Charges on capital outlay.

(ii) Annual cost of energy wasted.

(i) Annual charges on capital outlay

Fixed cost (insulator, cross arm, tower) $\propto$ $C_1 = P_1$

Variable cost (conductor) $C_2 \propto$ weight of the conductor

$\Rightarrow C_2 \propto$ density × volume

$\Rightarrow C_2 \propto$ density × Area (a) × length (l)

~~$C_2 \alpha l = C_2 \alpha a$~~

$\Rightarrow C_2 \propto a$

$\Rightarrow C_2 = P_2 a$ (P_2 is constant)

(ii) Annual cost of energy wasted.

This is the cost of energy lost in the conductor due to its resistance i.e I^2R losses

$C_3 \propto$ Electrical loss

$C_3 \propto I^2R$

$C_3 \propto I^2 \frac{\rho l}{a}$

$C_3 \propto \frac{I^2 \rho L}{a}$

$C_3 = \frac{P_3}{a}$

So Total annual cost

$C = C_1 + C_2 + C_3$

$C = P_1 + P_2 a + \frac{P_3}{a}$

In the above equation only area is variable, Therefore the total annual cost of transmission line will be minimum if differentiation of C w.r.t a is zero

$$\frac{d(C)}{da} = 0$$

$$\Rightarrow \frac{d}{da}\left(P_1 + P_2 a + \frac{P_3}{a}\right) = 0$$

$$\Rightarrow P_2 - \frac{P_3}{a^2} = 0$$

$$\Rightarrow P_2 = P_3/a^2$$

$$\Rightarrow \boxed{P_2 a = \frac{P_3}{a}}$$

Variable part of annual charges on capital outlay = Annual cost of energy wasted.

Kelvin's law :-

Therefore Kelvin's law can also be stated in an another way i.e the most economical area of conductor is that for which the variable part of annual charges is equal to the cost of energy losses.

Corona and Corona loss in transmission line

:- Corona is a phenomenon of ionisation of surrounding air around the conductor due to which luminous glow with hissing sound is rise is known as corona effect. (violet colour)

:- Air act as an insulator in between two current carrying conductors. But the air is not a perfect insulator.

:- It contains many free electrons and ions under normal condition.

:- When an electric field is established in the air between two conductors, the free ion in the aire will experience a force.

:- Due to this effect, the ions and free electrons get accelerated and moved away.

:- When they collide with one another and also slow moving uncharged molecules, the number of charge particle increases rapidly.

:- If the electric field is strong enough a dielectric breakdown of air will occur and an arc will form between the conductors.

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Ch- Over head lines

Components of overhead lines

i) The supports :- Poles or towers depending upon the working voltage and the region where these are used.

ii) Cross Arms and clamps :- These are either of wood or steel angle section and are used to support the insulator.

(iii) Insulators :- This is used to support the conductors.

(iv) Conductors :- Copper, aluminium or ACSR line which contains the current.

(v) Lightning Arrestors :- It discharge the excessive voltages built upon the line, to earth due to lightning.

(vi) Fuses and insulating switches :- It is used to isolate different parts of overhead system.

(vii) Continuous earth wire :- It is run on the top of the towers to protect the Line.

(viii) Spacer :- It is used to maintain space in the conductor.

(ix) Damper :- Damper is used to protect the conductor from vibration.

(x) Jumper : Jumper is used to isolate the defective part from the regular part.

(xi) phaseplate : The phase no is ~~maint~~ mention here.

(xii) Danger plate : The Danger plate contain the danger signs

xiii) Guywire or stay wire :- It gives support to the poles or towers.

Types of Line support

:- The line support are various types

(i) wooden poles

(ii) steel poles

(iii) RCC poles (Reinforced - cement - concrete)

(iv) steel towers

(i) wooden poles

:- It is one of the cheapest type of line support and used for lines where spans are short.

:- These are used in rural areas for transmit small amount of power at low voltage (440/220V)

:- They have single pole of square - wooden pole and 'A', 'H' type double pole. (used where greater strength is required)

:- wooden pole has natural insulating property. They are light in weight.

:- But it drawback is that their strength and durability cannot predicted with certainty.

(ii) Steel poles :-

:- The steel poles are three types

a) rail poles (as like the shape of track used for railways)

b) Tubular poles (round cross section)

c) Rolled steel joint (I cross section)

:- This pole possesses greater mechanical strength and so permit use of longer span.

:- It's cost is higher. Their life is longer than that of wooden poles.

:- They are used for transmission purpose at 11KV and 33KV respectively.

:- It's appearance and looks is good.

Reinforced-cement concrete (RCC) Pole

:- Concrete pole have greater strength and used in place of wooden pole.

:- It has very long life and maintenance is low.

:- It can be used for longer span.

:- concrete pole are very heavy and are liable to damage during loading, unloading and transportation. So these may be manufactured at site itself. This should avoid heavy transportation cost

:- These poles are two types in shape

a) Square cross section from bottom to top but the side of the square decreasing from bottom ~~totop~~ top.

b) Rectangular bottom and square top.

Steel tower

:- Tower is used for carrying the high voltage (above 230KV) transmission line.

:- They have greater mechanical strength and permit very long spans. Hence they are very suitable for crossing railway lines, rivers etc.

:- They may carry single circuit and double circuit.

Size and spacing of conductor

Types of conductor materials

:- There are mainly 4 type of conductor which can be used gold, silver, copper, Aluminium. But the cost of the gold and silver is very high than copper and aluminium. so we donot use gold and silver.

:- From copper and aluminium we regularly use aluminium and aluminium alloy but the conductivity capacity is more in copper.

~~So in the~~ In the transmission line we use aluminium and its alloy rather than copper because

(i) aluminium is cheaper than copper.

(ii) the resistance of the aluminium is higher than copper. But when we increase the area of aluminium conductor the resistance should minimize as $R = \rho \frac{L}{a}$

(iii) The weight of the copper is higher than aluminium.

(iv) corrosion is more in copper.

Types of aluminium conductor used in transmission line

(i) All aluminium conductor (AAC) :- All aluminium conductor are made up of one or more strands of aluminium wire.

:- It is used in urban areas where spacing is short and support are close.

:- It can be used in coastal region owing to its high degree of corrosion resistance.

:- It's strength is lesser than other type of conductor.

(ii) All Aluminium Alloy conductor (AAAC) :-

:- AAAC are made out of high strength aluminium-magnesium-silicon alloy.

- It has lighter weight, good strength and current carrying capacity is also good.

- It has excellent resistance to corrosion.

these conductores are designed to get better [s]trength to weight ratio.

[I]t is a better conductor than AAC and ACSR [bec]ause ~~its~~ it has good strength capacity [than] AAC and better corrosion resistance than [ACSR].

:- It is used in high voltage transmission line, industrial areas and coastal regions.

(iii). Aluminium conductor steel reinforced (ACSR)

:- ACSR is a standard conductor including a number of aluminium wire layers on stimulated steel wire core

:- Steel core gives extra strength to give support to the weight of the conductor.

:- It has both the qualities of good conduction and good strength.

:- Due to high strength it is used in high or long transmission line.

:- The corrosion resistance is less than other type of conductores.

Types of insulators

Materials for insulators

1. Porcelain:- It is produced by firing at high temperature, a mixture which essentially consist of china clay with some other substan

:- it can withstand great differences in temperature

:- It will not break easily in handling and during installation.

2. Glass :- It is strongere than porcelain and it has high resistivity.
:- It is transparent and easy to visual exmine.
:- It is used up to 25 KV voltage application.
:- The size is larger than other.

3. Steatite :- Steatite is magnesium-silicate
:- As compared to porcelain it has much bending stress.
:- So it is used when transmission lines take sharp turn.

Types of insulatores

- The most commonly insulatores used in the over head-lines are
1. Pin-type insulatores
2. Suspension type insulatory
3. Strain insulatores
4. Shackle insulatores.
5. Stay insulatores

1. Pin type insulatory :-

:- The Pin insulatores uses non conducting material like porcelain, ceramic, silicon rubber etc.
:- It is used in power distribution for the voltage up to 33 KV.
:- The pin insulatores has grooves on the upper end for keeping the conductor.

Advantages :-

:- It is used in high voltage distribution line.

:- It has high mechanical strength.

:- It is simple and require less maintenance.

