LEARNING MATERIAL OF

GENERATION, TRANSMISSION & DISTRIBUTION

PREPARED BY – ER. BIRENDRA BAI

&

ER. SUSHIL KUMAR SAHOO

CH-I Electricity Generation 5-12-15

→ The above increasing use of electric Pow for domestic, industrial & Commercial Purposes necessitates to provide electric power economically or bulk power with help of Power generating unit/Power plants

● → ~~This~~ The sitations placing Power generating equipment should be such that a maximum will criteron minimum expenditure

→ The operation of the plant should be so as ~~to~~ provide cheap reliable and continious service.

● **operation of a Power plant**

→ A Generating station essentially employs a prime mover coupled to an alternator to Provide electric power

→ The Prime mover converts energy ~~from some other source~~ from some other form to mechanical energy.

→ The alternator converter convert mechanical energy to electrical energy.

-> The electrical energy produce by these generating station is transmited & distribution for the help of conductor.

-> The generating station are classified as

1) steam power station (Thermal)
2) Hydroelectric power station.
3) Diesel power station.
4) Nuclear power station.

Steam power station

-> A generating station which convert heat energy of coal combustion in to electrical energy. It called steam power station

-> It works as Rankin cycle

-> The steam is produced in the boiler by utilizing the heat of coal combustion

-> The steam is expandent by ~~steam~~ Prime mover (steam turbine) and condensed in condenser to be fed to the boiler again

-> The steam turbine drives the alternator which convert mechanical energy to electric energy

→ This type of power station is suitable where coal and water are available in abundance and where large amount of electric power is generated.

Advantages of steam power station

→ The fuel used is quite cheap.

→ less initial cost as compare to other generating station.

→ It can be installed irrespective of the existance of coal. The coal can be transported to the site

→ It required less space compare to hydraulic power station

→ The cost of generation is less then Diesel Power station

Disadvantages

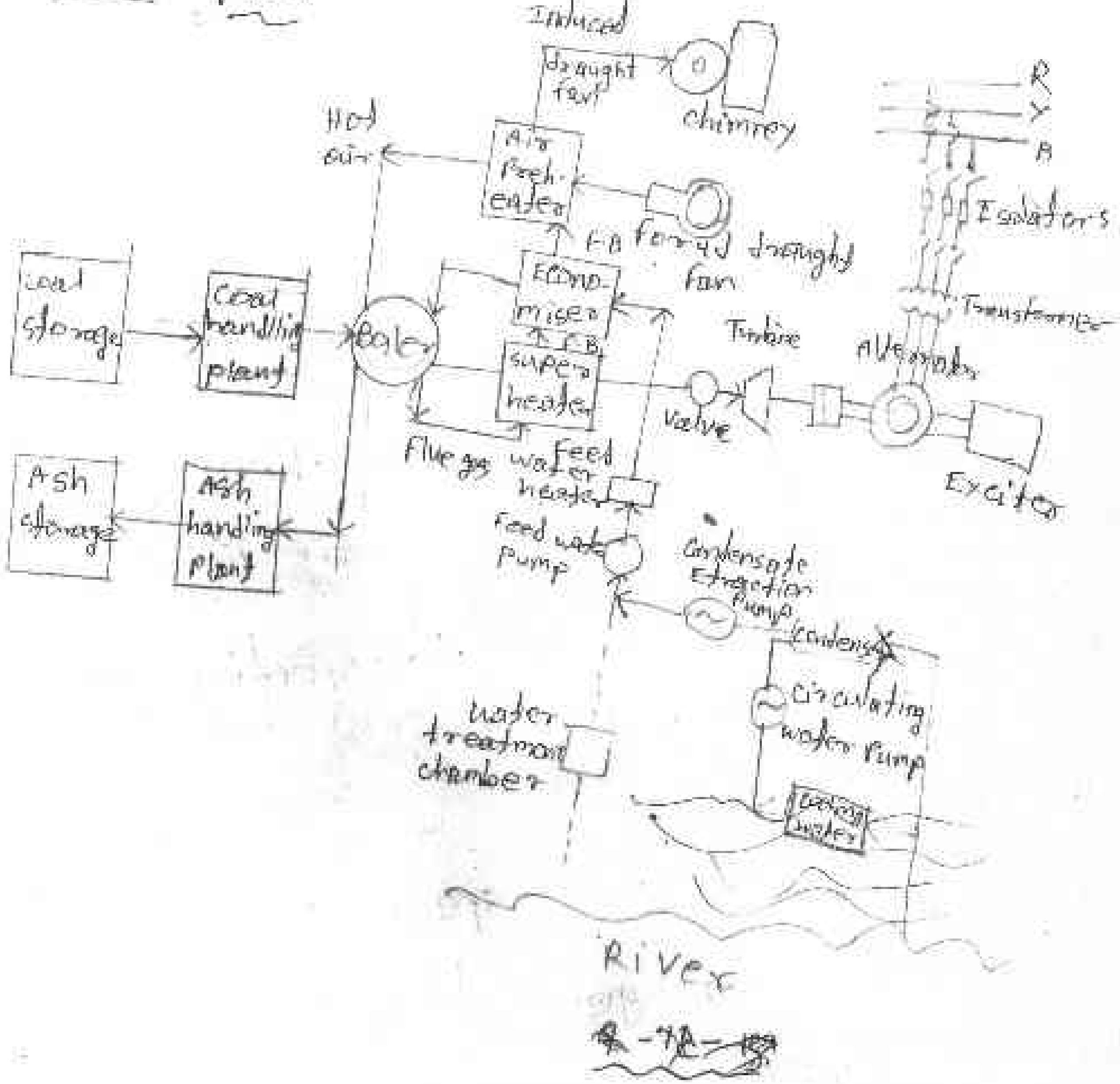
→ It polute the atmosphere due to the production of large amount of smokes and fumes

