LECTURE NOTE ON
GENERATION TRANSMISSION & DISTRIBUTION
4TH SEM ELECTRICAL ENGINEERING

Prepared By

Er. Sachin Kumar Satpathy

(Lect. In Electrical Engg.)

B.I.T ,SAMBALPUR

9.01.2018

Generation of Electricity:

- Conversion of energy from other sources found primarily in nature to electrical energy is referred as generation of electricity.

Power station:

- Where the bulk of electrical energy is generated, that site is called as Power Station.
- depending upon the source of energy converted into electrical energy, Power stations can be categorised mainly into three types:

1. Thermal Power station (coal).
2. Hydro/Hydel Power station (Water).
3. Nuclear Power station (Uranium).

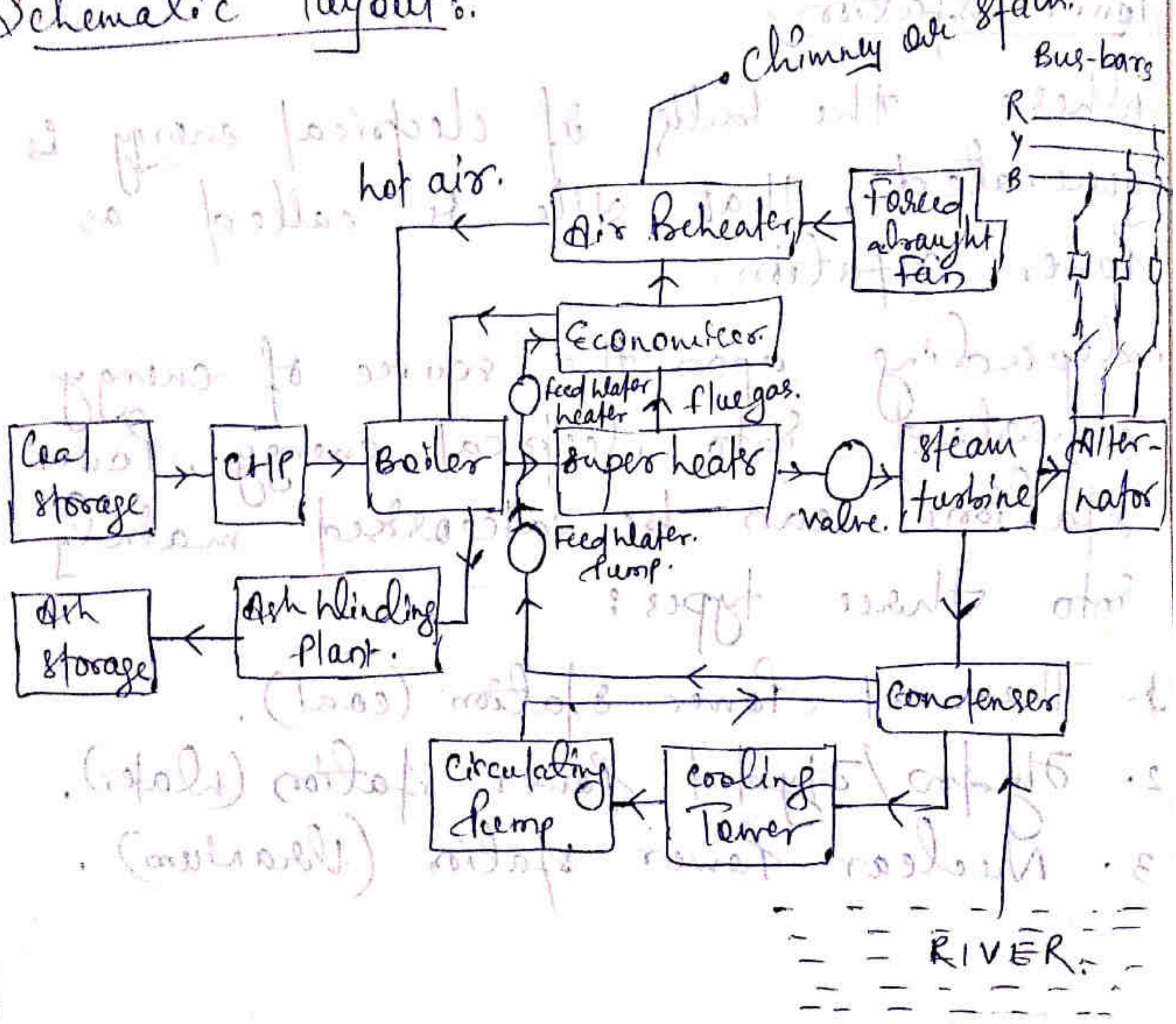
10.01.18

THERMAL POWER PLANT:

- The arrangement of a thermal power plant is mainly classified into the following 06 categories, they are:

1. Coal Handling Plant (CHP).
2. Steam Generating Unit.
3. Steam Turbine.
4. Alternator.
5. Feed Water Unit.
6. Condenser Unit.

Schematic layout:



10.10.18

• A thermal Power Station is a power station in which heat energy is converted to electric power.
• Water is heated, turns into steam and

11.01.18

HYDRO POWER PLANT:

spins a steam turbine which drives an electrical generator.

- After it passes through a turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine Cycle.
- The greatest variation in the design of thermal power stations is due to the different heat sources; fossil fuel dominates here, although nuclear heat energy and solar heat energy are also used.
- Certain thermal power stations are also designed to produce heat energy for industrial purposes, or district heating or desalination of water, in addition to generating electrical power.

Parts and Functions:

- In coal storage, bulk of coils are stored to supply the boiler.
- In Coal Handling Plant (CHP), coals of different sizes and shapes are crushed in small sizes to increase the efficiency.

- Boiler's by using crushed coal as a fuel, generates a high pressure, temperature steam.
- Super-heater increases the temperature of the steam to a very high value to fed it to the steam turbine.
- A steam turbine extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft.
- Alternator is an electrical generator that converts mechanical energy to electrical energy in the form of alternating current.
- As the alternator produces a 3-ϕ output, it is connected then to the bus-bars for the neccessary transmission and distrib-ution system.
- A condenser is a water-cooled shell and tube heat exchanger installed on the exhaust steam from a steam turbine in thermal power stations.
- Cooling tower is the heat rejection device that rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature

· Ash handling Plant system is required to handle ash for its proper utilization or disposal.

· Function of economiser is to recover some of the heat from the heat carried away in the flue gases up the chimney and utilize for heating the feed water to the boiler.

· Forced draught fans are used to regulate proper combustion and maximize efficiency of the fuel.

Advantages:

· Low fuel cost.
· Heat production system is simple.
· Easy mechanism.
· Same heat could be reused.
· Requires small space.
· Easy maintenance of power station.

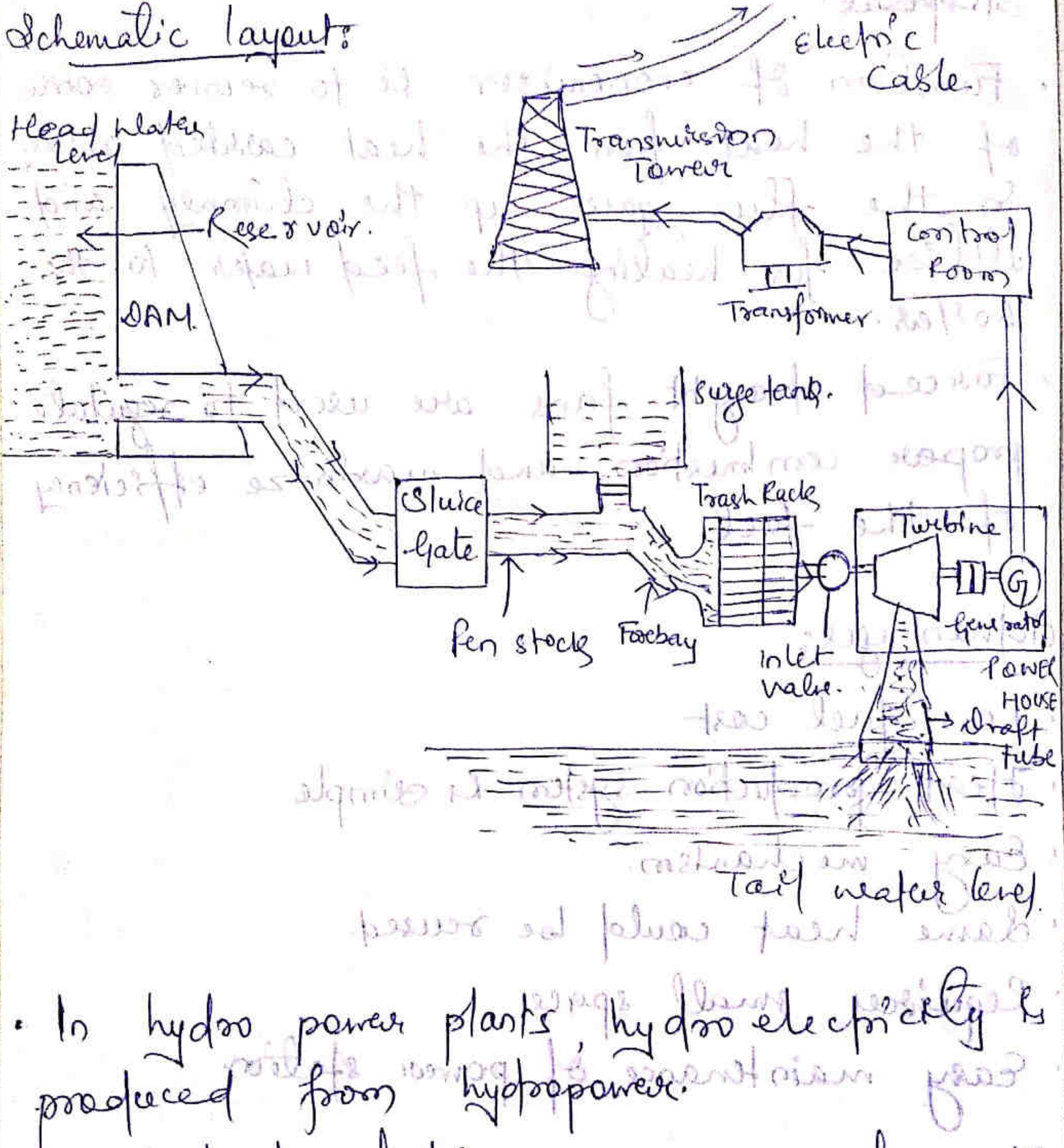
Disadvantages:

· Huge production of CO_2
· Low overall efficiency.
· Raises sea water level
· Thermal engines requires huge amount of lubricating oil that is very expensive.

11.01.18

HYDRO POWER PLANT:

Schematic layout:



- In hydro power plants, hydro electricity is produced from hydropower.
- Most hydro-electric power comes from the potential energy of dammed water driving a water turbine and generator. The power extracted from the water depends on the volume and on the difference in height between the source and the water's

outflow. This height difference is called the head. A large pipe (the penstock) delivers water from the reservoir to the turbine.

- Pumped storage method produces electricity to supply high peak demands by moving water between reservoirs at different elevations.
- At times of low electricity demand, the excess generation capacity is used to pump water into the higher reservoir.
- When the demand becomes greater, water is released back into the lower reservoir through a turbine.

<u>Parts and Functions</u>

- Hydroelectric power is produced as water passes through a dam and into a river below. The more water that passes through a dam, the more energy is produced. Once a dam is built, an artificial man-made lake is created behind the dam.
- A sluice is a water channel controlled at its head by a gate. A sluice gate is traditionally a wood or metal barrier sliding in grooves that are set in the sides of the waterway. It commonly

control water levels and flow rates in rivers and canals. When a sluice gate is lowered, water may spill over the top in which case the gate operates as a weir.

- A penstock is a sluice or gate or intake structure that controls water flow, or an enclosed pipe that delivers water to hydro-turbines and sewerage systems.

- A surge tank is a standpipe or storage reservoir at the down stream to absorb sudden rises of pressure, as well as to quickly provide extra water during a brief drop in pressure.

- The primary purpose of the trash rack is to protect the equipment by keeping floating leaves and trash from entering the turbines.

- In power turbines like reaction turbines, a diffuser tube is installed at the exit of the turbine known as draft tube. This draft tube at the end of the turbine increases the pressure of the exiting fluid at the expense of its velocity.

• Power house consist of Turbine and Generator. When high pressure water hits the turbine blades, the turbine rotates and rotates the generator armature, which produces electricity.
• The produced electricity is then transmitted through transmission towers.

Advantages:
• Once a dam is constructed, electricity can be produced at a constant rate.
• If electricity is not needed, the sluice gates can be shut, stopping electricity generation. The water can be saved for use another time when electricity demand is high.
• The lakes formed behind the dam can be used for irrigation purposes.
• don't pollute the atmosphere.

Disadvantages:
• dams are expensive to build.
• Flooding chances are more, which causes the destruction of natural environment

• Efficiency of a hydro power plant is 80-90 %.