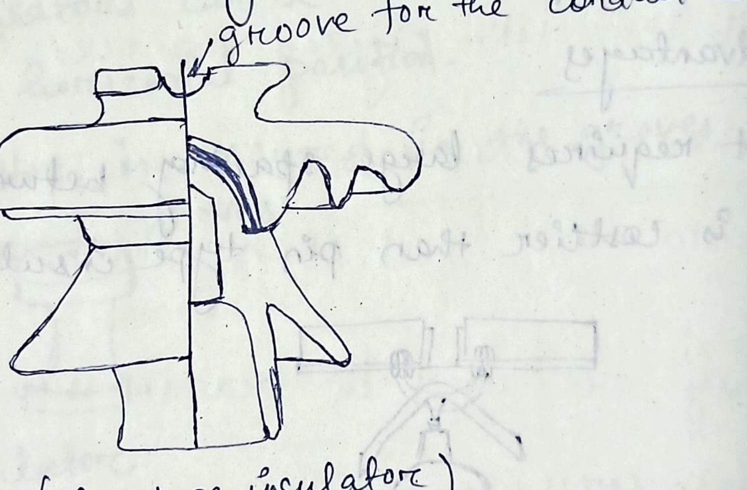
:- It can be used vertically and horizontally

Disadvantages:

:- Only used in distribution line.

:- The voltage rating is limited i.e upto 33KV.

:- It becomes bulky.



(Pin type insulator)

2. Suspension type insulator

:- Suspension type insulator consists number of porcelain insulator units connected with each other by metal links.

:- The conductor is connected at the buttom of the string.

:- Each unit disc is designed for 11KV. Hence by increasing number of discs very large voltage can be carried over

Advantages:-

(i) Each unit operates the voltage of about 11KV and hence depending up-on the voltage the appropriate no. of discs are connected in series with the string.

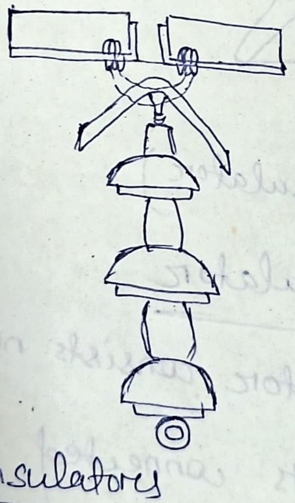
(ii) If one of the unit is damaged, it is replaced by a new one. No need of replacing the whole string.

(iii) flexibility is more

Disadvantages

(i) It requires large spacing between the conductor

(ii) It is costlier than pin type insulator.

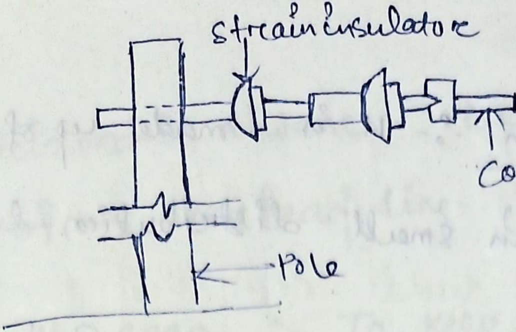


3. Strain insulators

:- When there is a dead end and there is a sharp corner in transmission line we use strain insulator.

:- It has high mechanical strength.

:- The discs of strain insulators are used in the vertical plane



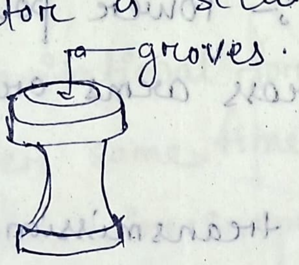
4. Shackle insulators

:- Shackle insulators is made from high quality porcelain material, since it is one of the best insulator.

:- It is otherwise called spool insulator which used in low voltage distribution lines.

:- These insulators can be mounted either in the vertical or horizontal position.

:- The conductor is secured in the groves.



5. Stay insulator

:- Such insulators are of egg shape and very small in size.

:- The arrangement of these insulators can be made among the line conductor and earth.

Types of cross-arm

Power pole cross arms :- These are particular types of cross arms used in power poles to connect conductor and insulator.

Types of Cross arm

wooden cross-arm :- It is made up of wood and generally used in small distribution line.

U shaped cross arm :- The cross arm is 'U' shaped and connected to the pole.

V shaped cross arm :- 'V' shaped cross arm is connected to the pole

Zig-Zag cross arm :- The cross arm is distributed like zig-zag manner on the pole.

1. **Power pole cross arm** :- Power pole cross arms are also called steel cross arms or pole cross arms.
   :- They are used in transmission line.

2. **Line-cross arm** :- they are manufactured using unique steel structure. This type of cross arm equally distributes the weight across the pole.

3. **Side arm** :- Cross arms are present at only one side of the pole. These are of same size.

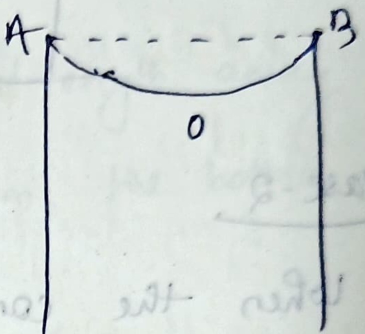
4. **Single arm** :- Only one cross arm is present on each side.

5. **Telephone pole crossarm** :- It allows for more than two links on each side of the cross-arm

Span :-

The horeizontal distance between consecutive supports of an overhead line is called span.

Length of the span :- To keep the cost of the transmission line minimum, the length of the span will maximum possible.



AB = span

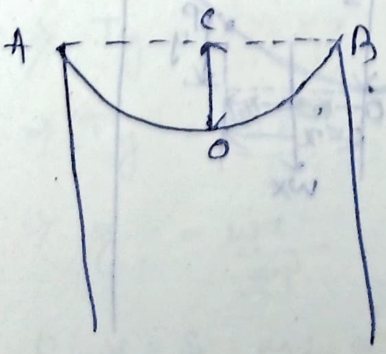
:- wooden pole – 40-50 metres.
steel pole – 50-80 metres
RCC poles – 80-100 metres
Steel tower – 100-300 metres

Sag

:- Due to gravitational force acting on the conductor, after some time a dip is produced in the transmission wire suspended between two supports. This dip is known as sag.

:- In other words the difference in level between the points of supports and lower point on the conductor is known as sag.

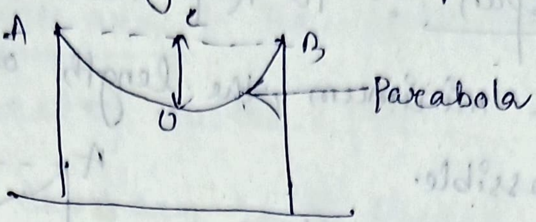
Ex:-



OC = sag.

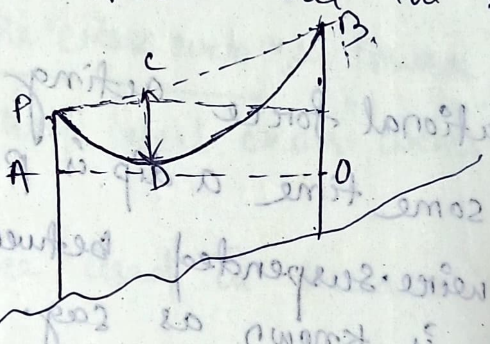
Case-1

When conductor is suspended between two supports at the same level, The sag curve is like parabola and sag is very small compared to other span.

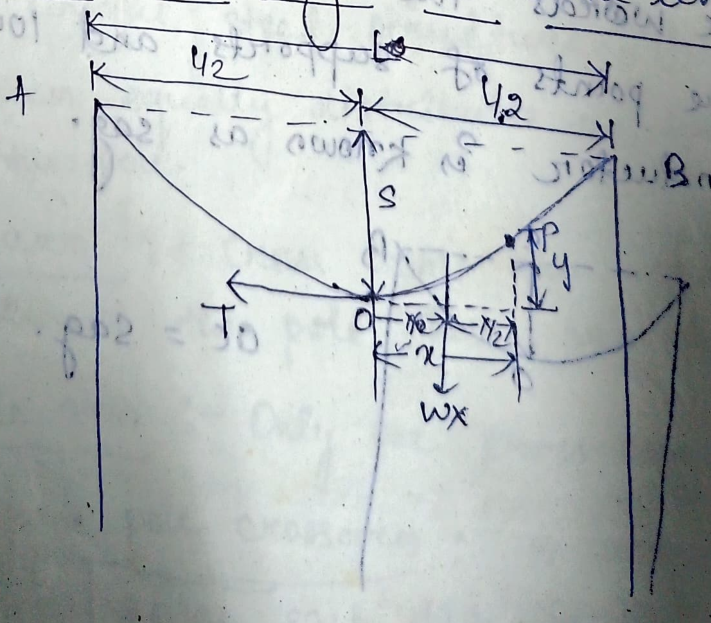


Case-2

When the conductor is suspended betn the two supports at different level, the sag curve is different but the span is same.



Calculation of sag at same level



Let A & B are the supports which hold the conductor

O is the lowest point of the conductor

~~L is the~~

L = length of the span

w = weight per unit of length conductor

T = Tension in the conductor

:- Consider a point 'p' which is 'x' length away from 'o' and y length high from the bottom point of the conductor.

:- It may be assumed that the curvature length 'op' = x

:- Two forces will be acted on the portion 'op'

a) weight of 'op' is wx which is acted at a distance x/2 from the point o

b) T tension is acted at point o.