→ It is costly in running cost as compare to hydroelectric plant

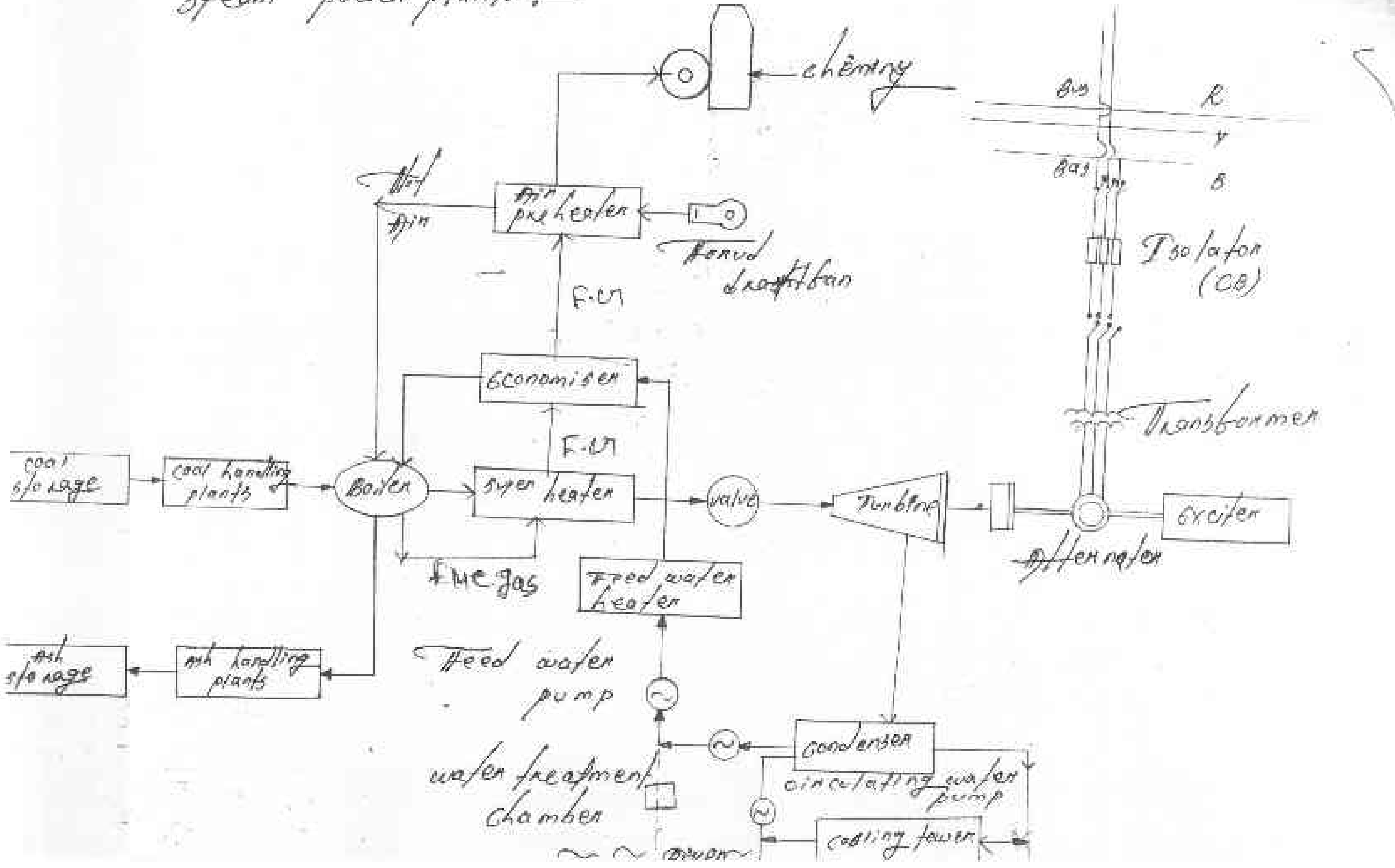
→ It provided soil polution/degradation

5-12-15

Schematic diagram of steam power plant



Schematic diagram of steam power plants :-



Arrangement of steam Power station 7-12-15

→ coal and Ash handling arrangements

→ steam generating plant.

→ steam turbines / Prime mover.

4 - Alternator necessary

5 - feed water

5. cooling arrangement

8-12-15

1. Coal and Ash handling arrangement.

The coal is transported to the power station by road or rail and it ~~s~~ stored in a coal ~~hand~~ storage Plant. From the coal storage plant coal is deliverd to coal handelling Plant where it is Pulverised (crushed in to small pieces) in order to increase the surface exposure.

→ Then the Pulverised coal is feed to the boiler by belt conveyours.

→ The coal is burned to the boiler and Ash Produced after complet combustion of coal is removed the Ash handling plant for disposate

→ The removal of Ash from boiler furnace Ash is necessary for Proper burning of coal

2. steam generating plant.

(a) boiler

The steam generating plant consist's of a boiler the heat of coal combustion is utilized to convert water in to steam at high temperature & pressure. the flue gasses produce is ~~exhausted gasses~~ exhausted to atmp by chimney

(b) Super heater.

The steam produced in boiler is weight and it pased through the super heater where it is dried ~~and~~ and super heated by the flue gass on their way to chimney

Benifites ~~of~~ -

(1) To increase the overall efficiency

(2) Too much condensation of turbine is avoided

(3) the super heated steam from super heater is failed to steam turbine through mainvalve

c) Economiser.

→ An economiser ~~an~~ is essentially and feed water heated and derive heat from the flue gasses

→ The economiser extracts a part of flue gas to increase the feed to water temperature.

(d) Airpreheater

· An air preheater increases the tempr of the air supplied for coal burning by deriving heat from the flue gasses air is drawn from the atmosphere by a forced draught fan and is passed through air preheater before suppling to boiler furnace the air preheater extracts heat from the