Imp-3

12.1.18

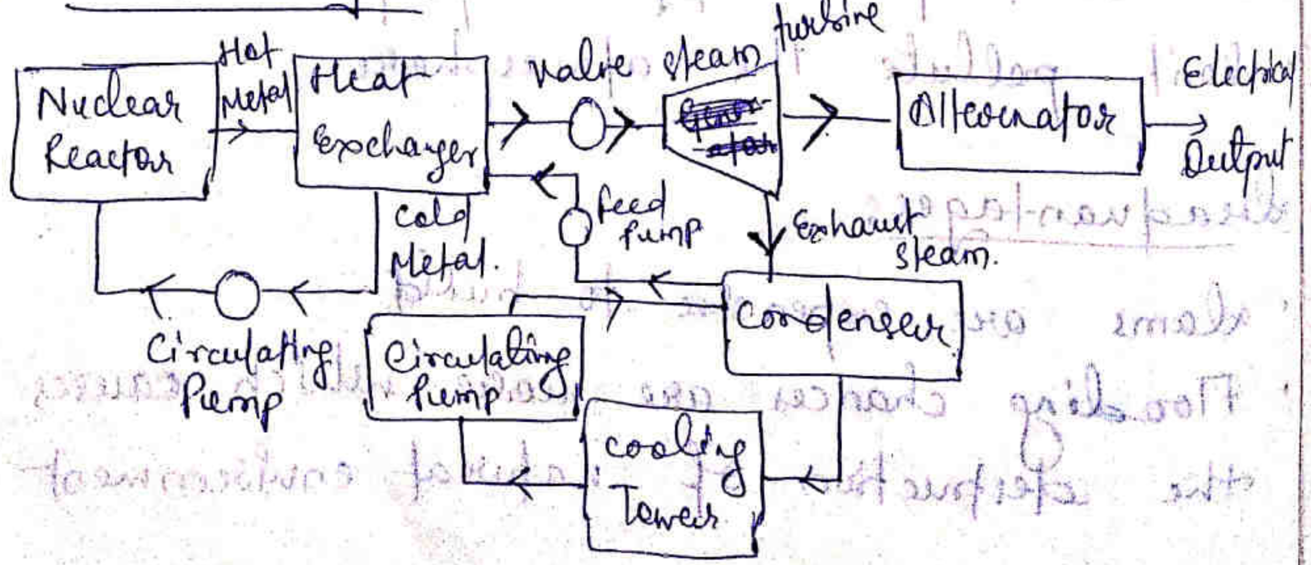
Nuclear Power Plants.

• A power plant where nuclear energy of radioactive elements is converted into electrical energy is called Nuclear Power Plant.

• The main parts of a Nuclear Power Plant are:

(I) Nuclear Reactor.
(II) Heat Exchanger
(III) Steam Turbine.
(IV) Alternator.

Schematic layout:



• A nuclear power plant or nuclear power station is a thermal power plant in which the heat source is a nuclear reactor.

• As is typical in all conventional thermal power stations the heat is used to generate steam ~~steam~~ which drives a steam turbine connected to an electric generator which produces electricity.

• Nuclear power stations are usually considered to be base load stations since fuel is a small part of cost of production.

• The fission in a nuclear reactor heats the reactor coolant. The coolant may be water or gas or even liquid metal depending on the type of reactor. This reactor coolant then goes to a steam generator and heats water to produce steam.

• The pressurized steam is then usually fed to a multi-stage steam turbine. After the steam turbine has expanded and partially condensed the steam, the remaining vapour is condensed in a condenser.

• The condenser is a heat exchanger which is connected to a secondary side such as a reservoir or a cooling tower. The water is then pumped back into the steam generator and the cycle begins again.

Parts and functions:

- The nuclear reactor is the heart of the station. In its central part, the reactor core's heat is generated by controlled nuclear fission. With this heat, a coolant is heated as it is pumped through the reactor and thereby removes the energy from the reactor. These usually rely on uranium to fuel the chain reaction.

- The purpose of the steam turbine is to convert the heat contained in steam into mechanical energy. The engine house with the steam turbine is usually structurally separated from the main reactor building.

- Alternator converts mechanical power supplied by the turbine to ac electrical power.

- A cooling system removes heat from the reactor core and transports it to another area of the station, where the thermal energy can be harnessed to produce electricity or to do other useful work.

- Condenser is a large cross flow tube and shell-heat exchanger that takes wet vapour, a mixture of liquid water and steam at saturation conditions, from the turbine-generator exhaust and condenses it back into subcooled liquid water so it can be pumped back to the reactor by the condensate and feedwater pumps.
- The water level in the steam generator and nuclear reactor is controlled using the feedwater system.

Advantages: 1m

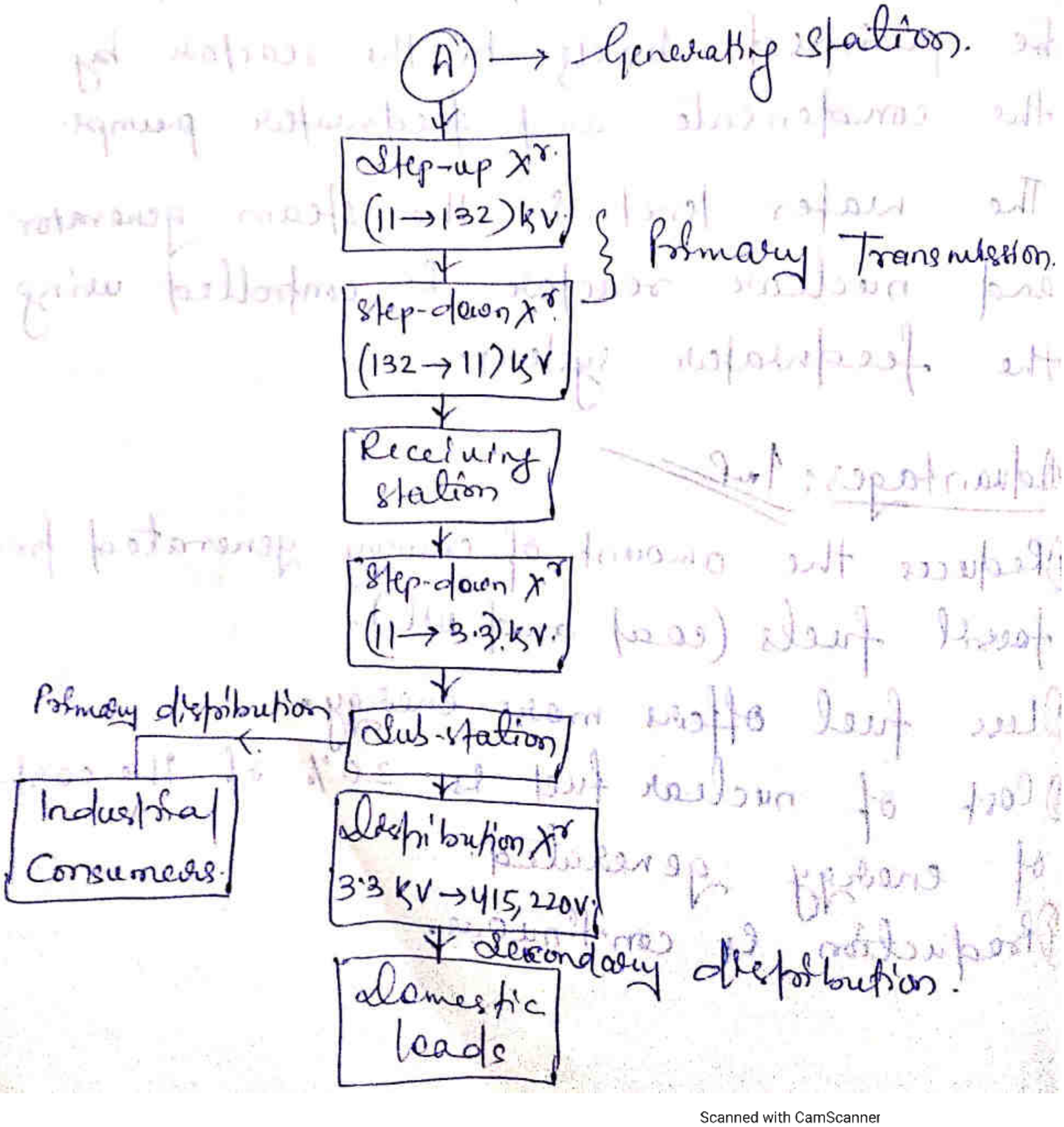
1. Reduces the amount of energy generated from fossil fuels (coal and oil).
2. Less fuel offers more energy.
3. Cost of nuclear fuel is 20% of the cost of energy generated.
4. Production is continuous.

Scanned with CamScanner

Disadvantages: Imp
- difficulty for the management of nuclear wastes.
- limited life.
- Investment is high.
- Thermal efficiency is about 33%.

16.1.18

Transmission and distribution layout:-



17.1.18

Voltage Regulation of a Transmission line:

- The difference in sending end voltage and receiving end voltage expressed as a percentage of receiving end voltage is called as voltage regulation of a transmission line.

- Mathematically,

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

where, V_s = sending end voltage.
V_R = receiving end voltage.

. The lower the voltage regulation, the better is the transmission.

Efficiency of a Transmission line:-

$$\eta = \frac{P_R}{P_s} \times 100\ \%$$

where, η = efficiency
P_R = Receiving end power.
P_s = sending end power.

$P_R = V_R I_R \cos\phi_R$. where, I_R = load ende current
$P_s = V_s I_s \cos\phi_s$. I_s = sending end current.
$\cos\phi_R$ = receiving end power factor

$\cos\phi_s$ = sending end power factor.

Kelvin's law:

• It is used for calculation of most economical size of a conductor.

$C_1 \propto a$ (area of cross-section)

$\Rightarrow C_1 = Pa$ (P = Proportionality constant) — eq (I).

$\boxed{C = C_1 + C_2}$

$C_2 \propto \frac{1}{a}$

$\Rightarrow C_2 = \frac{Q}{a}$ (Q = Proportionality constant) — eq (II).

Size of the conductor will mostly be economical when,

$\frac{dC}{da} = 0$ $\left[\begin{aligned} C &= C_1 + C_2 \\ &= Pa + \frac{Q}{a} \end{aligned} \right]$

$\Rightarrow \frac{d}{da}\left(Pa + \frac{Q}{a}\right) = 0.$

$\Rightarrow \frac{d}{da}(Pa) + \frac{d}{da}\left(\frac{Q}{a}\right) = 0.$

$\Rightarrow P + Q \cdot \frac{d}{da} a^{-1} = 0$

$\Rightarrow P + (-Q \cdot a^{-2}) = 0.$

$\Rightarrow P + \frac{-Q}{a^2} = 0.$

$\Rightarrow a^2 P = Q.$

$\Rightarrow a = \sqrt{\frac{Q}{P}}$

Putting the value of 'a' in eq (I),

$$C_1 = Pa$$
$$= P\sqrt{\frac{Q}{P}}$$
$$= \sqrt{P}\cdot\sqrt{Q} = \sqrt{PQ}.$$

Putting the value of 'a' in eq (II),

$$C_2 = \frac{Q}{a}$$
$$= \frac{Q}{\sqrt{\frac{Q}{P}}} = \sqrt{PQ}.$$

As, $C_1 = C_2$, so area of cross-section of the conductor will be most economical.

19.01.18

Corona Loss:

- Power loss occurs in a high voltage transmission line due to the phenomenon of corona. This loss is said to be corona loss.
- According to 'Peek', corona loss may be given by the following empirical formula, i.e.,

$$\boxed{P_c = 243.5\left(\frac{F+25}{\delta}\right)\sqrt{\frac{r}{d}}\,(V-V_d)^2\times 10^{-5}\ \text{kW/km/phase}} \quad (1)$$

Scanned with CamScanner

where, P_c = Corona loss

f = supply frequency

r = radius of conductor's cross-section

D = spacing ~~below~~ bet^n conductor

V = Phase voltage of conductor

V_d = disruptive critical voltage

δ = Relative air density.

- When the ratio of $\left(\frac{V}{V_d}\right)$ is greater than 1·8, the above formula holds good for the ratio $\left(\frac{V}{V_d}\right)$ less than 1·8

(Peterson's formula) $$P_c = \frac{21 \times 10^{-6} \times f \times V^2}{\left(\log_{10} \frac{D}{r}\right)^2} \times F \ \text{kW/km/phase}$$

$\left[3.37 \times 10^{-5}\right]$ book

F = a factor which depends upon the ratio of V/V_d

06.02.18

Design of Overhead Transmission lines:

Main Components:

1) Conductors,
2) Supports,
3) Insulators,
4) Cross arms,
5) Miscellaneous.

CONDUCTORS:

· Conducting Material: Properties: (desireable)

(i) - High electrical conductivity.
(ii) - High tensile strength in order to withstand mechanical stresses.
(iii) - Low cost so that it can be used for long distances.
(iv) - low specific gravity so that weight per unit volume is small.

Commonly used conductor materials:-

a) Copper
b) Aluminium
c) Steel-Cored aluminium.
d) Galvanised steel.
e) Cadmium steel.

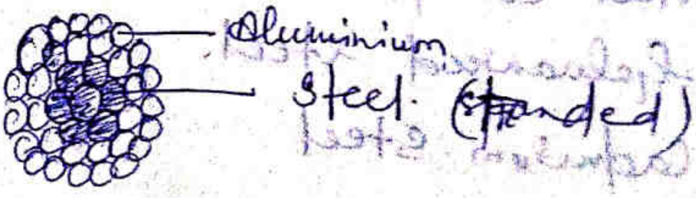
(a) Copper.

- High electrical conductivity
- Greater tensile strength
- Hard drawn copper used.
- High current density
- smaller cross-sectional area required
- High specific gravity
- High cost & less availability

(b) Aluminium.

- Cheaper & light in weight, for small span.
- small conductivity & tensile strength (60% of copper)
- Cross-sectional area of conductor larger than copper (Aluminium diameter = 1.26 times of copper)
- Higher tower with greater sag.
- Specific gravity lower than copper
- larger cross-arms required.
- Not suitable for long distance transmission

(c) Aluminium Conductor steel Reinforced (ACSR)



- To increase strength of aluminium conductors reinforced with a core of galvanised steel wires.
- Abbreviated as ACSR (Aluminium conductor steel reinforced)

Advantages of ACSR:-

- High mechanical strength can be utilized by using spans of larger lengths.
- Tower of smaller height can be used.
- A reduction in the no. of supports also include reduction in insulators and the risk of lines outage due to flash over or faults is reduced.
- losses are reduced due to larger diameter of conductor.
- High current carrying capacity.