Moments about point P =

$$Ty - wx \times \frac{x}{2} = 0$$

$$\Rightarrow Ty = wx \times \frac{x}{2}$$

$$\Rightarrow Ty = \frac{wx^2}{2}$$

$$\Rightarrow y = \frac{wx^2}{2T}$$

Clockwise (+)

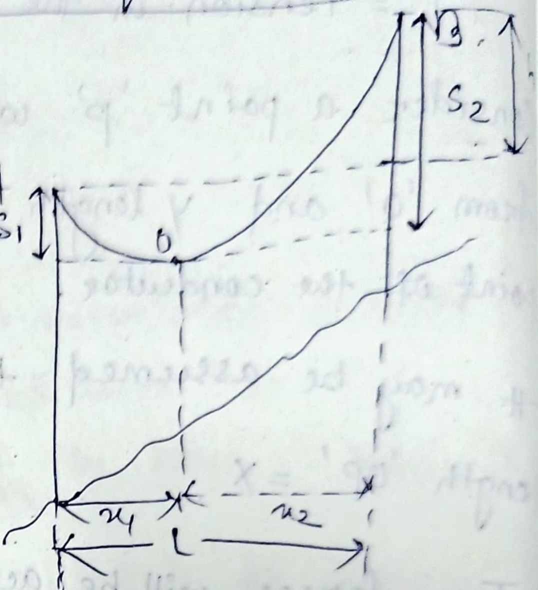
Anticlockwise (−)

At point o (y = S) and x = L/2

$\Rightarrow S = \frac{w\left(\frac{L}{2}\right)^2}{2T}$

$\Rightarrow \boxed{S = \frac{wL^2}{8T}}$ → formula for sag at equal level.

Calculation of sag at unequal level



Let A & B are the line support.

L = Span length

h = Difference in levels between two suppor

x_1 = distance of support at lower level from O

x_2 = distance of suppot at higher level from O

$S_1 = \frac{wx_1^2}{2T}$

$S_2 = \frac{wx_2^2}{2T}$

$\boxed{x_1 + x_2 = L}$ ——— (i)

$\Rightarrow S_2 - S_1 = \frac{wx_2^2}{2T} - \frac{wx_1^2}{2T}$

$\Rightarrow S_2 - S_1 = \frac{w}{2T}(x_2^2 - x_1^2)$

$\Rightarrow S_2 - S_1 = \frac{w}{2T}(x_2 + x_1)(x_2 - x_1)$

⇒ $S_2 - S_1 = \frac{w}{2T} L \times (x_2 - x_1)$

⇒ $h = \frac{wl}{2T}(x_2 - x_1)$

~~⇒ $x_2 - x_1 = \frac{wl}{2T}(x_2 - x_1)$ —— (ii)~~

~~eqn(i) + eqn(ii)~~

~~$x_2 + x_1 = l$~~

~~(+) $x_2 - x_1 = \frac{wl}{2T}(x_2 - x_1)$~~

⇒ $x_2 - x_1 = \frac{2Th}{wL}$ —— (ii)

eqn(i) + eqn(ii)

$x_2 + x_1 = l$

(+) $x_2 - x_1 = \frac{2Th}{wl}$

$2x_2 = l + \frac{2Th}{wl}$

$x_2 = \frac{l}{2} + \frac{2Th}{2wl}$

$x_2 = \frac{l}{2} + \frac{Th}{wl}$

eqn (i) − eqn (ii)

$$x_1 + x_2 = l$$

$$\underset{(-)}{x_2} - \underset{(+)}{x_1} = \underset{(-)}{\frac{2Th}{wl}}$$

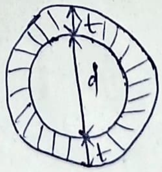
$$2x_1 = l - \frac{2Th}{wl}$$

$$\Rightarrow x_1 = \frac{l}{2} - \frac{Th}{wl}$$

$$\boxed{S_1 = \frac{w\left(\frac{l}{2} - \frac{Th}{wl}\right)^2}{2T}}$$ put the value of x_1 in eqn S_1

$$\boxed{S_2 = \frac{w\left(\frac{l}{2} + \frac{Th}{wl}\right)}{2T}}$$ Put the value of x_2 in eqn S_2.

Effect of Ice coating



Let d is the diametere of the conductor and t is the thickness of the ice coating.

$$S = \frac{wl^2}{8T}$$ (But the weight changes due to ice coating)

Cross sectional area of the conductor with ice coating

$$\pi/4\,(d+2t)^2 \; m^2$$

Cross sectional area of the conductor =

$$\frac{\pi}{4} d^2 \; m^2$$

Cross - sectional area of the ice coating =

$$\frac{\pi}{4}(d+2t)^2 - \frac{\pi}{4}d^2$$

$$\Rightarrow \frac{\pi}{4}\left\{(d+2t)^2 - d^2\right\}$$

$$\Rightarrow \frac{\pi}{4}\left\{(d+2t+d)(d+2t-d)\right\}$$

$$\Rightarrow \frac{\pi}{4}\left\{(2t+2d)(2t)\right\}$$

$$\Rightarrow \frac{\pi}{4}(4t^2+4dt) = \frac{\pi}{4}\left\{2(t+d)(2t)\right\}$$

$$= \pi(d+t) \times t$$

$$\Rightarrow \frac{\pi 4t}{4} \quad \Rightarrow \pi t(d+t)$$

volume of ice on unit meter of conductor =

Area x length

$$\Rightarrow \pi t(d+t) \times 1 = \pi t(d+t) \; m^3$$

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\Rightarrow \text{mass} = \text{Desity} \times \text{volume}$$

$$\Rightarrow \text{weight of ice } (W_i) = \text{Density} \times \pi t(d+t) m^3$$

$$= 915 \, kg/m^3 \times \pi t(d+t) \, m^3$$

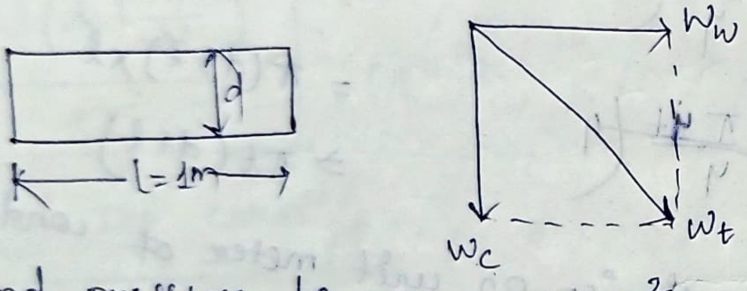
$$= 2870 \, t(d+t) \, kg$$

Now $S = \frac{(w+w_i)l^2}{8T}$ (w = weight of the conductor, w_i = weight of the ice per unit length

~~Effect of Ice loading with wind~~

Effect of wind on sag

Effect of wind on sag



Let wind pressure be P kg per m^2

$P = \frac{F}{A}$

$F = P \times A$ (F = wind force)

$\Rightarrow W_w = P \times A$

The projected area of the surface per meter length of the conductor =

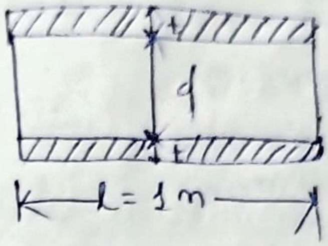
$\Rightarrow d \times 1 = d\ m^2$

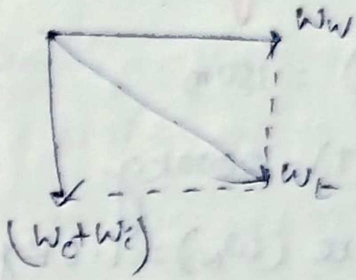
$W_w = P \times d$ kg

The resultant force $w_t = \sqrt{w_c^2 + w_w^2}$

$$\text{Sag} = \frac{w_t l^2}{8T}$$

Effect of wind and Ice on sag





Let wind pressure = P kg/m²

$P = \frac{F}{A}$

$\Rightarrow P = \frac{W_w}{A}$

$\Rightarrow W_w = P \times A$

The projected area of the surface per meter length of the conductor

$= (d + 2t) \times 1 = d + 2t \ m^2$

$W_w = P \times (d + 2t)$ kg

The resultant force $W_t = \sqrt{(W_c + W_i)^2 + W_w^2}$

$$\text{Sag} = \frac{W_t l^2}{8T}$$

W_c = weight of the conductor per meter length

W_i = weight of ice loading per meter length

W_w = wind load per meter length

(1) A transmission line has a span of 150 m between level supports. The conductor has a cross-sectional area of 2 cm^2. The tension in the conductor is 2000 kg. If the specific gravity of the conductor material is 9.9 gm/cm^3 and wind pressure is 1.5 kg/m length, calculate the sag?

(A) → Span (l) = 150 m

Tension (T) = 2000 kg

Wind force (W_w) = 1.5 kg/m

Weight of the conductor (W_c) = Specific gravity × volume of 1 m conductor.