... and increases its temp to air used for coal combustion.

9-12-15

2 steam turbines.

The dry and super heated steam from the super heater is feed to the steam turbines by the main valve. The heat energy of the steam when passing over the blades of turbine is converted in to mechanical energy after giving heat energy to turbine the steam is exhausted to the condenser

Alternator

The steam turbine is connect a alternator the alternator convert mechanical energy to power to electrical energy or power.

Feed water

The condensate from the condenser is used as feed water to the boiler

→ The feed water on its way to the boiler is heated by water heaters & economiser for raise the overall efficiency

Cooling arrangement:

→ To improve the efficiency of a plant the steam exhausted from turbine is condensate by mix a condenser

→ The circulating water takes of the heat of the exhaustat steam and itself becomes hot & it is discharge down the river.

→ In case of non availablity of water the sorce of supply (cooling tower ~~lattes~~ are used)

Choices of side.

→ supply of fuel

→ wher availablity of water.

→ wher tranpotation facility.

→ cost. type of land.

→ nearres to road sentre.

→ Distance from polluted area.

Efficiency of a steam power plant.

→ The over all efficiency of a steam power plant is very low about (29%) due to

(a) large amount of heat is losed in condenser.

(b) Heat losses that occure in various stages

→ Themal efficiency.

The ratio of heat equivalent of mechanical energy transmitade to the turbine shaft to the heat of combustion of coal is called thermal efficiency

= Thermal efficiency,

$$\eta_{thermal} = \frac{\text{Heat equivalent to mechanical energy}}{\text{heat of coal combustion}}$$

= Thermal efficiency is about (30 %)

> The overall efficiency is > than thermal [illegible]

<u>overall efficiency</u>

the ratio of heat equivalent of electrical o/p to the heat of coal combustion is called over-all η

$$\eta_{over\ all} = \frac{\text{Heat equivalent of electrical o/p}}{\text{Heat of coal combustion}}$$

overall η = thermal η × electrical η

Q) (1) A steam power station has over all efficien of ~~dunent~~ 20% & 0.6 kg of coal is burned per kW.h of electrical energy generated calcula the calorific value of fuel