(d) Galvanised steel.

- Very high tensile strength.
- long spans.
- Rural areas.
- Cheap.
- Poor conductivity of high resistance
- Not suitable for transmitting large power

over a long distance.

(e) Cadmium Copper

- Addition of 1% or 2% cadmium to copper
- Increased tensile strength by 50% than pure copper.
- Conductivity reduced by 15% below that of pure copper.
- Economical for lines of small cross-section due to high cost of cadmium.

Line Supports:

Properties:

- High mechanical strength to withstand weight of conductor
- Light in weight.
- Cheap in cost.
- Longer life.
- Easy accessibility of conductors for mainte-nance.

Types of line supports

- Wooden poles.
- steel poles.
- RCC poles. (Reinforced Concrete poles)
- lattice steel towers

Wooden Poles.

- shorter span upto 50 m.
- less cost & used for distribution purpose. for rural areas.
- Pesticides required, e.g., creosote oil.
- Used for voltage upto 20KV.
- smaller life (20-25 years)
- Less mechanical strength.
- Made of Sal or Chir. ~~wood~~
- Moderate cross-sectional area.

Steel Poles:.

- Greater mechanical strength.
- Longer life.
- larger spans.
- Used for distribution purpose in cities.

Reinforced Concrete poles (RCC):.

- Greater mechanical strength,
- Longer life,
- longer spans,
- Good outlook.
- little maintenance,
- Good insulating properties.
- Commonly used

Steel towers:

- longer life
- longer span
- Greater mechanical strength.
- Long distance at high voltage.
- Tower footings are usually grounded by driving rods into the earth. This minimizes lightening troubles as each tower acts as lightening conductor.

Types of Towers:

1) Suspension Tower.
2) Tension Tower
3) Angle Tower
4). End Tower.

08.02.18

SAG Imp - 10

- The straight distance between the two poles gives the shortest distance. Therefore to minimise the length of conductor, One may stretch conductor to make it straight
- But we also look after that the conductors

are in safe tension in order to permit safe tension in the conductors, they are not fully stretched but are allowed to have some dip.

- Thus the difference in level points of supports and lowest point on the conductor is called a sag.

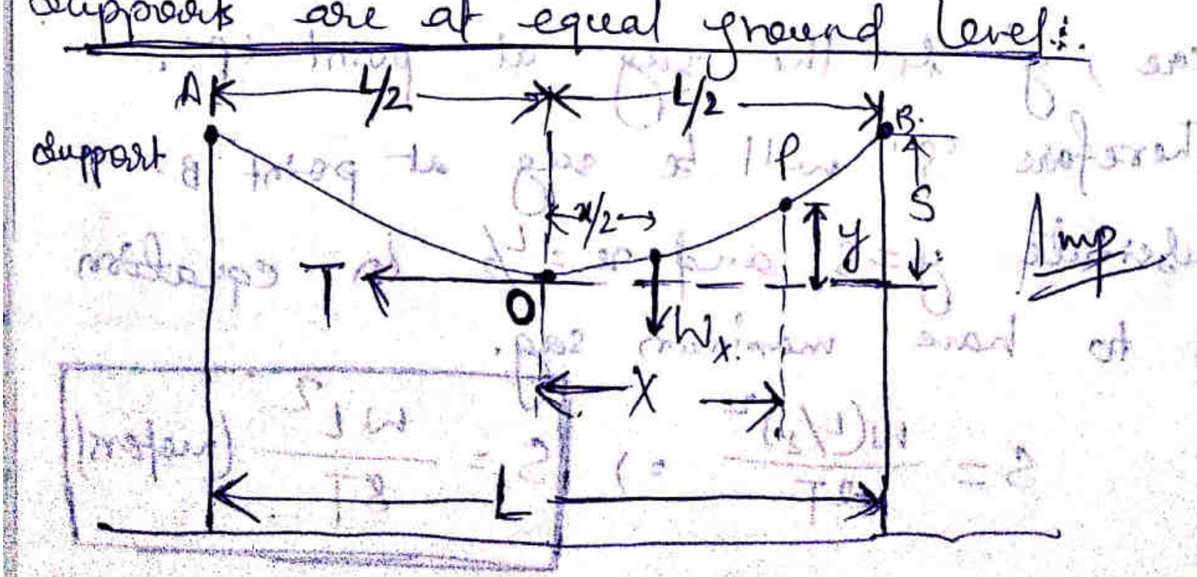
- The tension on the conductor depends on the following factors:

1. Weight of the conductor
2. Wind effect.
3. Ice loading
4. Temperature Variation

- While calculating sag, there arises two conditions:

— supports are at equal ground level.
— supports are at unequal ground level.

<u>Supports are at equal ground level:</u>



- Refer figure in which 'O' is the lowest point of the conductor spacing.
- L= Length of span in meters.
- W= Weight of the conductor per unit length.
- T= Tension on the conductor.
- Consider any point 'P' on the conductor whose co-ordinate are 'x' and 'y'.
- There are two forces acting on the portion 'OP':

1. Weight of the portion 'OP' acting downward at a distance $x/2$ from origin 'O'.
2. Tangential tension 'T' acting at points 'O'.

- Taking the moments of the above forces about point 'O', we have.

$$T \times y = W \cdot x \times \frac{x}{2}$$

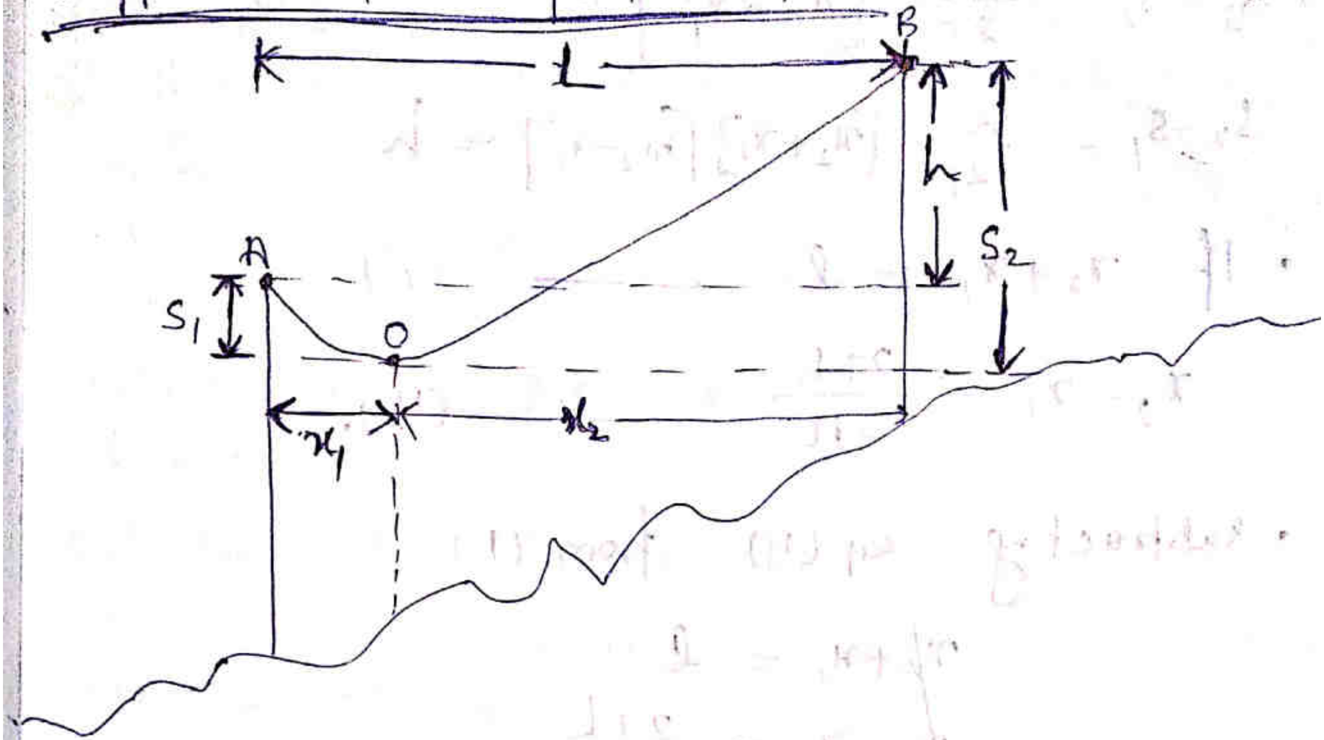
$$\therefore y = \frac{Wx^2}{2T} \quad \text{——— (1)}$$

- Here, y is the sag at point (P).
Therefore 'S' will be sag at point B.

$\therefore$ substitute $y = S$ and $x = L/2$ in equation (1) to have maximum sag.

$$S = \frac{W(L/2)^2}{2T} \Rightarrow \boxed{S = \frac{WL^2}{8T} \text{ (meters)}}$$

Supports at unequal Level



- fig. shows the position of lowest points 'O' of conductor which is not exactly at centre of distance 'l'.
- Therefore, 'x_1' is the distance of support at lower level from lowest point 'O'.

'x_2' is the distance of support at high level from lowest point 'O'.

- 'L' is span length $= x_1 + x_2$
- $h =$ difference betn two supports 'A' & 'B'.

$= (S_2 - S_1)$

- If 'W' is the weight per unit length of conductor, then.

Sag, $S_1 = \frac{Wx_1^2}{2T}$

Sag, $S_2 = \frac{Wx_2^2}{2T}$

$$S_2 - S_1 = \frac{W}{2T}\left[x_2^2 - x_1^2\right]$$

$$S_2 - S_1 = \frac{W}{2T}\left[x_2 + x_1\right]\left[x_2 - x_1\right] = h$$

- If $x_2 + x_1 = l$ ——— (I)

$$x_2 - x_1 = \frac{2Th}{WL} \quad \text{——— (II)}$$

- Subtracting eq (II) from (I)

$$\begin{aligned} \cancel{x_2} + x_1 &= l \\ - \cancel{x_2} - x_1 &= \frac{2Th}{WL} \\ \hline 2x_1 &= l - \frac{2Th}{Wl} \quad \text{——— (III)} \end{aligned}$$

- Adding eq (I) and (II),

$$\begin{aligned} x_2 + x_1 &= l \\ + \quad x_2 - x_1 &= \frac{2Th}{WL} \\ \hline 2x_2 &= l + \frac{2TH}{Wl} \quad \text{——— (IV)} \end{aligned}$$

- Using eq (3) and (4), values of x_1 and x_2 can be found out. Further S_2 and S_1 can be easily calculated.

9.02.18

Q. A 132 kV transmission line has the following data:

$W = 680$ kg/km

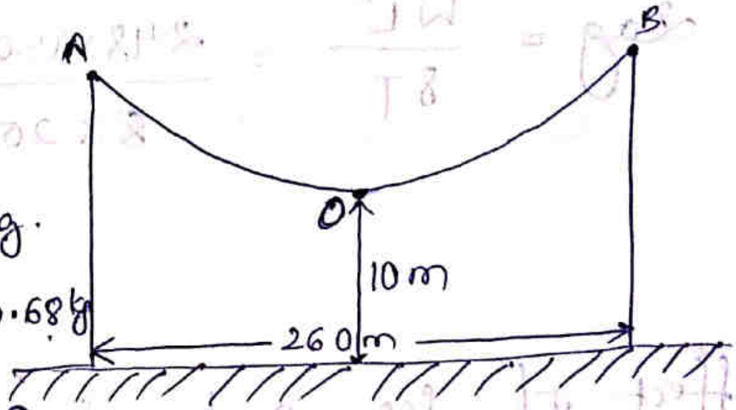
$L = 260$ m

Ultimate strength $= 3100$ kg.

Safety factor $= 2$

Calculate the height above ground at which the conductor should be supported. Ground clearance required is 10 m.

A.



$W = 680$ kg/Km.

$\Rightarrow$ 1000 m $= 680$ kg.

1 m $= \frac{680}{1000} = 0.68$ kg

~~260 m $= 0.68 \times 260$~~

~~$= 176.8$ kg~~

$$S = \frac{WL^2}{8T} = \frac{\cancel{176.8}\ 0.68 \times (260)^2}{8 \times \cancel{3100}\ 1550} = 3.707$$

$$\text{Working Tension} = \frac{\text{Ultimate strength}}{\text{safety factor}} = \frac{3100}{2} = 1550 \text{ kg}$$

- The height above ground level at which the conductor should be supported is,

$(3.707 + 10)$ m $= \boxed{13.707 \text{ m}}$

Scanned with CamScanner

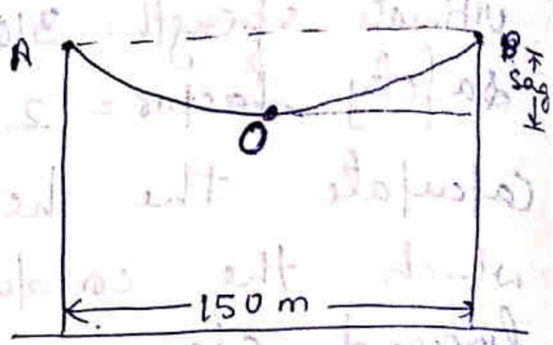
Q. A transmission line has a span of 150 m working under tension 2000 kg. If the weight per metre length of conductor is 2.48 kg. Then find out the sag.

A. Given,

$L = 150$ m

$T = 2000$ kg.