$= 9.9 \, gm/cm^3 \times 2 \, cm^2 \times 100 \, cm$

~~= 19800 gm = 19.8 kg~~

$= 1980 \, gm = 1.98 \, kg$

$W_t = \sqrt{(W_c)^2 + (W_w)^2}$

$= \sqrt{(1.98)^2 + (1.5)^2}$

$= 2.48 \, kg$

Sag $S = \dfrac{W_t l^2}{8T} = \dfrac{2.48 \times (150)^2}{8 \times 2000} = 3.48 \, m$

(2) A 220 KV transmission line uses ACSR conductor whose data is given as under

Weight of the conductor = 844 kg/km

Span length = 300 meter

Allowable safe tension = 7850 kg

~~(i) Calcu~~

(ii) Calculate sag?

(ii) Calculate the height above ground at which the conductor should be supported when ground clearance required is 7m.

Ans → $W_c = 0.844 \text{ kg/km}$

$= 0.844 \text{ kg/m}$

$T = 7850 \text{ kg}$

$l = 300 \text{ m}$

(i) $\text{Sag} = \frac{Wl^2}{8T}$

$= \frac{0.844 \text{ kg} \times 300^2}{8 \times 7850 \text{ kg}}$

$= 1.21$ meter

(ii) Therefore, the conductor should be supported at a height of $7 + 1.21 = 8.21$ m above the ground level.

Ch- Performance of short & Medium lines

Classification of Transmission line

The overhead transmission line can be classified as

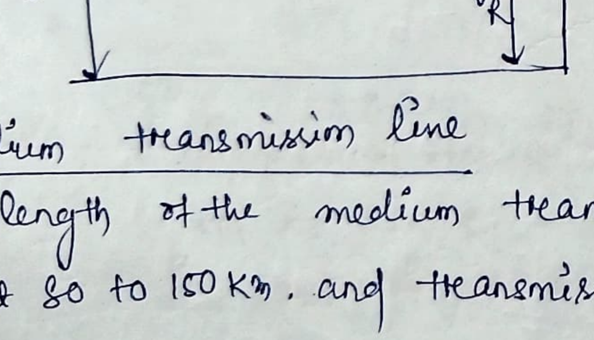
(i) short transmission line
(ii) Medium transmission line
(iii) long transmission line

(i) Short transmission line :-

:- The length of the short transmission line is about 50 to 80 Km and the transmission voltage is up to 33KV.

:- In short transmission line the effect of the capacitance is too small as the length of the line and voltage is very small.

:- So in the calculation of short transmission line the effect of capacitor is ignored and only resistance and inductance of the transmission line are considered and they are connected in lamped circuit.



(ii) Medium transmission line

:- The length of the medium transmission line is about 80 to 150 Km. and transmission voltage is up to 132KV.

:- In this line the effect of capacitance using be taken into account.

:- The capacitance of line is uniformly distributed over the entire length of transmission line but to simplify the calculations in medium transmission lines, the capacitance effect is considered as lumped either at both receiving and sending ends or at the centre of the transmission line.

(iii) Long transmission line

:- The length of the long transmission line is more than 150 Km and the line voltage is very high.

:- The capacitance effect can not be considered as lumped, it is considered as distributed.

Voltage Regulation of a transmission line

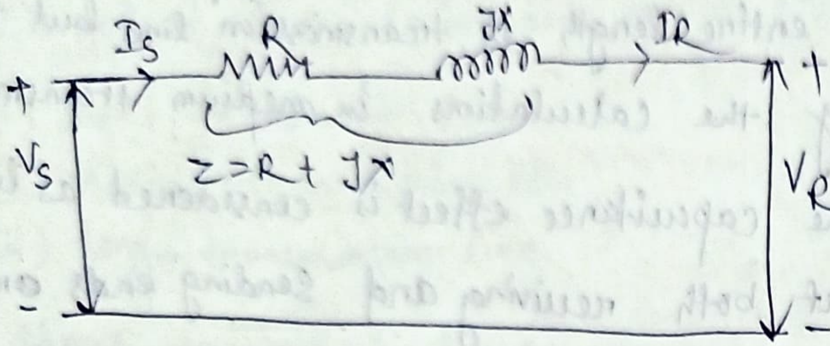
The voltage regulation is defined as the droop in receiving end voltage from no load to full load expressed as percentage of receiving end voltage mathematically

$$\% \text{ voltage regulation} = \frac{V_S - V_R}{V_R} \times 100$$

where V_S = Sending end voltage

V_R = Receiving end voltage.

Expression for voltage Regulation on a Short transmission line



:- For short length, the shunt capacitance of this type of line is neglected and other parameters like electrical resistance and inductor of these short lines are lumped.

:- Hence the equivalent circuit, ~~taking~~ is represented is given above.

:- V_R = Receiving end voltage
V_S = Sending end voltage
I_R = Receiving end current
I_S = Sending end current
$\cos\phi_R$ = Power factor of the load
$\cos\phi_S$ = Power factor at the sending end.
Z = Total impedence

$$Z = R + JX$$

:- Hence the Shunt câpacitance is neglected

$$I_S = I_R \Rightarrow I_S = I_R = I$$

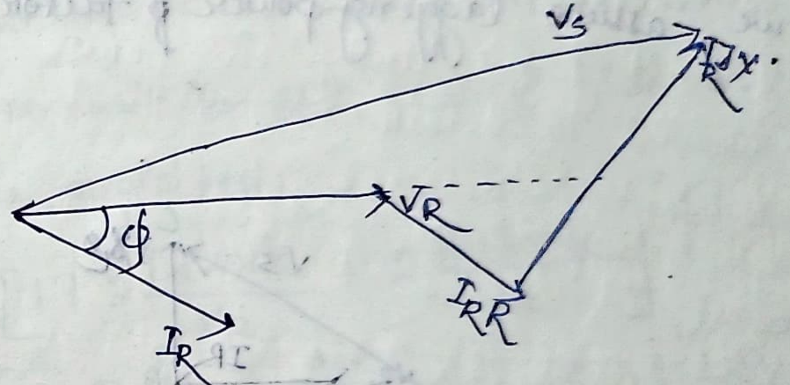
:- Sending end voltage $\Rightarrow V_S = V_R + I_R(R+JX)$

V_S = ~~V_R + I_R (R~~ $\Rightarrow V_S = V_R + I_R Z$

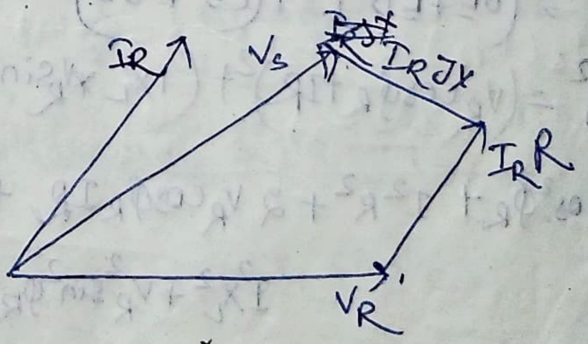
vector diagram | phasor diagram

- ~~Take receiving end current ($I_R = I$) in the reference~~
- Take receiving end voltag V_R as reference

case -1
for lagging power factor

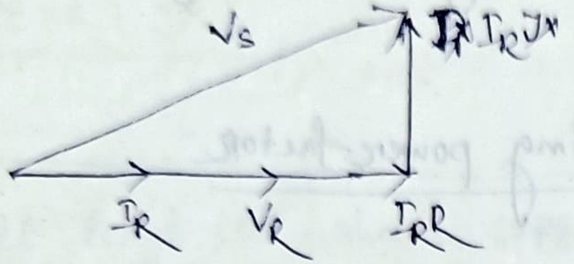


Case -2
for leading power factor

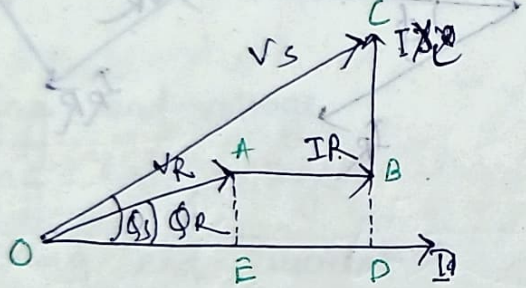


Case-3

for unity Power factor



Here the nature of the power factor is not given so we assume lagging power factor.