Data given

$\eta_{overall} = 0.2 / 20\%$

0.6 kg of coal

To find

calorific value of fuel

Let, the calorific value of fuel be x kcal/kg

$0.6\,kg = 0.6 \times x$ kcal

$$\eta_{overall} = \frac{\text{Heat equ. of electrical en}}{\text{Heat of coal combustion}}$$

$$\Rightarrow 0.2 = \frac{860}{0.6x}$$

$$\Rightarrow x = \frac{860}{0.6(0.2)} = 7166.66 \text{ kcal}$$

(7166.66)

Q) A thermal station has max^m demand 20000 kW load factor 40%, boiler efficiency 85%, turbine efficiency 90%, coal consumesion 0.9 per kWH, cost of 1 tun of coal = 300 Rs determine.

(i) thermal efficiency

(ii) coal bill per annum/year

1) Given Data

max^m demand 20000 KW

turbine η = 90 % = 0.90

Coal combustion 0.9 per KWH.

load factor = 40% = 0.40

boiler η = 85 % = 0.85

Cost of 1 ton of coal is Rupeis 300

Required

(i) thermal efficiency

(ii) Coal bill per year.

Soln ① Thermal efficiency

~~overall η = η thermal × boiler η × turbine η~~

$$\eta_{thermal} = \eta_{boiler} \times \eta_{turbine}$$

$= 0.85 \times 0.90$

$= 0.766 \times 100$

$= \boxed{76.6\ \%}$

Unit generated / annum

= max^m demand × load factor × Hour in a years.

$= 20000 \times 0.4 \times 8760$

$= 7008 \times 10^4$ KWh

Coal consumption/annum

$= 0.9 \times 7008 \times 10^4$

$= \frac{63072000}{1000}$

$= 63072$ tons.

Coal bill per year.

63072×300

$= \boxed{18921600 \text{ Rs}}$

Q) A 100 MW steam station uses coal of calorific value 6400 kcal/kg thermal efficiency of station is 30% and electrical efficiency is 92%. Calculate the coal combustion per hour. when the station is delivery it's full rate o/p

Given

steam station uses - 100 MW

calorific value = 6400 kcal/kg.

$\eta_{thermal} = 30\% = 0.3\%$.

$\eta_{electrical} = 92\%$

* coal combustion per hour ?

$\eta_{overall} = \eta_{thermal} \times \eta_{electrical}$

$= 0.3 \times 0.92 = 0.276$ $= 0.276 \times 100 = 27.6\%$

unit generate per hour.

$100 \times 10^6 \times 1 = 10^8$ kWh

heat produced per hour. $H = \frac{\text{Elect. o/p in heat unit}}{\eta_{overall}}$

$$= \frac{10^8 \times 860}{0.276} = 3.11 \times 10^{11} \text{ K Cal}$$

Coal consumption / hour

$$= \frac{H}{\text{calorific value}}$$

$$= \frac{3.11 \times 10^{11}}{6400} = 48686594.2 \text{ kg.}$$

16-12-15

~~Hauchra~~ Hydroelectric power station.

→ A generating station which utilizes the potential energy of water at high level for the generation of electrical energy in called hydroelectric power station.

Hydroelectric power station are generally located in hilly areas wher dams can be bilt conveniently and larg water resurver can be obtained.

In a hydroelectric power station water head is created by constructing and dam across the river or lake.

from the dam the water is led to a water turbine. The water turbine capture the energy in the falling water and changes the ~~hydrau~~ haudroulic energy to mechanical energy at the turbine shaft.

The turbine drive the alternator which converts mechanical energy to electrical energy.

→ hydrolic power station are popular because the reserve's that is coal & oil are depleting day by day.

→ They have the added impotance for flood control storage of water for irrigation and water for driking purposes.

Advantages.

→ It required's no fuel, as water is used for the generation of electrical energy.

→ It is quit neat & clean as no smoke or ash is not produced.

→ It required's very small running charges because water is the source of energy which is available free of cost.

→ It is comparitively smple in construction and required's less mentnance.

→ It doesn't required long starting time like a steam power station. such plant can be put in to service instantly.

→ It is robust and has a larger life

→ such plant serves many purposes. In addition to the generation of electrical energy they also help in irregation and controling floods

→ Although such plants required attention of highly skilled ~~person~~ person

Disadvantages.

→ It involve high capital cost due to construction of dam.

→ There is uncertainty about the availability of use amount of water due to dependents on weather conditions.

→ ~~scaled~~ skilled and experiance hands are required to builed the plant.