$W = 2.48$ kg



$$\text{Sag} = \frac{WL^2}{8T} = \frac{2.48 \times (150)^2}{8 \times 2000} = \boxed{3.4875 \text{ m}}$$

Effect of ice and wind loadings:

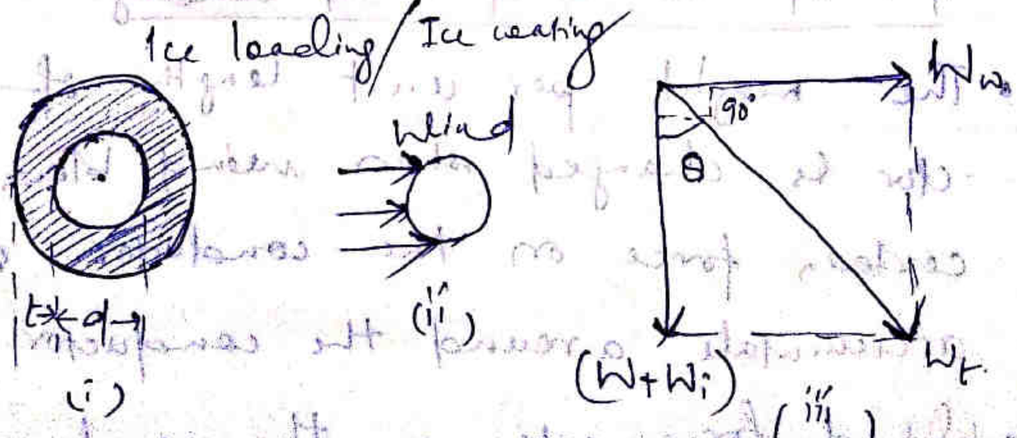
The weight per unit length of the conductor is changed when wind blows at a certain force on the conductor and ice accumulates around the conductor.

- Wind force acts on the conductor

20.02.18

Effect of Ice and Wind loadings:

- The above formulae for sag are true only in still air and at normal temperature when the conductor is acted by its weight only. However, in actual practice, a conductor may have ice coating and simultaneously subjected to wind pressure. The weight of ice acts vertically downwards, i.e., in the same direction as the weight of conductor. The force due to the wind is assumed to act horizontally, i.e., at right angle to the projected surface of the conductor. Hence, the total force on the conductor is the vector sum of horizontal and vertical forces as shown in the following figures



Total weight of conductor per unit length,

$$\boxed{W_t = \sqrt{(W+W_i)^2 + (W_w)^2}}$$

where,

W = weight of conductor per unit length.
= conductor material density × volume per unit length.

W_i = weight of ice per unit length.
= density of ice × volume of ice per unit length.
= density of ice × $\frac{\pi}{4}\left[(d+2t)^2 - d^2\right] \times 1$
= density of ice × $\pi t(d+t)$

W_w = wind force per unit length
= wind pressure per unit area × projected area per unit length.
= wind pressure × $[(d+2t) \times 1]$

Effect of Ice and Wind loading.

- The weight per unit length of the conductor is changed when wind blows at a certain force on the conductor and ice accumulate around the conductor.
- Wind force acts on the conductor to change the conductor self weight per unit length horizontally in the direction of the

air flow.

- Ice loading acts on the conductor to change the conductor self weight per unit length vertically downward.
- Considering wind force and ice loading both at a time, the conductor will have a resultant weight per unit length.
- The resultant weight will create an angle with the ice loading downward direction.

Let us assume, 'W' is the weight of the conductor per unit length, 'W_i' is the weight of ice per unit length.

W_i = density of ice x Volume of ice per unit length.

$$= \text{density of ice} \times \frac{\pi}{4}\left[(d+2t)^2 - d^2\right] \times 1$$

$$= \text{density of ice} \times \pi t(d+t)$$

'W_w' is the force of wind per unit length

W_w = wind pressure per unit area x projected area per unit length.

$$= \text{wind pressure} \times [d+2t \times 1]$$

So, the total weight of the conductor per unit length is.

$$\boxed{W_t = \sqrt{(W+W_i)^2 + (W_w)^2}} \text{ and } \boxed{\tan\theta = \frac{W_w}{W+W_i}}$$

INSULATORS:

- Transmission line insulators are devices used to contain, separate or support electrical conductors on high voltage electricity supply networks. Transmission insulators come in various shapes and types; including individual or strings of disks, line posts or long rods. They are made of polymers, glass and porcelain, each with different densities, tensile strengths and performing properties in adverse conditions.
- There are several types of insulators but the most commonly used are pin type, suspension type, strain insulator and shackle insulators.

1) Pin type,
2) Suspension type,
3) Egg or stay type,
4) Shackle type, &
5) Strain type.

22.02.18

Performance of Transmission lines:

Classification of Transmission lines:

- Depending upon the length of the transmission line, it be divided into three types,

1) Short Transmission line, <50 km, <20 KV
2) Medium " " , >50, < 150 km 20 KV-100 KV
3) Long " " > 150 km greater than 100 KV

27.02.18

Short Transmission line:

Equivalent Circuit:

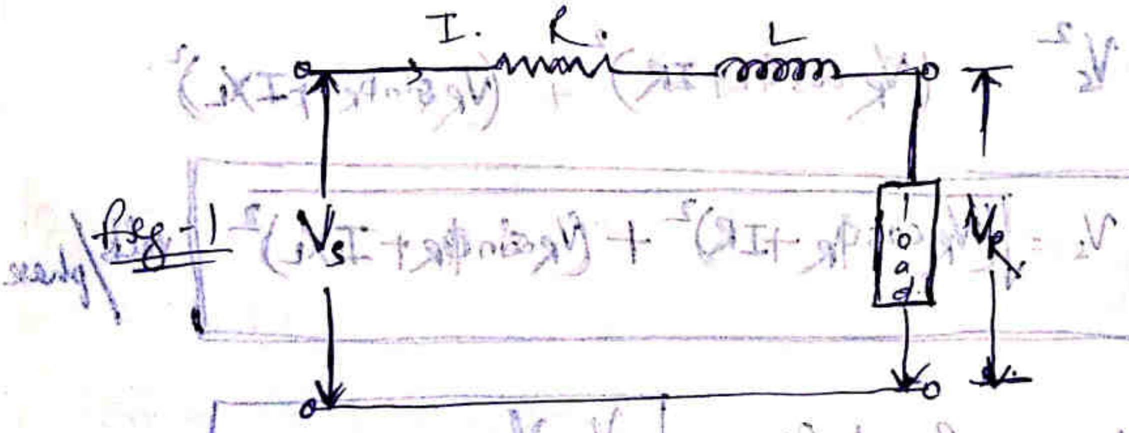


fig-1

Phasor Diagram

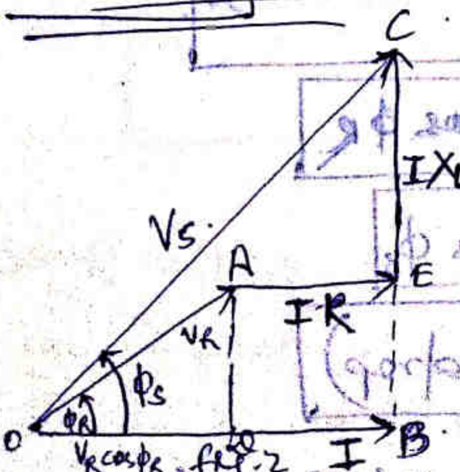


fig-2

where
R = Loop resistance
L = loop inductance
I = loop current = $I_R = I_S$
I_R = receiving end current
I_S = sending end current.
V_S = sending end voltage
V_R = receiving end voltage.

ϕ_S = sending end power factor.
ϕ_R = receiving end power factor.

Calculations:-

- For a lagging receiving end power factor $\cos\phi_R$ and reference vector as loop current I, the phasor diagram for a short T.L of equivalent circuit as fig 1 is represented by fig-2.

- From fig-2, we can write

$$OC^2 = OB^2 + BC^2$$

Now, $OB = OD + DB = V_R\cos\phi_R + IR$

$BC = BE + EC = V_R\sin\phi_R + IX_L$

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

$$\Rightarrow \boxed{V_s = \sqrt{(V_R\cos\phi_R + IR)^2 + (V_R\sin\phi_R + IX_L)^2}} \text{ volts/phase}$$

Imp

(1) Voltage Regulation = $\boxed{\dfrac{V_s - V_R}{V_R} \times 100\%}$

(2) Power delivered = $\boxed{V_R \times I \times \cos\phi_R}$

(3) Power send = $\boxed{V_s \times I \times \cos\phi_s}$

(4) Power loss = $\boxed{I^2R \text{ (Ohmic drop)}}$

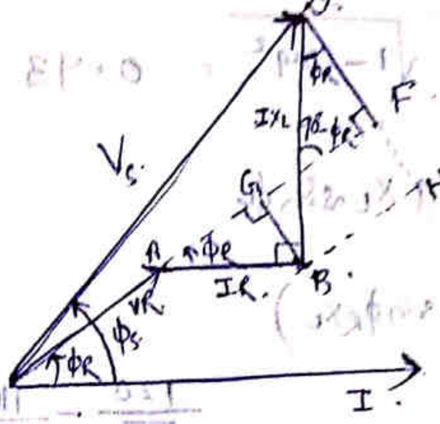
(5) or Efficiency(η) = $\dfrac{\text{Power delivered}}{\text{Power send}} \times 100\%$

$= \dfrac{\text{Power delivered}}{\text{losses + Power delivered}} \times 100\ \%$

$= \dfrac{V_R I \cos\phi_R}{I^2 R + V_R I \cos\phi_R} \times 100\ \%$

06.03.18

Calculation of approximate value of 'V_s'.



(Phasor diagram for Short T.L)

In the above figure, for $\phi_s - \phi_R$ very less,

$OD = OF$.

$\Rightarrow OD = OA + AG + GF$.

$\Rightarrow \boxed{V_s = V_R + IR\cos\phi_R + IX_L\sin\phi_R}$ for single phase

Q. A short 3-phase transmission line with an impedance $6 + j8\ \Omega$ per phase has V_s & V_R of 120 kV & 110 kV respectively. The transmission line has some receiving end load at 0.9 p.f (lag). determine the ~~total~~ o/p power & sending end power factor.

A Given data:

$\cos\phi_R = 0.9$.

$V_s = \frac{120}{\sqrt{3}}$ kV

$V_R = \frac{110}{\sqrt{3}}$ kV.

$P_{o/p} = V_R I \cos\phi_R = ?$

$\cos\phi_s = ?$

$R = 6\ \Omega$.

$X_L = 8\ \Omega$.

$\cdot\ \sin\phi_R = \sqrt{1-\cos\phi_R^2} = \sqrt{1-0.9^2} = 0.43$

1) $V_s = V_R + IR\cos\phi_R + I X_L \sin\phi_R$.

2) $V_s = V_R + I(R\cos\phi_R + \sin\phi_R X_L)$.

3) $I = \frac{V_s - V_R}{R\cos\phi_R + \sin\phi_R \times X_L} = \frac{\frac{120}{\sqrt{3}} - \frac{110}{\sqrt{3}}}{(6\times 0.9)+(8\times 0.43)}$

$= 0.65$ A.

$\cdot\ P_{out}^{(1\phi)} = V_R I \cos\phi_R = \frac{110}{\sqrt{3}} \times 0.65 \times 0.9 =$

07.03.18

Performance of Medium TLs

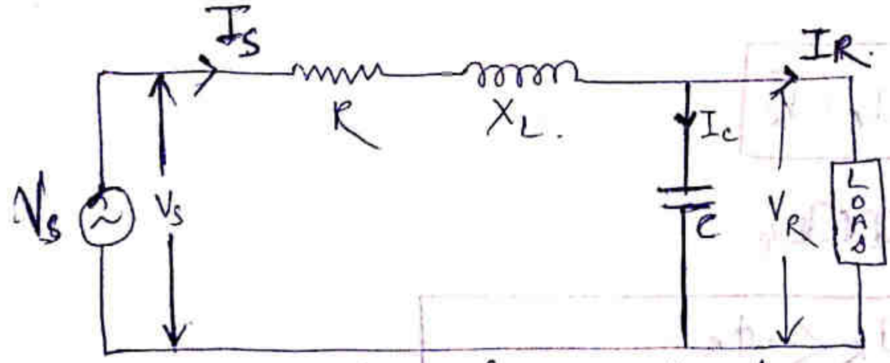
There are 3 methods:

(I) END CONDENSER METHOD.

(II) NOMINAL T METHOD.

(III) NOMINAL π METHOD.

END CONDENSER METHODS -



Equivalent ckt diagram

In the above figure,

$\vec{V_S}$ = Sending end voltage

$\vec{V_R}$ = Receiving end voltage.

R = loop resistance.

X_L = loop inductive reactance.

$\vec{I_S}$ = Sending end current.

$\vec{I_R}$ = receiving end current.

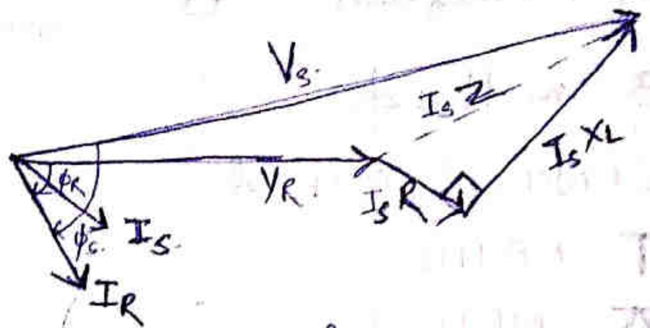
$\vec{I_c}$ = current in capacitor.

C = capacitance.