From the right angled triangle OCD we have,

$$(OC)^2 = (OD)^2 + (CD)^2$$

$$\Rightarrow (V_s)^2 = (OE + ED)^2 + (CB + BD)^2$$

$$\Rightarrow (V_s)^2 = (V_R \cos\phi_R + IR)^2 + (IX_L + V_R \sin\phi_R)^2$$

$$(V_s)^2 = V_R^2 \cos^2\phi_R + I^2R^2 + 2 V_R \cos\phi_R IR + I^2X_L^2 + V_R^2 \sin^2\phi_R + I^2X_L^2 + 2V_R \sin\phi_R IX_L$$

$$(V_s)^2 = \left[V_R^2 (\cos^2\phi_R + \sin^2\phi_R) + 2V_R I (R\cos\phi_R + X_L \sin\phi_R) + I^2(R^2 + X_L^2)\right]$$

$$\Rightarrow (V_S)^2 = \left[V_R^2 + 2V_R I(R\cos\phi_R + X_L\sin\phi_R) + I^2(R^2+X_L^2)\right]$$ (45)

$$\Rightarrow (V_S)^2 = V_R\left[\right.$$

$$\Rightarrow (V_S)^2 = V_R^2\left[1 + \frac{2IR\cos\phi_R}{V_R} + \frac{2IX_L\sin\phi_R}{V_R} + \frac{I^2(R^2+X_L^2)}{V_R^2}\right]$$

$$\Rightarrow V_S = V_R\sqrt{\left[1 + \frac{2IR\cos\phi_R}{V_R} + \frac{2IX_L\sin\phi_R}{V_R} + \frac{I^2(R^2+X_L^2)}{V_R^2}\right]}$$

$$\Rightarrow V_S = V_R\left[1 + \frac{2IR\cos\phi_R}{V_R} + \frac{2IX_L\sin\phi_R}{V_R} + \frac{I^2(R^2+X_L^2)}{V_R^2}\right]^{1/2}$$

Here the voltage drop IR and IX_L are small, their square will be still smaller, so the last term is neglected.

$$\Rightarrow V_S = V_R\left[1 + 2\frac{IR\cos\phi_R}{V_R} + 2\frac{IX_L\sin\phi_R}{V_R}\right]^{1/2}$$

$$\Rightarrow V_S = V_R\left[1 + 2\frac{I}{V_R}\left(R\cos\phi_R + X_L\sin\phi_R\right)\right]^{1/2}$$

Taking Binomial approximation

$$(1+a)^n = 1 + na$$

$$\text{So } V_S = V_R\left[1 + \frac{I}{V_R}(R\cos\phi_R + X_L\sin\phi_R)\right]$$

$$\Rightarrow V_S = V_R + IR\cos\phi_R + IX_L\sin\phi_R$$

$$\Rightarrow V_S - V_R = IR\cos\phi_R + IX_L\sin\phi_R$$

voltage drop $(V_S - V_R) = IR\cos\phi_R + IX_L\sin\phi_R$

$$\% \text{ Voltage Regulation} = \frac{IR\cos\phi_R + IX_L\sin\phi_R}{V_R} \times 100$$

For leading power factor

$$\% \text{ Voltage Regulation} = \frac{IR\cos\phi_R - IX_L\sin\phi_R}{V_R} \times 100$$

So voltage regulation in a short transmission line

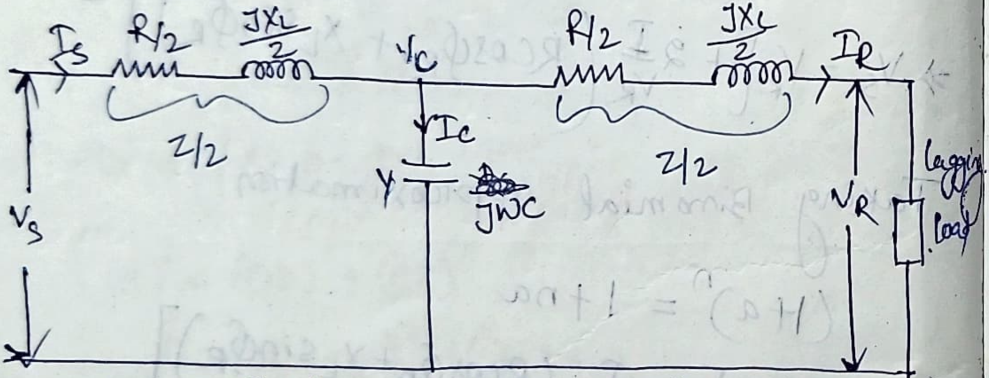
$$\frac{IR\cos\phi_R \pm IX_L\sin\phi_R}{V_R} \times 100$$

Expression for Medium transmission Line

There are two types of medium transmission line network that we study in power system.

1. Nominal π-network
2. Nominal T-network

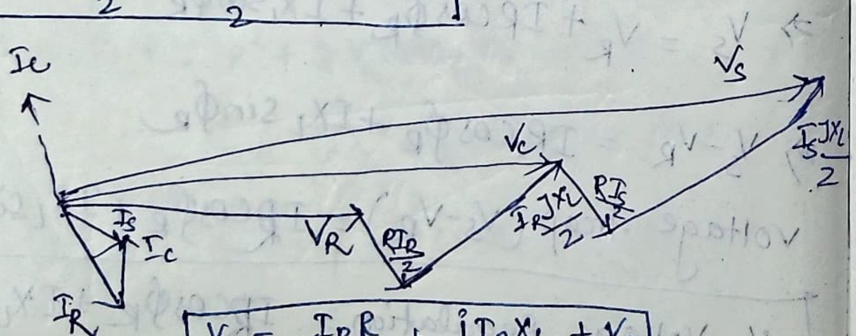
Nominal T-network



$$V_S - I_S(R/2) - JI_S(X_L/2) - V_C = 0$$

$$V_S = \frac{I_S R}{2} + \frac{JI_S X_L}{2} + V_C$$

$I_S = I_C + I_R$



$$V_C = \frac{I_R R}{2} + \frac{jI_R X_L}{2} + V_R$$

$V_c = V_R + I_R \frac{Z}{2}$

$I_c = V_c Y$

$= (V_R + I_R \frac{Z}{2}) Y$

$I_s = I_R + I_c$

$= I_R + V_R Y + I_R \frac{YZ}{2}$

$= V_R Y + I_R (1 + \frac{YZ}{2})$

$V_s = V_c + I_s \frac{Z}{2}$

$= V_R + I_R \frac{Z}{2} + I_s \frac{Z}{2}$

Put the value of I_s

$V_s = V_R + I_R \frac{Z}{2} + \left[V_R Y + I_R (1 + \frac{YZ}{2})\right] \frac{Z}{2}$

$V_s = V_R + I_R \frac{Z}{2} + (V_R Y + I_R + I_R \frac{YZ}{2}) \frac{Z}{2}$

$V_s = V_R + I_R \frac{Z}{2} + \frac{V_R YZ}{2} + \frac{I_R Z}{2} + \frac{I_R YZ^2}{4}$

$V_s = V_R (1 + \frac{YZ}{2}) + I_R Z (\frac{1}{2} + \frac{1}{2} + \frac{YZ}{4})$

$V_s = V_R (1 + \frac{YZ}{2}) + I_R Z (1 + \frac{YZ}{4})$

% Voltage regulation $= \frac{V_s - V_R}{V_R} \times 100$

$\Rightarrow \boxed{= \frac{\left[V_R (1 + \frac{YZ}{2}) + I_R Z (1 + \frac{YZ}{4})\right] - V_R}{V_R} \times 100}$

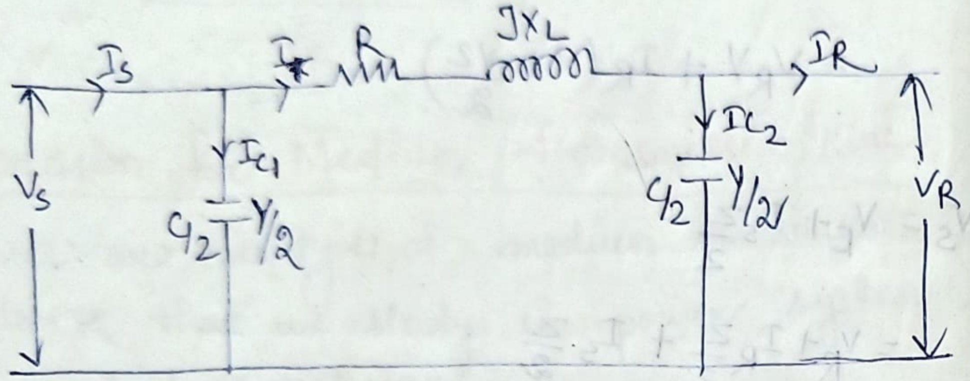
Undere no load condition

$I_R = 0$; $I_S = I_C$

and $V_R = V_C = \frac{I_C}{Y} = \frac{1}{Y}\left[\frac{V_S}{\frac{Z}{2}+\frac{1}{Y}}\right] = \frac{V_S}{\left(\frac{YZ}{2}+1\right)}$