→ It required high cost of transmission lines as the plant is located in hilly areas which is quit away from the consumer

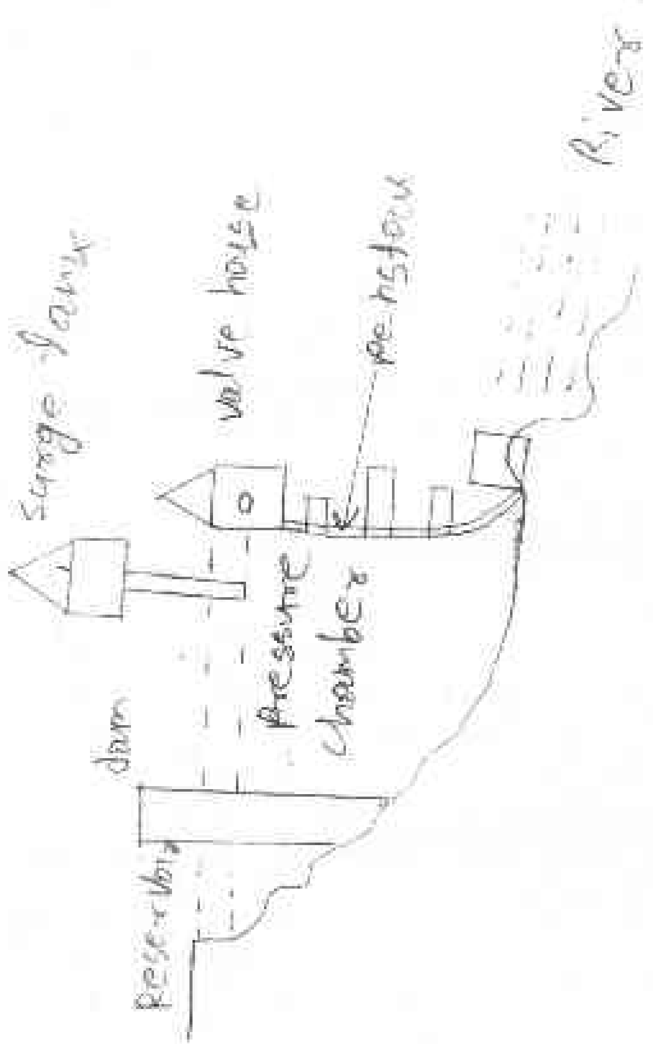
17+12+15

Schematic arrangement of Hydroelectric power station

17-12-15

simple

Although a hydroelectric power station involve the conversion of hydroelecEnergy in to electrical energy, yet it requireds many arrangements for Proper working & efficiency.



→ The dam is constructed across a river or lake and water from catchment area collects at the back of the dam to form a reservoir.

→ A pressure tunnel is taken of from the reservoir and water is brought to the valve house at the start of the penstock.

→ The valve house contain sluice valve at automatic isolating valve. The forme controls the ~~wat~~ water flow to the power house and the latter cuts off waste the supply of water when the penstock burst

→ from the valve house water is take to the water turbine through a use steel pipe known as Penstock

→ The water turbine converts ~~hydr~~ Hydraulic energy to mechanical energy.

→ The turbine drives the alternator which convert mechanical energy to electrical energy

→ A surge tank is build before the valve house.

→ ~~Its~~ surge tank fun is protect the penstock from bursting in case the turbine gate is suddenly closed

→

Choices of site for Hydroelectric Power station.

→ Availability of water

→ storage of water.

→ cost & type of land

→ where transportation facilities

Constituent's of Hydroelectric plant.

→ Constituent of hydroelectric plant are.

(a) Hydraulic structure.

(b) water turbines.

(c) Electrical equipments.

Hydraulic structure.

→ Hydraulic structure is a Hydroelectric power station include Dam, spillways, head works, surge tank, Penstock

Dam.

→ A dam is a barrier which stores water and creat's water head.

Spill·ways.

Some times the river flow exceeds the storage capacity of the reserver. such a situation arises during heavy rain fall in catchment area. In order to discharge the surplus water from the storage reserves in to the river on the down street side of dam spillways are used

<u>Head works</u> 17-12-15

→ The head works consists of the diversion structure at the head of intake. They generally include sluices ~~to~~ for by passing segments and valves for controling flow of water to the turbine. To avoide head losses and cavitation

<u>surge tank</u>

A surge tank is a small reserve or tank (open at the top). in which water level rises or fall's to reduce pressur swings in the conduit/process.

It is located near the biggning of the conduit. when the turbine is running of a stady load there is no surged in the flow of water i.e. the quantity of water flowing in to conduit is just sufficient to meet the turbine requirement

→ when load on turbine decreases the governor closes the gates of turbine reducing water supply to the turbine

→ on the other head when load on the turbine increase additional water is drawn from the surge tank to meet the increased load requiredment

<u>penstock</u>.