$\cos\phi_R$ = Receiving end power factor (lagg)

$\cos\phi_s$ = sending end power factor

Phasor diagram for End condenser method



From the above figure,

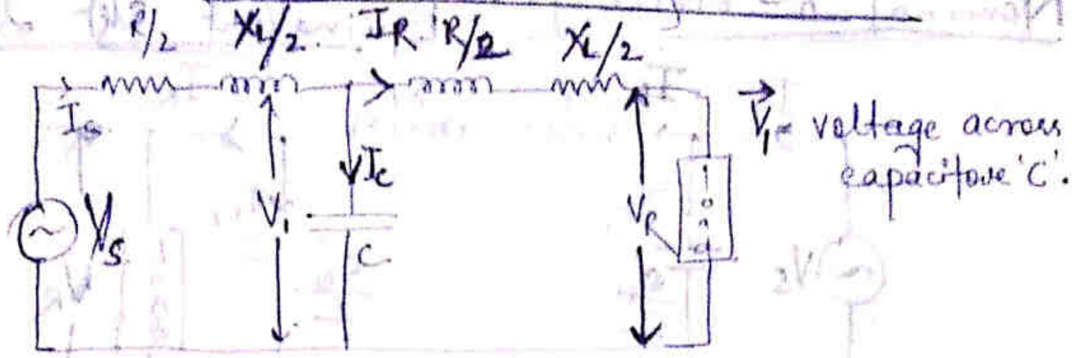
- $\vec{V}_S = \vec{V}_R + \vec{I}_S \vec{Z}$
- $\boxed{\vec{I}_S = \vec{I}_C + \vec{I}_R}$
- $\vec{I}_C = -J\omega C\vec{V}_R$
- $\vec{I}_R = I_R \angle -\phi_R$
  $= I_R(\cos\phi_R - J\sin\phi_R)$
- $\vec{Z} = R + JX_L$
- $V.R = \dfrac{\vec{V}_S - \vec{V}_R}{\vec{V}_R} \times 100\,\%$ (per phase)
- Efficiency $(\eta) = \dfrac{P_{o/p}}{P_{i/p}} \times 100\,\%$

$= \dfrac{P_{o/p}}{P_{out} + \text{losses}} \times 100\,\%$

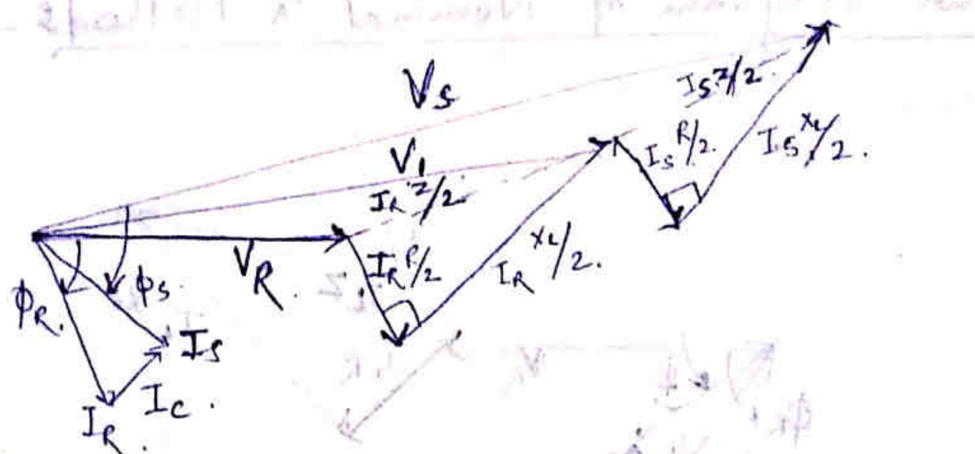
$= \dfrac{V_R I_R \cos\phi_R}{(V_R I_R \cos\phi_R + I_S^2 R)} \times 100\,\%$ (per phase)

(ii) NOMINAL T- METHODS

Equivalent ckt diagram



Phasor diagram of Nominal T-Method:-



From figure,

$\vec{V_s} = \vec{V_R} + I_R\left(\frac{Z}{2}\right) + I_s\left(\frac{Z}{2}\right) \Rightarrow \vec{V_R} + \frac{Z}{2}\left(I_R + I_s\right)$

$\boxed{\vec{I_R} = I_R\angle-\phi_R = I_R\cos\phi_R}$

$\boxed{\vec{I_s} = \vec{I_R} + \vec{I_c}}$

$\vec{I_c} = -J\,\omega C\,\vec{V_1}$ $\left[\because I_c = \frac{V}{JX_C} = \frac{V_1}{J/\omega C} = \frac{V_1\omega C}{J} = -J\omega C V_1\right]$

$\vec{V_1} = \vec{V_R} + \vec{I_R}\times\frac{\vec{Z}}{2}$

$\%R = \frac{\vec{V_s} - \vec{V_R}}{\vec{V_R}} \times 100\%$ (per phase)

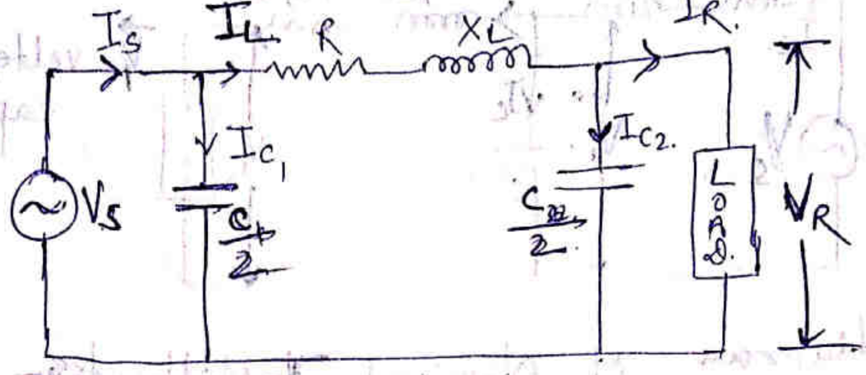
Efficiency (η) (1-φ) $= \frac{P_{o/p}}{P_{o/p} + \text{losses}} \times 100\%$

$\boxed{\text{Losses} = I_s^2\frac{R}{2} + I_R^2\frac{R}{2} = \left(I_s^2 + I_R^2\right)\frac{R}{2}}$

$= \frac{V_R I_R\cos\phi_R}{V_R I_R\cos\phi_R + \left(I_s^2 + I_R^2\right)\frac{R}{2}} \times 100\%$

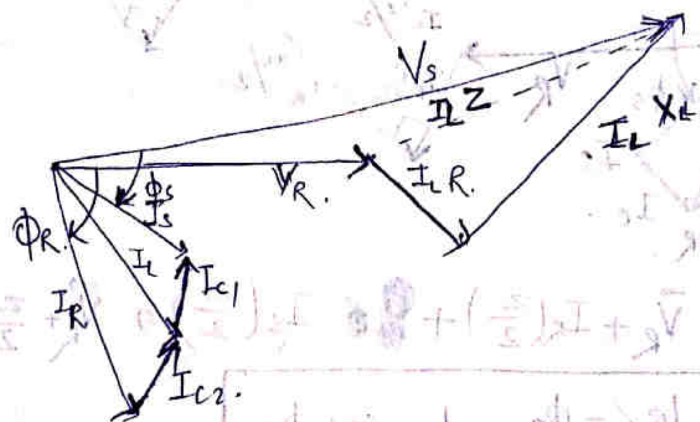
08.03.18

Nominal π Method:- Equivalent ckt diagram



Equivalent ckt diagram.

Phasor diagram of Nominal π Method:-



Here,

$$\boxed{\begin{aligned} I_S &= I_L + I_{C_1} \\ &= I_{C_2} + I_R + I_{C_1} \end{aligned}}$$

$(\because I_L = I_{C_2} + I_R)$

Again,

$$I_R = I_R \angle -\phi_R = I_R(\cos\phi_R - J\sin\phi_R)$$

$$I_{C_1} = J\omega \frac{C}{2} V_S$$

$$I_{C_2} = J\omega \frac{C}{2} V_R$$

$$\boxed{\begin{aligned} V_S &= V_R + I_L R + J I_L X_L \\ &= V_R + I_L Z \\ &\text{where } Z = R + J X_L \end{aligned}}$$

13.03.18

Voltage level Classifications.

- 0 – 300 KV → High Voltage (HV)
- 300 – 765 KV → Extra High Voltage (EHV).
- > 765 KV → Ultra High voltage (UHV)

Need for EHV 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. This will lead to increase in transmission efficiency.
- With decrease in transmission current, size of conductor required reduces which decreases the volume of conductor.
- The transmission capacity is proportional to square of operating voltage. Thus the transmission capacity of line increases with increase in voltage.
- With increase in level of transmission voltage, the installation cost of the transmission line per km decreases.
- The number of circuits and the land requirement for transmission decreases with the use of higher transmission voltages.

Problems involved in EHV-AC Transmission

- Corona loss & radio interference occurs.
- Highly insulated line supports required leading to higher cost.
- Erection difficulties occurs.
- Insulation needs.
- The cost of transformers, switchgear equipments & protective equipments increases with increase in transmission line voltage.
- The EHV Lines generates electrostatic effects and electromagnetic fields which are harmful to human being & animals.

HVDC Transmission:

- Basic principle:

→ The basic principle of HVDC transmission is to rectify the ac power to a voltage level of around 200 kv (both polarity) and to transmit power over a two cable or a pole line to a converter operating in inverter mode.

- Thus power is fed to other ac system Power flow can be made in either direction.

3 basic steps are:

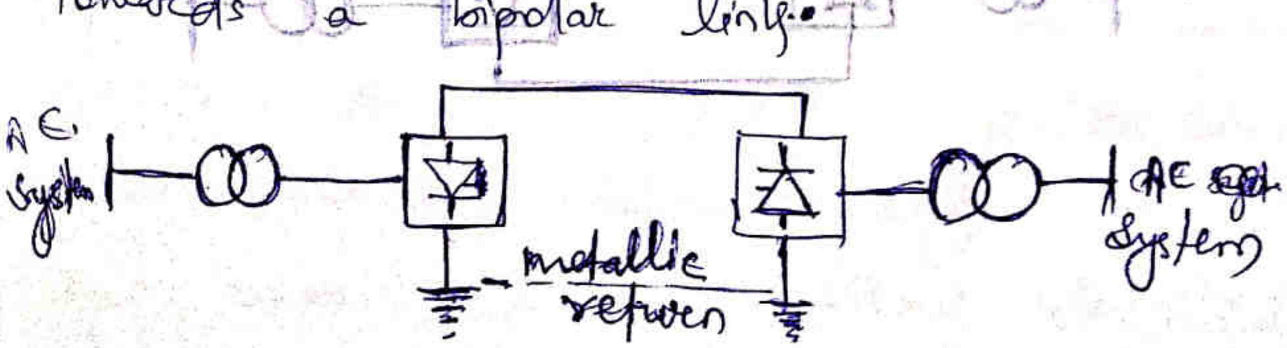
1. Convert AC into DC (rectifier)
2. Transmit DC.
3. Convert DC into AC (Inverter)

HVDC links can be broadly classified into.

- Monopolar links.
- Bipolar links.
- Homopolar links.

MONOPOLAR links:

- It uses one conductor.
- The return path is provided by ground or water.
- Use of this system is mainly due to cost considerations.
- A metallic return may be used where earth resistivity is too high.
- This configuration type is the first step towards a bipolar link.

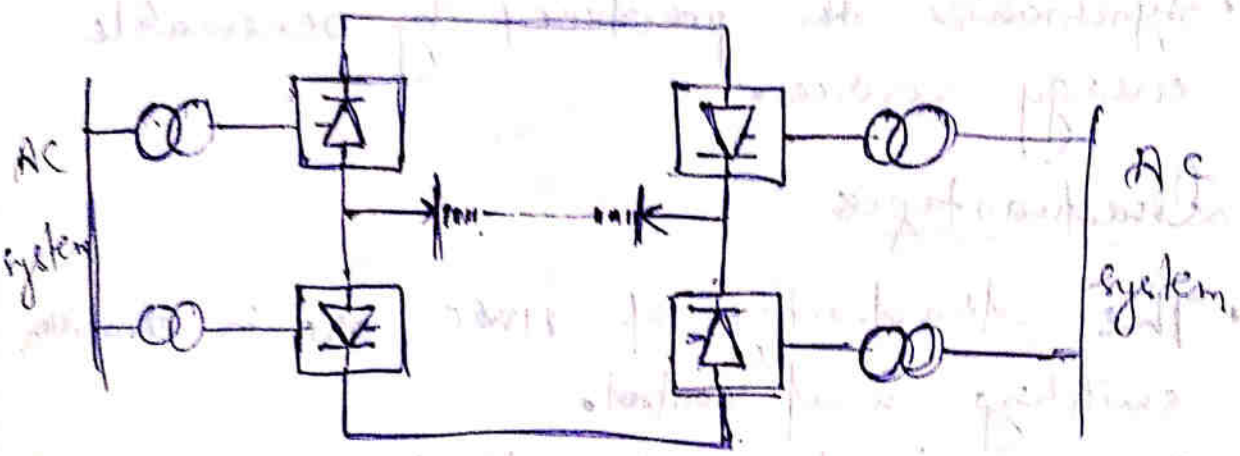


Bipolar Links

- It uses two conductors, one positive and the other negative.
- Each terminal has two converters of equal rated voltage connected in series on the dc side.
- The junctions between the converters is ground.
- currents in the two poles are equal and there is no ground current.
- If one pole is isolated due to fault, the other pole can operate with ground and carry half the rated load (or more using overload capabilities of its converter line).

Homopolar links:

- It has two or more conductors all having the same polarity, usually negative.
- Since the corona effect in DC transmission lines is less for negative polarity, homopolar link is usually operated with negative polarity.
- The return path for such a system is through ground.



Advantages:

- In a number of applications, HVDC is more effective than AC transmission. Examples include; Undersea Cables, where high capacitance causes additional AC losses (e.g. 250 km Baltic Cable between Sweden and Germany).
- Long power transmission without intermediate taps, for example, in remote areas Power transmission and stabilization between unsynchronized

Ac distribution systems.

- Connecting a remote generating plant to the distribution grid.
- Reducing line cost; 1) fewer conductors; 2) thinner conductors since HVDC does not suffer from the skin effect.
- Facilitate power transmission between different countries that use AC at different voltages and frequencies.
- Synchronize AC produced by renewable energy sources.