% regulation $= \frac{V_C - V_R}{V_R} \times 100$

Nominal π network



$V_S = V_{C1}$

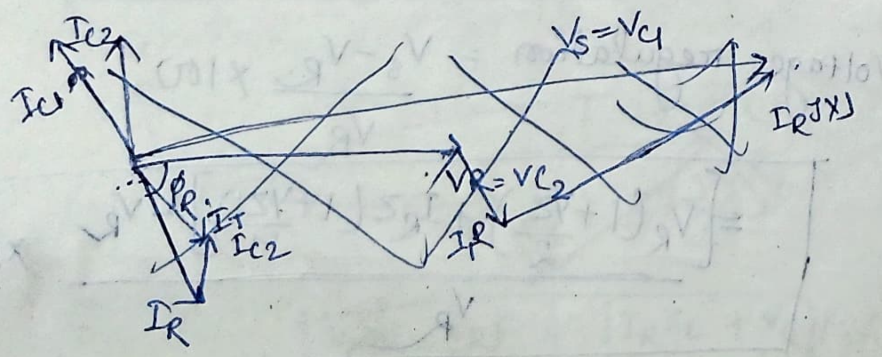
$I_S = I_{C1} + I_T$

$V_S = I_T R + I_T J X_L + V_{C2}$ ——— (i) $\Rightarrow V_S = I_T R + I_T JX_L + V_R$

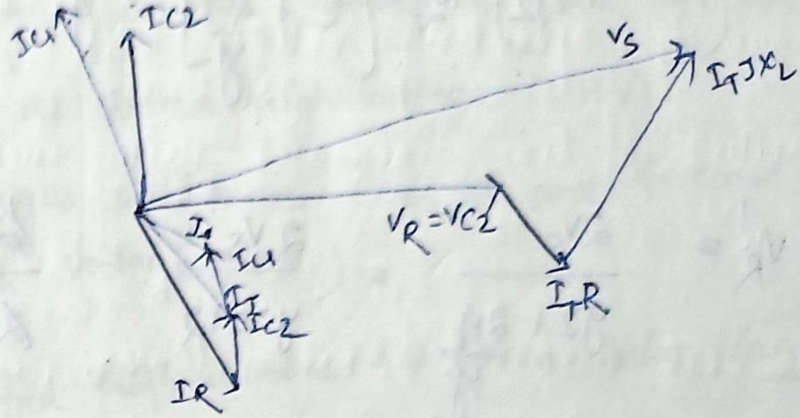
$V_{C2} = V_R$

$I_T = I_{C2} + I_R$

Consider the load as lagging



Phasor diagram



$$I_T = I_R + I_{C2}$$

$$= I_R + V_R \frac{Y}{2}$$

$$V_S = V_R + I_T Z \quad (Z = R + jX_L)$$

$$\Rightarrow V_S = V_R + (I_{C2} + I_R) Z$$

$$= V_R + \left(I_R + V_R \frac{Y}{2}\right) Z$$

$$= V_R + I_R Z + \frac{V_R Y Z}{2}$$

$$\boxed{V_S = V_R\left(1 + \frac{YZ}{2}\right) + I_R Z}$$

$$I_S = I_{C1} + I_T$$

$$= I_T + V_S \frac{Y}{2}$$

$$= I_R + V_R \frac{Y}{2} + V_S \frac{Y}{2}$$

$$= I_R + V_R \frac{Y}{2} + \left\{V_R\left(1 + \frac{YZ}{2}\right) + I_R Z\right\}$$

Under no load condition

$I_T = I_{C2}$

$$V_R' = \frac{V_s}{\left[Z + \frac{2}{Y/2}\right]} \times \frac{1}{Y/2} = \frac{V_s}{\left[Z + \frac{2}{Y}\right]} \times \frac{2}{Y}$$

$$V_R' = \frac{2V_s}{YZ + \frac{2Y}{Y}} = \frac{2V_s}{YZ+2} = \frac{2V_s}{2\left(1+\frac{YZ}{2}\right)}$$

$$V_R' = \frac{V_s}{1+\frac{YZ}{2}}$$

$$\% \text{ regulation} = \frac{\text{No load voltage} - \text{Full load voltage}}{\text{Full load voltage}}$$

$$= \frac{V_R' - V_R}{V_R}$$

Ch- EHV Transmission

:- Voltages less than 300KV are termed as High voltages

:- The voltages in the range of 300KV to 765KV are known as Extra high voltage (EHV).

:- The voltages which are 765 KV are termed as Ultra high voltage (UHV)

EHVAC [Extra high voltage AC transmission line]

:- Hydroelectric powerplant, steam power plant and nuclear powerplant are normally placed faraway from the load centre according to their favorable condition.

:- So we require the transmission of generated electric power over very long distance. This require high voltage for transmission

Necessity of EHVAC transmission

:- With the increase in transmission voltage for same amount of power to be transmitted current in the line decreases. which reduces I^2R losses (or copper losses. So the transmission efficiency increases.

$P = VI$

$\Rightarrow V = \frac{P}{I}$

[voltage ↑ current ↓ I^2R loss ↓

so efficiency ↑]

:- With decrease in transmission current, size of the conductor required reduces which decreases the volume of the conductor.

:- The transmission capacity is proportional to square of operating voltage. Thus transmission capacity of line increases with increase in voltage.

:- The cost associated with tower, insulation and different equipment is ~~propotional to the voltage~~ ~~So or~~ decrease with increase in voltage level.

:- It improved voltage regulation because the voltage drop decreases. ~~$Z_c = \sqrt{L/C}$~~ ~~$SIL = \frac{3V^2}{Z_c}$~~

:- With increase in voltage the surge impedance loading increases.

$$Z_c = \sqrt{L/C}$$

$$SIL = \frac{3V^2}{Z_c}$$

:- The no. of circuit and the land requirement reduces as transmission voltage increases.

:- With increase in level of transmission voltage the installation cost of the transmission line per km decreases.

Problem involved in EHV transmission

(i) Corona effect :- If the voltage increases the corona effect also increases and corona loss will more.

(ii) Interference with communication signal :- If any communication line or internate line is near EHV transmission line, it will effected by the high voltage.

(iii) No of disc will increase :- We know in suspension type insultor each disc is designed for 11kV, if voltage increases the no. of disc also increases.

(iv) Line to ground clearance :- some problem faced in maintain line to ground clearance as the weight increases

(v) Hight of the tower should increase :- To maintain the line to ground clearance we have to increase our height of the tower.

(vi) Cost increases due to insulation and tower :- Increase in no. of disc and increase in height of tower leads to more cost in installation.

(vii) Rating of SGPD :- The ratings of protection device fuse, relay etc should increase which leads to increase in cost.

HVDC (High voltage direct current transmission line) (54)

:- A HVDC electric power transmission system uses direct current for bulk transmission of electric power over a long distance by overhead transmission lines.

:- It is also used to interconnect ~~separate~~ power systems where alternating current connections cannot be used.

:- In an HVDC system electric power is taken from one point in a 3-ϕ AC network, converted to DC in a converter system.

:- HVDC transmission ~~depends on~~ system may only need a few skilled staff for operation and maintenance.

Advantages of HVDC transmission line

(i) Cheaper in cost :- HVDC transmission line require two pole conductors while AC system requires 3 conductor (R, Y, B) to carry power.

(ii) No skin effect :- There is no skin effect in dc, so there is uniform distribution of current over the section of the conductor.

(iii) Low transmission loss :- Due to high voltage for the same power current is less, so I^2R loss is very less.

(iv) It contain only resistance :- In DC transmission line there is only resistance means the inductive reactance and capacitive reactance is absent.

(v) ~~Less~~ voltage regulation :- There is no inductance and capacitance. Hence voltage drop due to inductance ~~is~~ doesnot exist in dc transmission line. Thus voltage regulation is better in case of dc transmission

(vi) Two AC systems having different frequencies can be interconnected using HVDC transmission lines. This is not possible in HVAC transmission system.

(vii) Less corona loss :- Corona loss is less in dc transmission line.

(viii) Efficiency is ~~high in~~ higher than AC transmission line.

(ix) It can be used in both overhead and underground transmission system.

(x) Less Interference :- HVDC has minimum audible noise as well as minimum radio, TV interference

Disadvantages of HVDC transmission line

(i) We cannot able to step-up and step down the dc voltage in transformer.

(ii) HVDC system depends on AC system.

(iii) ~~cos~~ High cost of converting and inverting equipments are required for HVDC transmission.

(iv) The converter control is quite complex.

(v). Limitation of converter ~~is~~ (It cannot convert higher voltage)

(vi) Stress in switch gear protection device is more.

CH- DISTRIBUTION SYSTEMS

:- In general the distribution system is the electrical system between the stepdown substation fed by transmission system and the consumers meters.

:- The most important requirement for such distribution system is that electrical power should be distributed to the consumers efficiently and economically. *

:- Energy transmitted at the voltage which is used is called secondary distribution, for example 230 V is given to the residence and 400 V is given to the factory.