Penstock are open or closed conduits which carry water to the turbine

* They are made of concrit or steel

* Concrit is suitable for low hades(< 30m) and the steel is designed any. hade

<u>water turbines</u>.

> water turbines are used to convert the energy of falling water in to mechanical energy

→ The principle types of water turbines are

i) impuls turbines.

ii) Reaction "

<u>i Impuls turbine</u>.

Impuls turbine are used for high hade in impuls turbine the entair presser of water is converted in to kinetic energy in a nozzle and the velocity of jet drives the wheel (Ex- peltot wheel)

→ It consist's of a wheel feeted with ~~etc~~ elliptical buckets along it's periphery

Reaction turbine

→ These are used for low and meddium head.

→ The importance type of reaction turbines are

(a) francis turbine.

(b) kaplan turbine

Problems

A Hydroelectric power station is supplied from a reserver of capacity 5×10^6 cubic meter at a head of 200 meter find the total energy avilable in KWh if the overall efficiency is 75%.

Given

capacity - 5×10^6 cubic m.

hate, h = 200 m.

~~weight =~~

over all eff. 75 or 0.75

weight of the water avilable

= Volume of the water × density

$= 5 \times 10^6 \times 1000 = 5 \times 10^9$ kg.

$= 5 \times 10^9 \times 9.81 = 4.905 \times 10^{10}$ N.

Electrical energy avilable =

weight of water × overall efficiency.

$= 4.905 \times 10^{10} \times 200 \times 0.75 = 735 \times 10^{12}$ Ws

$735 \times 10^{12} \div 3600 = 5677.0833 \times 1000 = 5.677$ kwh

2) water fro a hydroelectric station is obtained of a reservoir with a head of 100.m calculate the electrical energy generated per h cubic meter of water. If the Hydraulic eff. be 0.86 & the electrical eff. 0.92

Given

$H = 100$

Discharge $Q = 1\ m^3/s$

$\eta_{hydraulic} = 0.86.$

$\eta_{elec} = 0.92$

$\eta_{overall}\ \eta = 0.92 \times 0.86 = 0.7912$

weight of water avilable per secon

$w = Q \times 100 \times 9.81$

$=$

Nuclear power plant. 18-12-15

A generating station in which nuclear energy convert in to elect. energy is called Nuclear power plant.

→ In nuclear power plant having elements such as Uranium (U_{235}) & Thorium (Th_{232}) are subjected to nuclear fission in a special apparatus called (reactor)

→ The heat energy thus release is utilized in raising steam at high temp^n & Pressure

The steam runs the steam turbine which convert's the steam energy in to mechanical energy. The turbine drives the alternator which convert's mechanical energy to electrical energy

The most important features of a nuclear power station is the huge amount of electrical energy can be produced from a relatively small amount of nuclear fuel as compared to other.