Disadvantages

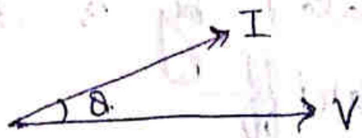
- The disadvantage of HVDC are in conversion, switching and control.
- Expensive inverters with limited overload capacity.
- Higher losses in static inverters at smaller transmission distances.
- The cost of the inverters may not be offset by reductions in line construction cost and lower line loss.
- High voltage DC circuit breakers are difficult to build because some mechanism must be included in the circuit breaker to force current to zero, otherwise

arcing and contact wear would be too great to allow reliable switching.

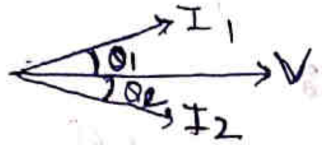
15.03.18

Power Factor:

If voltage phasor and current phasor are represented as below, then,



$\cos\theta$ = power factor
θ = phase angle between 'V' & 'I'.

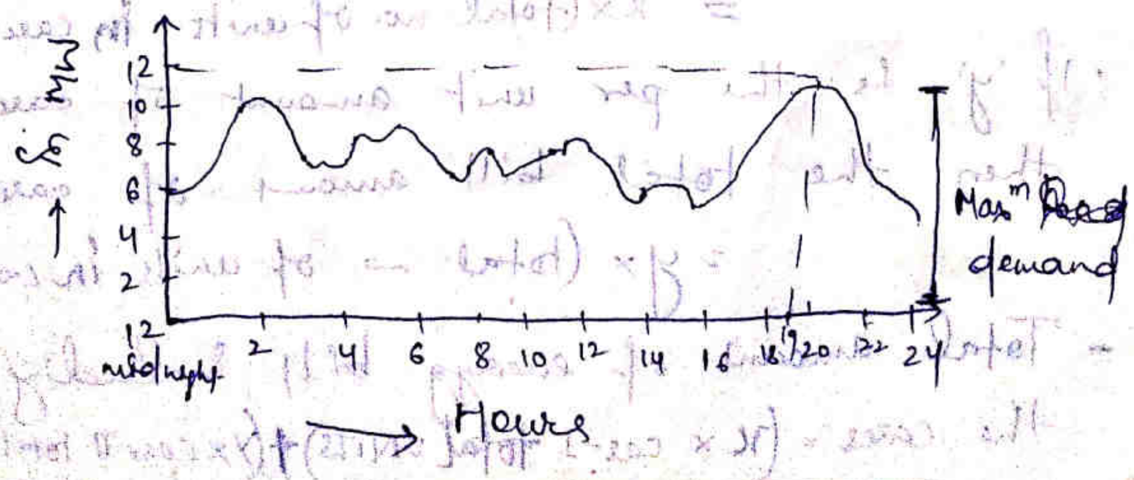


$\cos\theta_1$ = power factor (lead)
$\cos\theta_2$ = power factor (lagg)

16.03.18

Load Curves:

→ The plot of loads on a power station during various times in a day is called as load curves.



20.03.18

TARIFF:

- The money rate at which electrical energy is supplled to a consumer is called as tariff.

Types of calculations:

- May be calculated by 3 different methods.

(I) Flat-Rate Tariff
(II). Block-Rate Tariff.
(III) Two-Part Tariff.

(I) Flat Rate Tariff:

- In this method, two different calculations are done.

case I: One for total energy consumed by light & fan load. or light loads.

case II: Another for total power consumed by heavy power loads, i.e., motors, etc.

- If 'x' is the per unit amount of case-I then the total bill amount of case-I,

$= x \times$ (total no. of units in case-I)

- If 'y' is the per unit amount of case-II, then the total bill amount of case-II,

$= y \times$ (total no. of units in case II)

- Total amount of energy bill including both the cases = ($x \times$ case-I total UNITS) + ($y \times$ case-II total UNIT

- One limitation of this method is that, it uses two energymeters for seperate cases loads.

(II) Block Rate Tariff:

- In this method, UNITS consumed are divided into 'BLOCKS' having individual bill rates
- For example:- if 1st BLOCK = first 50 UNITS, 2nd BLOCK = second 100 UNITS.
- If Block-I = x rate per UNIT &
  BLOCK-II = y rate per UNIT, then.

Total energy consumed $= \{(50 \times x) + (100 \times y)\}$

(III)- Two Part Tariff:

- It consists of two parts:

1) Constant cost upon Maximum KVA deman charges for the month, e.g. Rs 100 per KVA max^m demand.
2) KWH charges, e.g. Rs. 0.50 per KWH consumed.

- Two separate meters are installed in customers premises (i) KVA max. Demand ~~factor~~ meter, (ii) KWH meter.
- The main drawback in this type of tariff is that if the consumer uses electricity sparingly (economical) and say for most of the period he is out of station, unnecessarily he will have to pay the fixed charges.

Q- A consumer has four bulbs of 60 W each running for 8 hrs a day, 2 fans of 125 W each running 10 hrs a day, one motor of 1 HP running 2 hrs a day. If per unit rate for 1st 100 UNITS is Rs = 3.40 & after that per UNIT rate is Rs 4.10. Then find out total bill for July 2017 using block rate method.

A

Sl.No	Name	Individual Power	Quantity	total time	Total 'P' WH	Total 'P' in KWH
1	Bulbs	60 W	4	8 Hrs	1920	1.92
2	Fans	125 W	2	10 Hrs	2500	2.5
3	Motor	746 W	1	2 Hrs.	1492.	1.492

- Total power consumed in 1 day = 5.912 KWH.
- Total UNITS consumed in July-17 = 5.912 × 31 = 183.272 UNITS
- 1st 100 UNITS Rs 3.40, then 100×3.40 = 340.
- After 100 UNITS = Rs 4.10, then..

  183.272 − 100 = 83.272 UNITS

  ⇒ 83.272 × 4.10 = 341.4152 Rs.
- Total Bill = 340 + 341.4152

  = Rs 681.42

H.W

- demand factor = $\frac{\text{Maximum load}}{\text{Connected load.}}$

- The max^m demand of a power station is equal to the max^m load on the station considered in a given period.

- Load factor = $\frac{\text{MWH generated in a given period}}{\text{Max}^m \text{ demand} \times \text{Hours of operation in a given period.}}$

$= \frac{\text{Average demand or load}}{\text{Max}^m \text{ demand or load.}}$

$= \frac{\text{No. of units generated}}{\text{No. of Units which could have been generated.}}$

$= \frac{\text{MWHr}}{\text{Peak MW} \times \text{Hrs.}}$

- Diversity factor = $\frac{\text{Sum of individual consumers' max}^m \text{ demands}}{\text{Max}^m \text{ load on the station.}}$

- Plant capacity factor = $\frac{\text{MWHr Produced}}{\text{MW capacity} \times \text{Total hours.}}$

$= \frac{\text{MWHr Produced}}{\text{MWhr could be produced}}$

27.03.18

UNDERGROUND CABLES

- Underground cables are used in low voltage, high voltage and extra high voltage systems for supplying power to bus bars and loads.
- Cables have the following advantages as compared to the overhead lines.

1. Cable transmission are not subjected to thunderstorms, lighting and other ~~serve~~ severe weather condition.
2. Reduces accidents caused by breaking of the conductors.
3. Its use does not spoil the beauty of the cities.
4. Required for indoor connection.

General Construction of UCs -

1. Cores: Cables have generally one or more of stranded copper or aluminium conductors.

- Each core has its insulation and shield over the insulation.

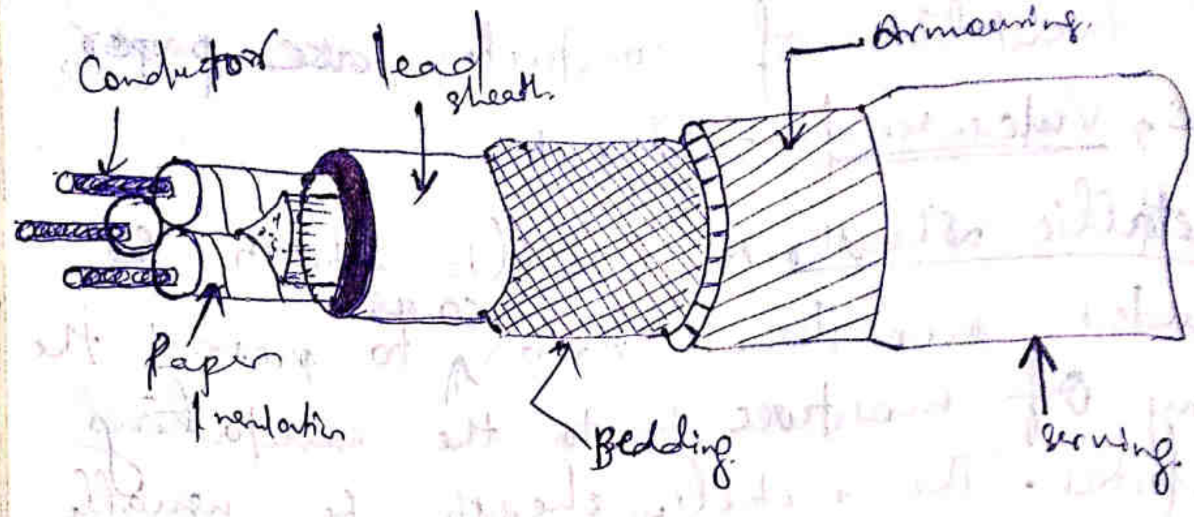
(2) - Insulations: The different insulations used for insulation of conductors are paper, PVC, Vulcanised rubber, etc.

(3) metallic sheath:- A metallic sheath is provided over the insulation so as to prevent the entry of moisture in to the insulating material. The metallic sheath is usually of lead or lead alloy.

(4) Bedding (inner sheath):- Over the metallic sheath comes a layer of bedding which consists of paper tape compounded with a fibrous material. Also sometimes Jute strands is also used for bedding.

(5) Armouring:- It is provided to avoid mechanical injury to the cable and it consists of one or two layers of galvanised steel wires.

(6) Servings:- Over and above the armouring a layer of fibrous material is again provided which is similar to that of bedding but called as serving.



3 - core

CABLE CLASSIFICATIONS

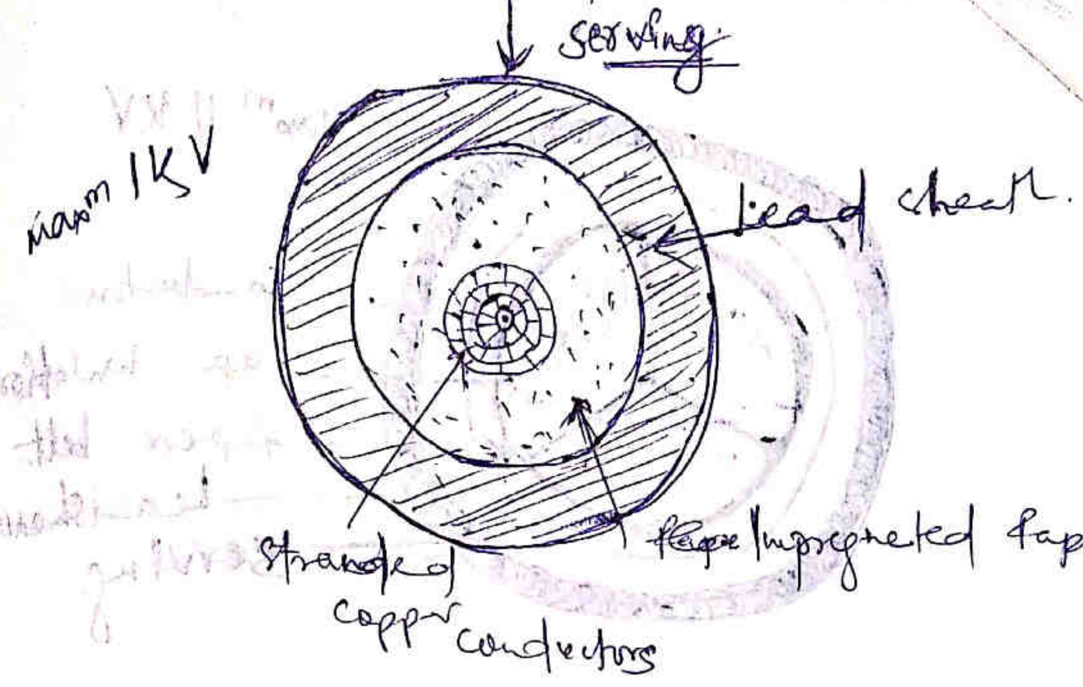
- Classification Based upon voltage Ratings of the Cables.

1. LT Cable = Maxm 1000 V (1 KV)
2. HT Cables = Maxm 11 kV.
3. Super Tension Cables = Maxm 33 kV.
4. EHT Cables = Maxm 66 kV.
5. Extra super voltage cables = 132 kV or More

- Classification Based upon construction of the cable.

1. Belted (up to 11 kV)
2. SCREENED (from 22 kV to 66 kV)
3. PRESSURE (beyond 66 kV)

LT Cable Construction



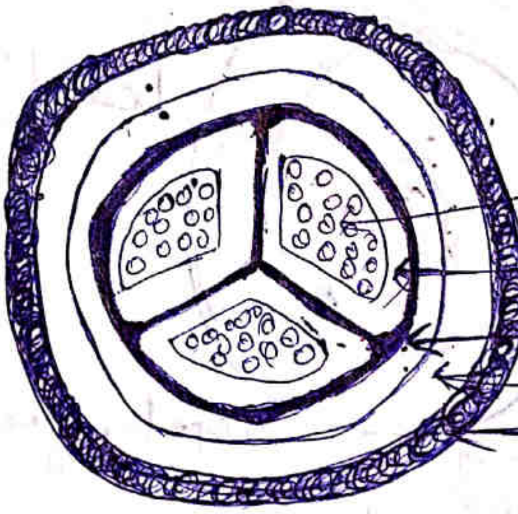
① It consists of one circular core of tinned stranded copper (or aluminium) insulated by layers of impregnated paper.