Connection scheme of distribution centre

According to the scheme of connections the distribution system may be ~~eat~~ classified as

(i) Radial system

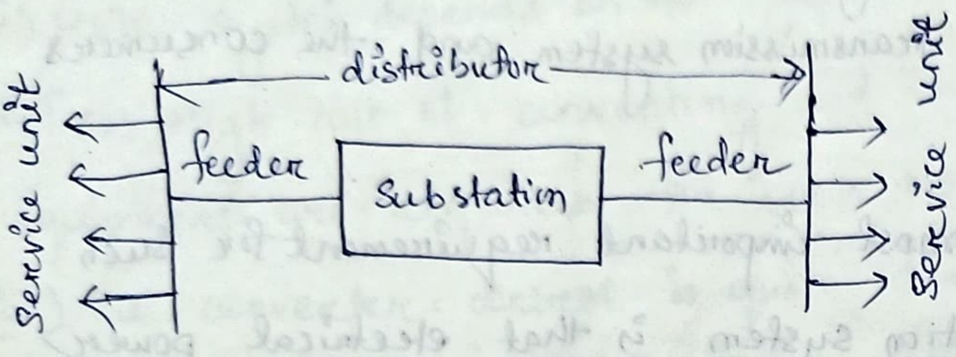
(ii) Ring main system.

(iii) Interconnected system.

Radial system

:- In this system separate feeders radiate from a single substation and feed the distributor at one end only.

:- This system is employed when power is generated at low voltage and substation is located at the centre of the load.



Disadvantages :-

:- The consumers are dependents on a single feeder, a fault on the feeder causes interruption of supply to all the consumers.

:- The end nearest to the supply point of the distributer is heavily loaded.

:- It cannot used for a long distance.

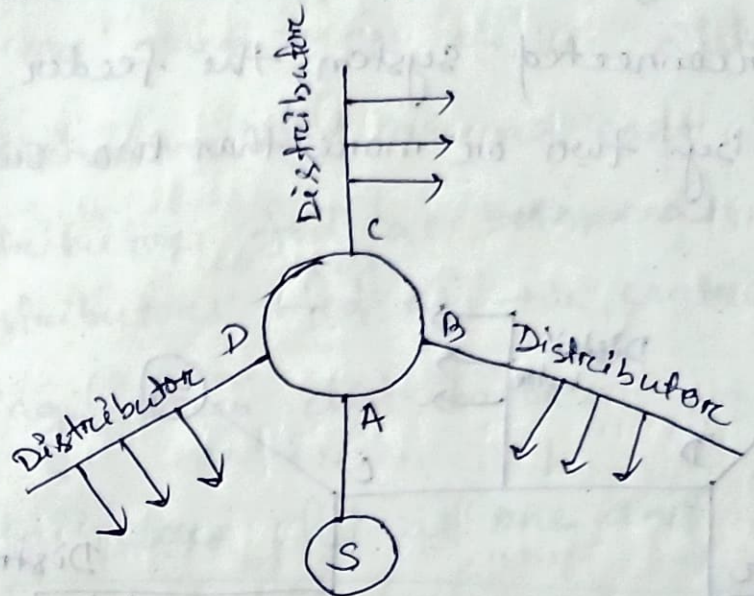
Advantages

:- This system is simplest.

:- The initial cost is minimum.

:- The system is employed when the electrical energy is generated at low voltage.

Ring main or loop system



:- when the distributor is supplied by two sides it is called a ring main distribution system

:- In this system the feeder closes on it-self. i.e it forms a complete ring and hence name ring mains.

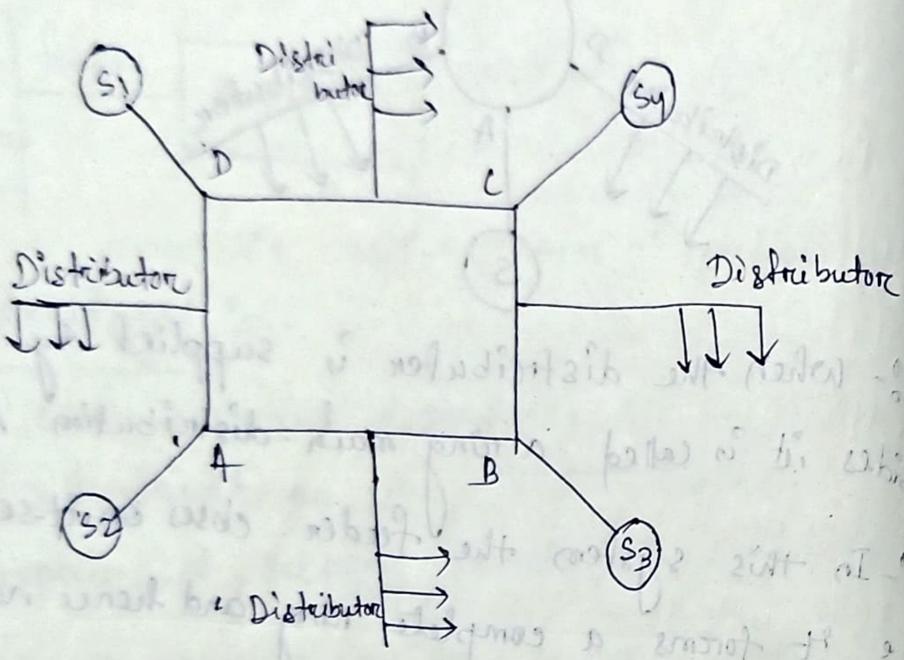
:- In the upper figure the substation s supplies to the closed feeder ABCDA. The distributors are connected to point B, C and D of the feeder.

Advantages

1. In the event of ~~fat~~ fault on any system of feeder, the continuity of supply can be maintained.
2. This reduces fluctuation in voltage at the consumers terminals.

Interconnected System

:- In an Interconnected system the feeder ring is energized by two or more than two Sub-Stations.



:- In the above diagram the closed feeder ring ABCDA is supplied by four stations S_1, S_2, S_3, S_4 at point D, A, B, C respectively.

:- Distributors are connected to points E, F, G, H

Advantages

:- In the event of fault on any section of the feeder, the continuity of ~~sy~~ supply to all the consumers can be maintained by isolating the faulty section.

:- If any area is fed from one substation then being peak hours of load, it can be fed from the other.

Types of dc distributors

There are four types of dc distributors

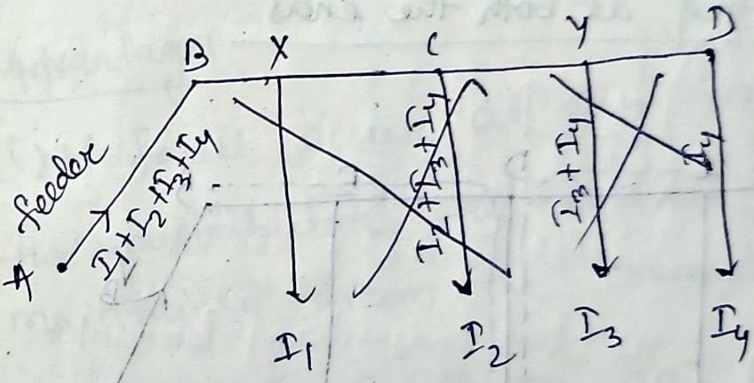
(i) Distributors fed at one ends

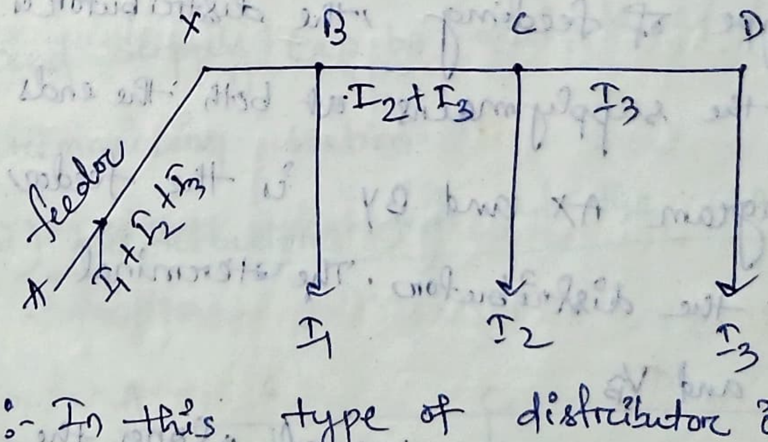
(ii) Distributors fed at both ends

(iii) Distributors fed at the centre

(iv) Ring main distributor.