Advantages of nuclear power station

→ Amount of fuel required is very small

→ There is considerable saving in the cost of fuel

→ It required very less space as compare to other statio

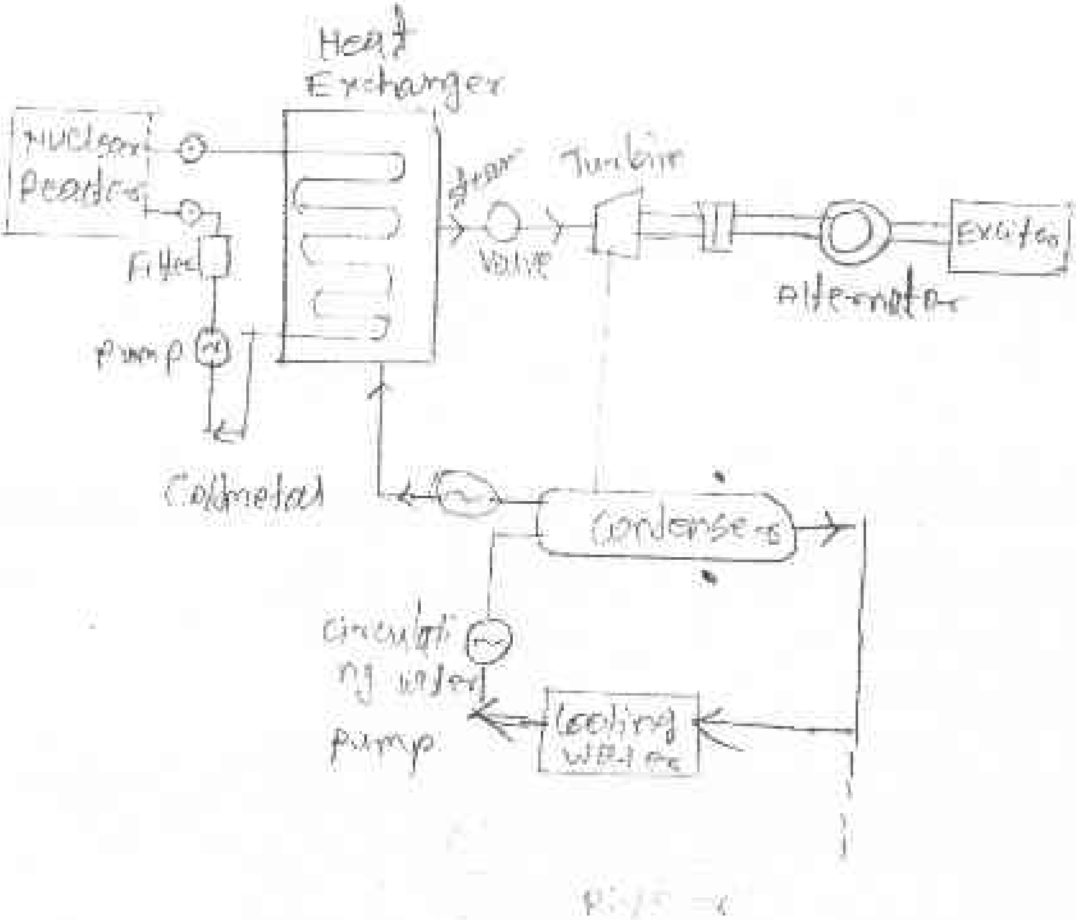
→ It has low running charges as a small amount of fuel is used for producing bulk electrical energy.
→ This type of plant is very economical for producing bulk ~~water~~ amount of elect. power.
→ It can be located near the load centres because it doesn't required large quantity of water and need no be placed near coal ~~mine~~ mines. the cost of primary distribution is reduced.
→ There are large deposits of nuclear fuel all over the world. such plant can ensure continuit supply of electrical energy for 1000 of years
→ It ensures reliability of operation

Disadvantages.

→ The fuel used is expensive and dificult to recover.
→ The capital cost on a nucler plant is very high.
→ Erection and commissioning of the plants required greater technical knowhow
→ The fission by product's are generally radio active and may cause a danerous amount of radioactive polution
→ mentanans charges are high due to ~~standar~~ standardsization
→ not well suited for varying loads
→ The disposatal of the biproduct which

are reactive is a big problem

schematic diagram



19-12-15

Transmission of electrical power.

Elektric supply system.

The conveyence of electric power from a power station to consumers premises is called electric supply system.

→ It can be broadly classified into 2 type.

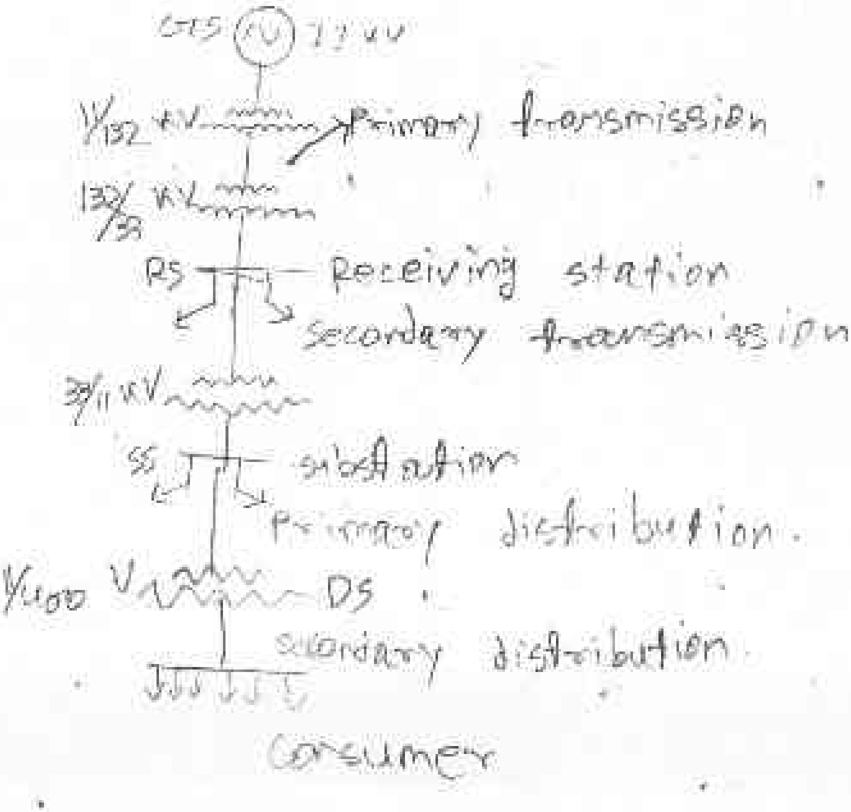
(1) DC & AC system.