② The insulation is surrounded by a lead sheath which prevents the entry of moisture into the inner parts.

③ In order to protect the lead sheath from corrosion, an overall serving of compounded fibrous material (jute, etc) is provided.

Imp-12 HT CABLE

Maxm 11 KV



→ The cores are insulated from each other by layers of impregnated paper.

→ Another layer of impregnated paper tape, called paper belt is wound round the grouped, insulated cores.

→ The gap between the insulated cores is filled with fibrous insulating material (jute, etc) so as to give circular cross-section to the cable.

06.04.18

CH-06 DISTRIBUTION SYSTEM

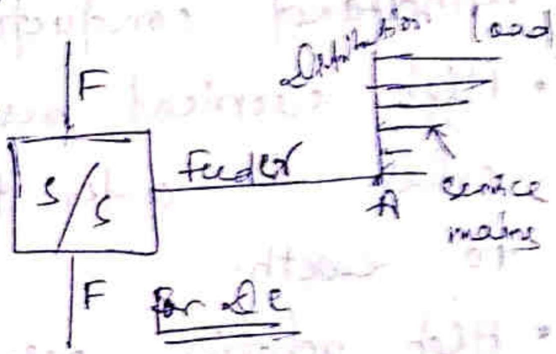
Distributions:-

· Power distribution in modern day can be classified basing upon:-

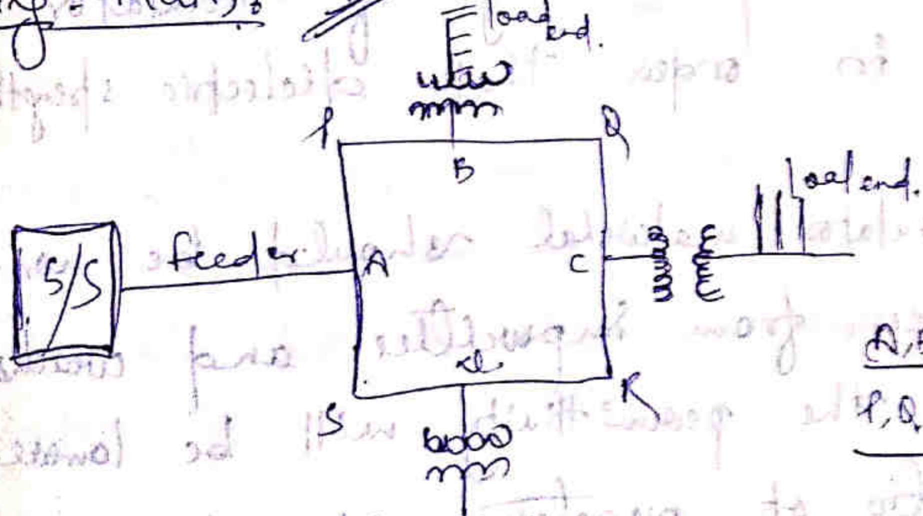
(i) Nature of current.
(ii) Connection Scheme.

(1) According to 'Nature of current', distribution may be divided into:
a) AC distribution
b) DC distribution

(2) According to 'Connection scheme', distribution may be divided into:
a) Radial
b) Ring-main
c) Interconnected

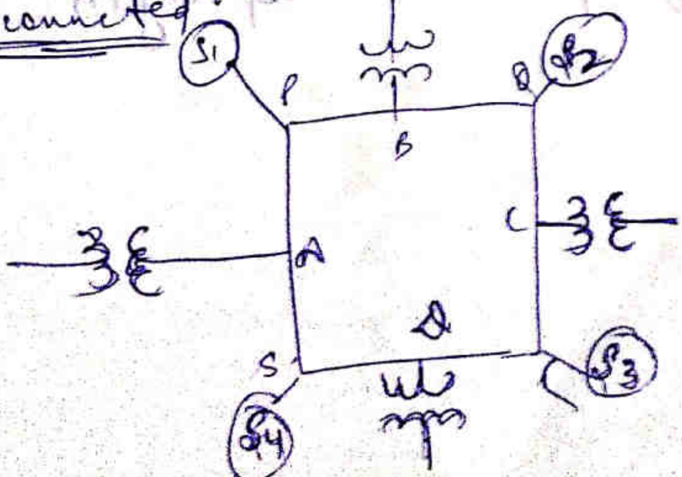


Ring-Main:- Imp



A, B, C, D are feeders
P, Q, R, S are loop

Inter_connected:-



① INSULATORS

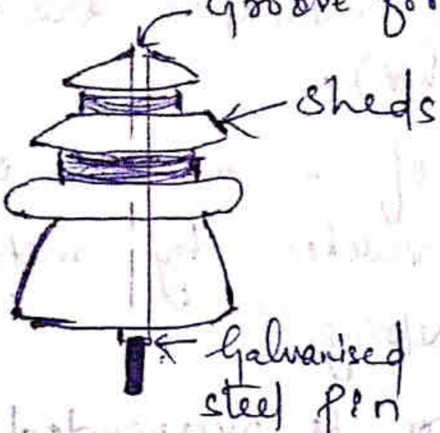
1) PIN TYPE
2) suspension Type
3) shackle Type
4) strain Type.
5) stay or Egg type.

desireable properties.

- High mechanical strength in order to withstand conductor load, wind load, etc.
- High electrical resistance of insulator material in order to avoid leakage currents to earth.
- High relative permittivity of insulator material in order that dielectric strength is high.
- The insulator material should be non-porous, free from impurities and cracks otherwise the permittivity will be lowered.
- High ratio of puncture strength to flashover.

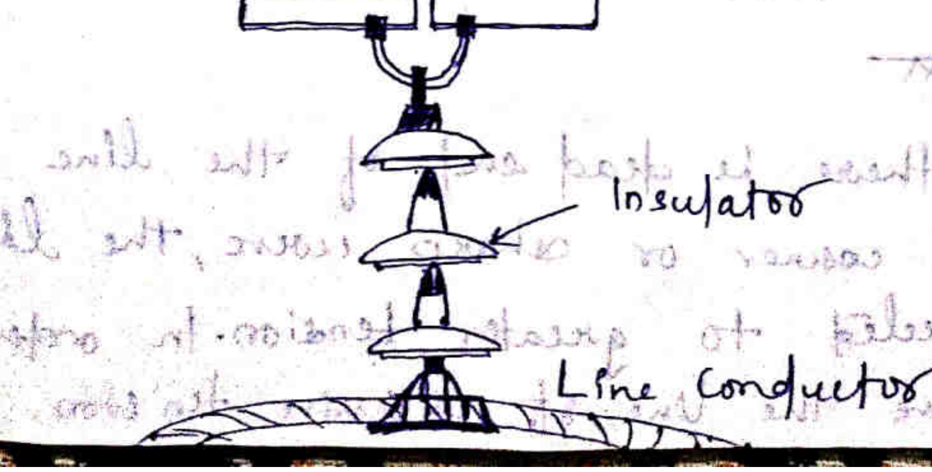
Scanned with CamScanner

PIN TYPE



1. As the name suggests, the pin type insulator is secured to the cross-arm on the pole.
2. There is a groove on the upper end of the insulator for housing the conductor.
3. The conductor passes through this groove and is bound by the annealed wire of the same material as the conductor.
4. Pin type insulators are used for transmission and distribution of electric power at voltages upto 33 KV.
5. For pin type insulators, the value of safety factor is about 10.

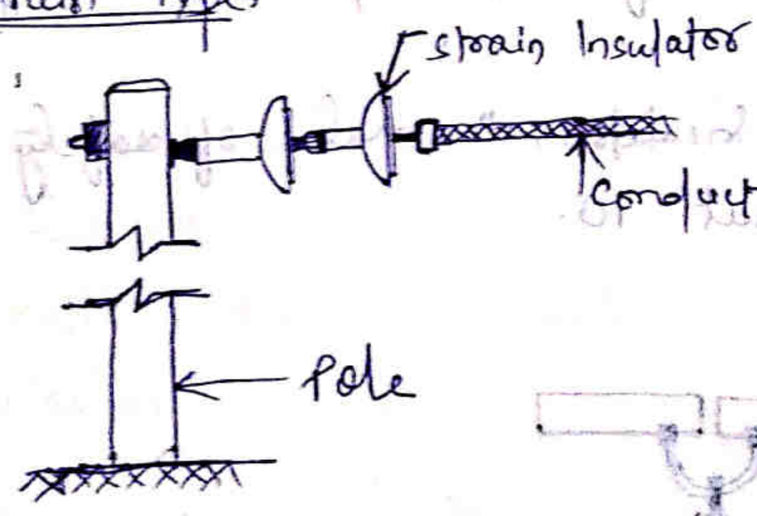
Suspension Type



(1) These type of insulators are used for high voltages (> 33 KV).
(2) They consist of a number of porcelain discs connected in series by metal links in the form of a string.
(3) The conductor is suspended at the bottom end of this string while the other end of the string is secured to the cross-arm of the tower.
(4) The number of discs present depends upon the working voltage.

Advantages:
(1) These are cheaper than pin-type insulators.
(2) Each disc usually represents 11 KV.
(3) Greater flexibility.

Strain Types



(1) When there is dead end of the line or there is corner or sharp curve, the line is subjected to greater tension. In order to relieve the line, of excessive tension,

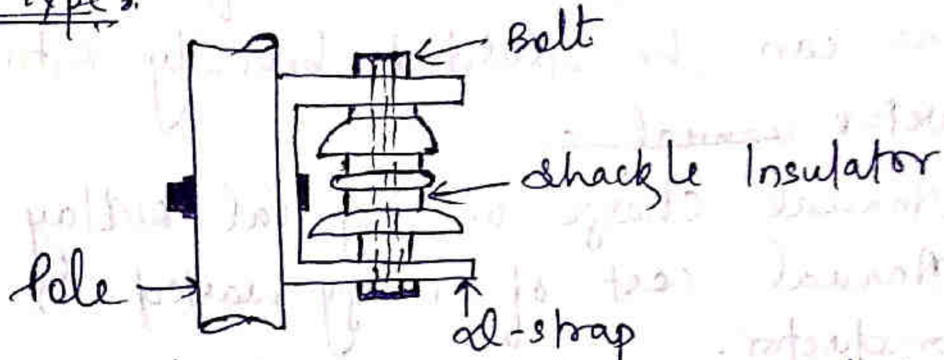
spans insulators are used.

2. It consist of an assembly of suspension type insulators.

3. The discs are used in the vertical plane.

4. When the tension in lines is exceedingly high, as at long river spans, two or more strings are used in parallel.

Shackle Types.



1. These are frequently used for low distribution lines.

2. These are either used in a horizontal or in a vertical position.

3. They can be directly fixed to the pole with a bolt or to the cross-arm.

KELVIN's LAW: Imp-2

- This law is stated by Lord Kelvin in 1881.
- Kelvin's law states that, "the most economical area of conductor is that for which the total annual cost of transmission line is minimum".

- The total annual cost of a transmission line can be divided broadly into two parts:
(I) Annual charge on capital outlay.
(II) Annual cost of energy wasted in the conductor.

Annual charge on capital outlay:

- This is the capital cost of complete installation of a transmission line.
- In case of an overhead system, it will be the capital cost of conductors, supports and insulators and the cost of their erection.
- For an overhead line, insulator cost is constant, conductor cost is proportional to the area of cross-section and the cost of supports and their erection is partly constant and partly proportional to the area of cross section of the conductor

So, annual charge on an overhead transmission line can be expressed as: (6)

$$\text{Annual charge} = P_1 + P_2 a \quad \text{— eq (i)}.$$

where, P_1 & P_2 are constants.

a = area of x-section of conductor in m^2.

Annual cost of energy wasted:

- This is the amount of cost lost mainly in the conductor due to I^2R losses.
- Assuming current to be constant, so, energy lost in the conductor is proportional to resistance.
- As resistance is inversely proportional to the area of x-section, so, the energy lost in the conductor is inversely proportional to the area of cross-section.

$$\text{Annual cost of energy wasted} = \frac{P_3}{a} \quad \text{— eq (ii)}.$$

where, 'P_3' is a constant.

- Total annual cost (C) = $(P_1 + P_2 a) + \frac{P_3}{a}$.

$$\Rightarrow C = P_1 + P_2 a + \frac{P_3}{a} \quad \text{— eq (iii)}.$$

- Total cost will be minimum, if

$$\frac{dC}{da} = 0$$

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

$$\Rightarrow \frac{d}{da}P_1 + \frac{d}{da}P_2 a + \frac{d}{da}\frac{P_3}{a}$$

$$\Rightarrow 0 + P_2 + \frac{\left(\frac{d}{da}P_3\right)a - \left(\frac{d}{da}a\right)P_3}{a^2}$$

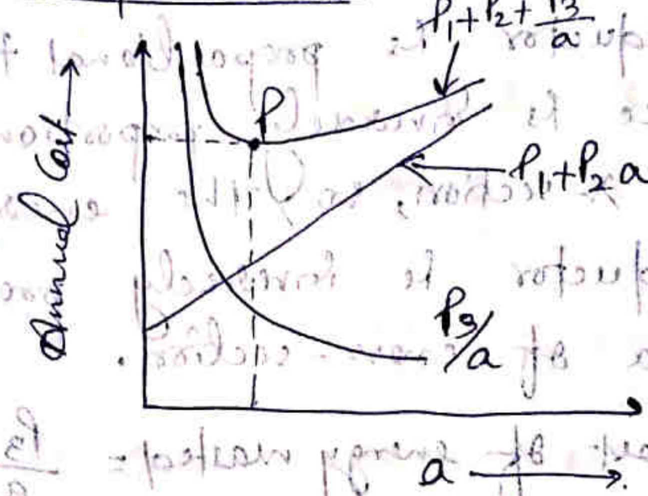
$$\Rightarrow P_2 + \frac{a0 - P_3}{a^2}$$

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

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

So, **Variable part of annual charge on capital outlay = Annual cost of energy wasted.**

<u>Graphical representation:</u>



- Point 'P' represents the most economical area of cross-section.