(i) Distributors fed at one end





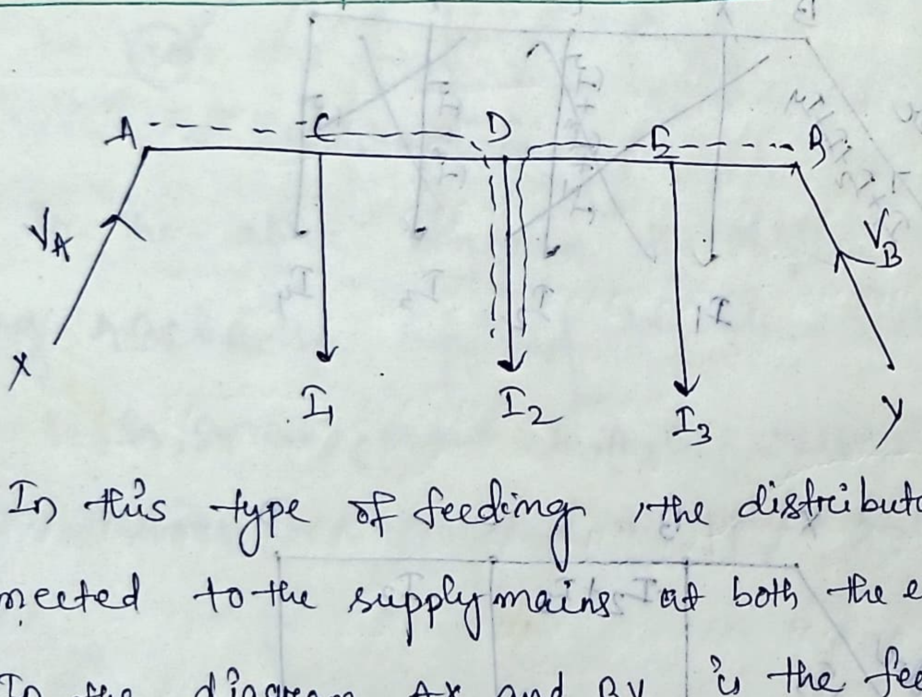
:- In this type of distributor is connected to supply mains at one end and loads are trapped at different point along the path of the distributor.

:- In the diagram XD is the distributor line (G.2) which is fed by at point X by AX feeder.

→ In this case the current away from feeding point and voltage across the loads away from feeding point goes on decreasing.

→ In case of any fault occurs in any section of distributor, the whole distributor is required to be disconnected from the supply for repair for continuity

(ii) Distributors fed at both the ends



:- In this type of feeding, the distributor is connected to the supply mains at both the ends

:- In the diagram AX and BY is the feeder and AB is the distributor. The terminal voltage is V_A and V_B

:- The load I_1, I_2, I_3 are tapped along the length of the distributor at C, D, E respectively

:- The voltage at ~~porr~~ both the ends may equal or different.

:- In case of load voltage first goes on decreasing and reaches its minimum value, again increasing and reaches the maximum value when reaching the other feeding point.

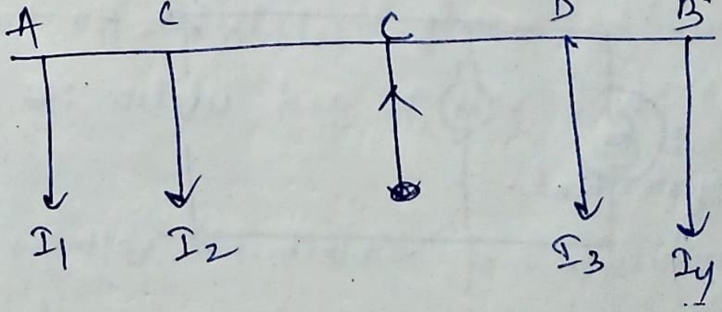
:- The point of minimum voltage is never fixed and shifts with the variation of load on the different section of the distributors.

Advantages

(i) If fault occur at any feeding point of the distributor the continuity of supply is maintained from the other feeding end.

(ii) In case of fault on any section of the distributor, the faulty section can be disconnected and supply can be maintained to the remaining section.

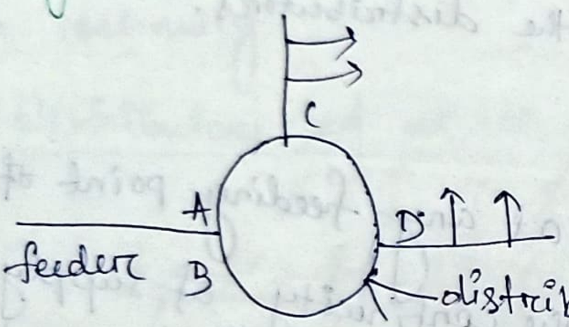
(iii) Distributors fed at the centre



:- In this type the centre of the distributor is connected to the supply mains

:- It is equivalent to two singly fed distributors, each distributor having common feeding point and length equal to half of the equal length.

Ring mains distributors



:- In this type the distributor is in the form of a closed ring. The two ends being brought together to form a closed ring.

:- The main advantages of ring main distributor is that in case of some fault on any section of the distributor the faulty section can be isolated from both the side and supply is maintained.

DC distribution

:- Electric power is almost generated, transmitted and distributed as ac. However, for certain applications dc supply is absolutely necessary.

:- For instance dc supply is required for dc motor operation, for battery charging etc.

:- For this purpose ac power is converted into dc power at the substation by rectifier.

:- The dc supply from the substation may be obtained in the form of

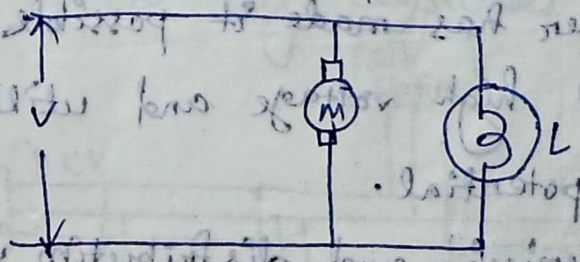
(i) 2 wire dc distribution system.

(ii) 3 wire dc distribution system.

(i) 2 wire dc distribution system

:- Such system uses two conductors, one as positive and other is negative conductor.

:- The load such as lamps, motors etc. are connected in parallel in between these two conductors.

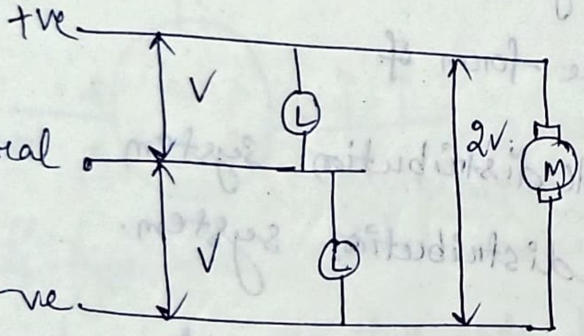


ii) 3-wire dc distribution system

- Such system use three conductors, two outer conductor (one positive and othe negative) and one middle conductor (neutral).

:- The voltage between outer conductor is 2V. and heavy loads are connected.

:- The voltage between one outer conductor and middle conductor is V volt and light loads are connected.



AC distribution

:- In general electrical energy is generated, transmitted and distributed in the form of alternating current.

:- The alternating voltage can be conveniently changed in magnitude by means of a transformer.

:- Transformer has made it possible to transmit ac power at high voltage and utilise it at a safe potential.

:- High transmission and distribution voltages have greatly reduce the current in the conductore and resulting line losses.

:- AC distribution system is two types

(i) Primary distribution system

(ii) Secondary distribution system

(i) Primary distribution system

:- It is the part of ac distribution system which operates at voltage somewhat higher than general utilization.

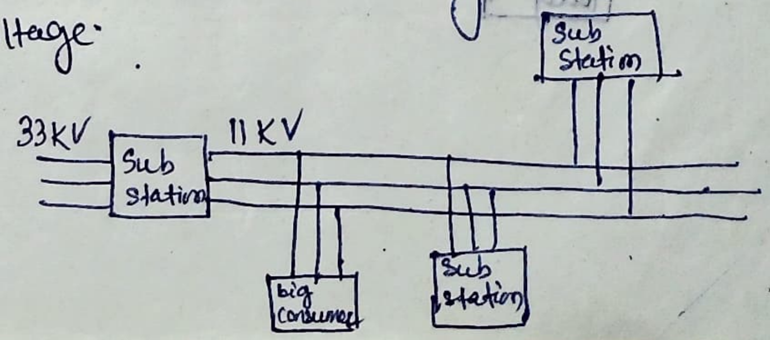
:- The most commonly used primary distribution voltage are 11KV, 66 KV and 33 KV.

:- Due to economic consideration primary distribution is carried out by 3-phase system.

:- Electric power from the generating station is transmitted at high voltage to the substation located in or near the city.

:- At this substation voltage is stepped down to 11 KV with the help of step down transformer.

:- Power is supplied to various substation for distribution or to big consumers at this voltage.



ii) Secondary distribution system

:- In this part of AC distribution system the range of voltage is at 440 | 230V which is the ultimate consumer utilization.

:- The primary distribution circuit delivers power to various substation called distribution substation.

:- The substation are situated near the consumer's locality and contain step-down transformer.

:- At each distribution substation the voltage is stepped down to 400V. The voltage between two phase is 400V and between any phase and neutral is 230V.