<u>Limitations:</u>

- This law doesn't take into account of mechanical strength, corona loss, etc.
- Interest and depreciation can't be determined accurately.
- The conductor size determined may be too small for the safe carrying of necessary current.
- Energy loss estimated will not be accurate without actual load curves.

Advantages of HVDC over HVAC Transmission

(8)

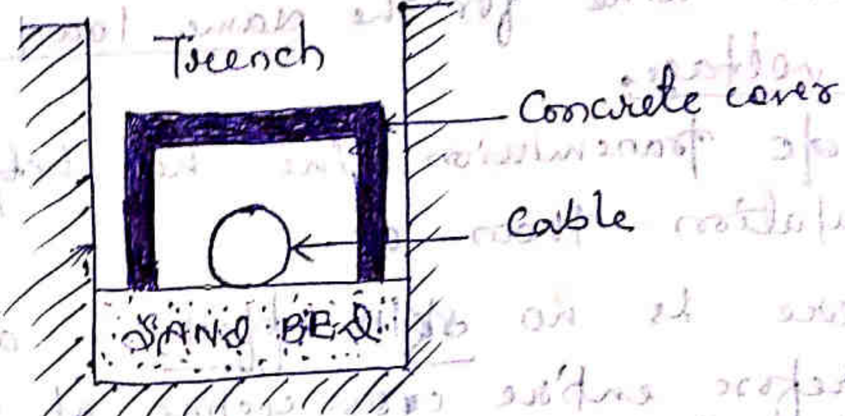
1. It requires only two conductors as compared to three for a.c transmission.
2. There is no inductance, capacitance, phase displacement and surge problems in d.c transmission.
3. Due to the absence of inductance, the voltage drop in a d.c transmission line is less than the ac line for the same load and sending end voltage.
4. A dc transmission line has better voltage regulation than ac.
5. There is no skin effect in a dc system. Therefore entire cross-section of the line conductor is utilized.
6. For the same working voltage, the potential stress on the insulation is less in case of dc system than that in ac system.
7. A d.c line requires less insulation than a.c line.
8. A dc line has lesser interference with communication circuits than ac.

Various methods of UG cable layings.

There are three main methods of laying underground cables:-

1. direct laying,
2. draw-in system, &
3. solid system.

DIRECT LAYINGS



- A trench is dug and is covered with a layer of fine sand to prevent the cable from moisture from ground.
- Concrete cover is provided to protect the the cable from mechanical injury.

Advantages.

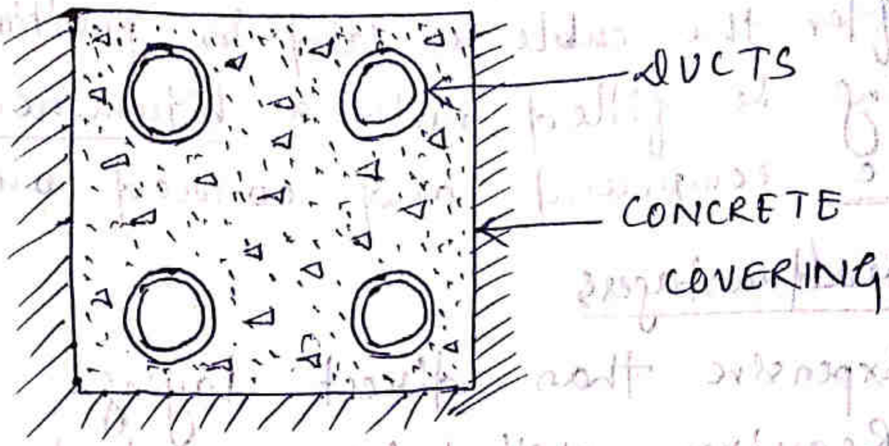
- It is a simple and less costly method.
- Best conditions for dissipating heat generated in the cables
- Clean & safe method and free from external disturbances.

Disadvantages

- Maintenance cost is very high.

- Localisation of fault is difficult
- Cannot be used in congested areas where excavation is expensive and inconvenient.

DRAW-IN SYSTEMS.



- Ducts of glazed stone or cast iron or concrete are laid in the ground with manholes at suitable positions along the cable route.

Advantages:

- Repairs can be made without opening the ground.
- Maintenance cost is low.
- Fewer chances of faults due to strong mechanical protection provided by the system.

Disadvantages:

- Initial cost is high
- Unfavourable conditions for dissipation of heat.

SOLID SYSTEMS

- In this method, cables are laid in open pipes or troughs dug out in the earth along the cable route.
- Troughs are of cast iron.
- After the cable is laid in position, the troughing is filled with a bituminous or asphaltic compound and covered over.

Disadvantages

- Expensive than direct laying.
- Requires skilled labour and favourable weather conditions
- Poor heat dissipation facility.

Causes of Low Power Factor ($\cos\phi$)

- Induction motor contributes for lagging p.f of the station.
- X^r at the sub-stations have lagging p.f because they draw magnetising current which causes the total current to lag behind the voltage.
- Industrial heating furnaces have very low lagging p.f.
- Arc lamps which operate at low p.f.
- Synchronous motors, rotary converters may work

at leading p.f.

Methods of improvement of p.f ($\cos\phi$)

1. By the use of Capacitors

- They are connected in parallel with the supply mains and take current leading by 90° from the mains which neutralizes the reactive lagging component of the load current.
- Basically this reduces the phase difference between the voltage and current.

2. With the help of a synchronous condensers

- It is also known as synchronous motor and is the only motor which can also be worked at leading p.f.
- For inductive loads, these are connected towards load side and is over-excited.
- This makes it behave like a capacitor.
- It draws the lagging current from the supply or supplies reactive power.

3. Phase Advancers.

- This is an ac exciter mainly used to improve p.f of induction motor.
- It improves the p.f by providing the

exciting ampere turns to produce required flux at slip frequency.

3. Static VAR Sources (SVS):

- Thease are thyristor controlled shunt capacitors and shunt reactors.
- They provide step less dynamic p.f correction.

Methods of reducing Corona Effects

1. BY INCREASING CONDUCTOR SIZES.

- By this, the voltage at which corona occurs is raised and hence corona effects are considerably reduced.
- This is one of the reasons that ACSR conductors which have a larger cross-sectional area are used in transmission lines

2. BY INCREASING CONDUCTOR SPACING:

- By doing this, the voltage at which corona occurs is raised and hence corona effects can be eliminated.
- Spacing can't be increased too much otherwise the cost of supports may increase

3. By USING CORONA RINGS

- It is electrically connected to the high voltage conductor, encircling the points where corona discharge may occur.
- The ring distributes the charge across a wider area due to its smooth round shape.

1 imp-8

INFORMATIONS CONVEYED FROM A LOAD CURVES

- Load duration curve determines the load variation during different hours of the day.
- It indicates the peak load which determines the maxm demand on the power station.
- The area under the load curve gives the total energy generated in the period under consideration.
- The area under the curve divided by the total number of hours gives the load.
- The ratio of the area under the load curve of the total area of the rectangle in which it is contained gives the load factor.

Objectives of Tariffs. Imp-14

1. Equal distribution of costs

- The most important objective is the fairly equal distribution of the cost of energy supply to different classes of users.
- Charges to be applied for consumption should be justification for each category of use.

2. Recovery of capital investments

- Recovery of the cost incurred in all elements of power system, i.e., Generation, Transmission & distribution of Energy.

3. Recovery of running costs

- Recovery of the cost incurred in operation and maintenance and supply of equipment

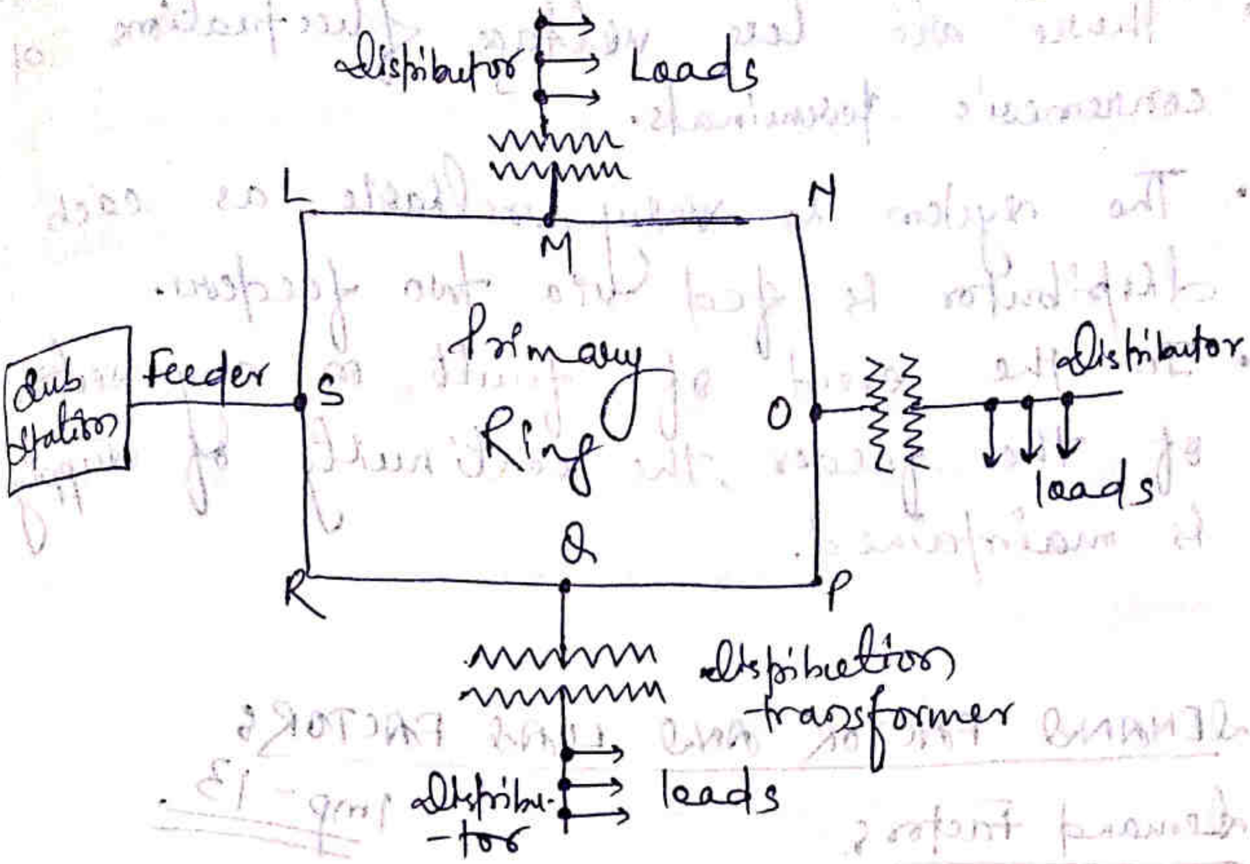
4. Recovery of miscellaneous costs

- Recovery of cost invested in miscellaneous services such as,

1. Cost of metering equipment
2. Billing
3. Cost of the collection.

Scanned with CamScanner

RING-MAIN DISTRIBUTION SYSTEMS (Imp-1)



- In this system, the primaries of distribution transformers form a loop.
- The loop circuit starts from the sub-station bus-bars, make a loop through the area to be served and returns to the substation.
- The above figure shows the single line diagram of ring main system for ac distribution where substation supplies to the closed feeder LMNOPQRS.
- The distributors are tapped from different points ; M, O and Q of the feeders through distribution transformers.

Advantages:

- There are less voltage fluctuations at consumer's terminals.
- The system is very reliable as each distributor is fed via two feeders.
- In the event of fault on any section of the feeder, the continuity of supply is maintained.

DEMAND FACTOR AND LOAD FACTOR: Imp - 13

Demand Factor:

- It is the ratio of the maximum coincident demand of a system to the total connected load of the system.
- $$\text{Demand Factor} = \frac{\text{Maximum demand}}{\text{Total load connected}}$$
- It is expressed as a percentage or in a ratio.
- It is always less than 1.
- It changes from time to time
- The lower the demand factor, the less system capacity required to serve the connected load.

Scanned with CamScanner

Load Factors:

- It is the ratio of the actual load of equipment to full load of equipment.
- Load factor $= \dfrac{\text{Actual load}}{\text{Full load}}$
- Another formula's for load factor.

Load factor $= \dfrac{\text{MWH generated in a given period}}{\text{Max}^m \text{ demand} \times \text{Hrs of operation in a given period}}$

$= \dfrac{\text{Average demand or load}}{\text{Max}^m \text{ demand or load}}$

$= \dfrac{\text{No. of units generated}}{\text{No. of units which could have been generated}}$

- It is always less than 1.
- It is used for determining the overall cost per unit generated.
- For almost const loads, the load factor is close to unity.

- Max^m demand of an installation is the max^m rate of consumption expressed in amperes, kW or kVA.
- It doesn't include the levels of current

Scanned with CamScanner

flowing under overload or short circuit conditions.

Diversity Factors

- It is the ratio of the sum of the individual max^m demands of the various sub circuit of a system to the max^m demand of the whole system.

$$\text{diversity factor} = \frac{\text{Sum of Individual max}^m \text{ demands}}{\text{max}^m \text{ demand of the system}}$$

- It is always greater than 1.
- Greater the diversity factor, lesser is the cost of generation of power.