(2) overhead or underground. system.

Now and as three phase three where AC system is adopted for Generation & transmission of electr power. The large network of conductor is brodly divided in to 2 parts.

(1) Transmission system.

(2) Distribusion "



Generating station (GS)

The figure 'GS' represents the generating station where electrical power is produced by three phase alternator operating parallel.

→ The usually generation station 11 KV

→ For economy in the transmission of electric power the generation voltage is stepd in to 132 KV at the generating station with the help of 3-phas transformer.

→ Generally the primary transmission is carried at 66 KV or 132 KV or 220 KV or 400 KV

Primary transmission.

The electric power at 132 KV is transmited by 3-phase 3 wire overhead system to the outskirts the city this formes the primary transmission.

Secondary transmission.

The primary transmission line terminates at the receiving station (RS) which usully lies at the outskirts of the city

→ At the receiving end the voltag is reduced at 33 KV by stepdown transformer from this station electrical power is transmited at 33 KV by three phas 3-wire overhead system to various substations (SS) located at the strategic points in the city. This formes the secondary transmission.

Primary distribution

The secondary transmission lilen end to the substationsyy where voltag reduces from 33 KV to 11 KV, three phase three wire.

→ The 11 KV lines sur along the important road sides of the city. This forms the primary distribution.

→ It may be noted that being consumer are generally supplied power at 11 KV for further handling with there own substations

secondary distribution

The electric power from primary distribution line (11 KV) is delever to distributions substations (DS

→ This substations are located near the consumer localityes and step down the voltage to 400 V, ~~and 3 wire~~ 3 phase, 4 wire for secondary distribution

Elements of a transmission line. 5-2-2016.

a) conductor.
b) stepup & stepdown transformers.
c) line insulators.
d) supports
e) protective devices.
f) voltage regulating devices.

Economics of power transmission.

i) Economic choice of conductor size.
ii) " " of transmission voltage.

Economic choice of conductor size.

The determination of proper size of conductor for the line is of vital importance. The most economical area of conductor is that for which the total annual cost of transmission line is minimum. This is called kelvins law.

-> The total annual cost of transmission line can be divided in to two parts.

a) annual charge on capital outlay
b) " cost of energy wasted in conductor

1). Anual charge of capital

The anual charge on an overhade transmission line can be expressed as

Anual charge ~~$P_1 + P_2$~~ $P_1 + P_2 a$

where,

P_1 & P_2 are constant's and 'a' is the cross-section of the conductor.

2- Anual cost of energy wasted.

The energy loss is mainly due to I^2R loss in the conductor.

⇒ Anual cost of energy wasted

$$= \frac{T_3}{a}$$

where,

T_3 is a constant

⇒ Total anual cost, $c = P_1 + P_2 a + \frac{T_3}{a}$ / $\frac{P_1 + P_2 a + T_3}{a}$

~~Here~~ In the above expression the only variable 'a' (cross-section)

Therefore the total anual cost of transmission line will be minimum is the differencation of 'c' with respect to 'a'

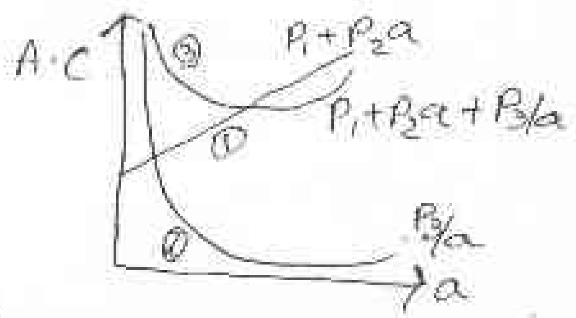
$$= \frac{d(c)}{da} = 0 \quad = \frac{d}{de}(P_1 + P_2 a + P_3/a) = 0$$

$$= P_2 + \left(-\frac{P_3}{a^2}\right) = 0 \qquad P_2 = \frac{P_3}{a^2}$$

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

That is variable part of anual charge is equal to anual cost of energy wested

Therefore, The ~~total anu~~ most economical area of conductor is that for which the variable part of ~~ene~~ anual charge is equal to the cost of ~~the~~ energy loss of per year.



Limitation of Kelvins law.

→ It is not easy to estimet the energy loss in the line. without actual load curve, which are not available at the time of estimation.

→ The assumption that anual cost on account of intrest & depreciation on the capital out lay is in the form $P_1 + P_2 a$ is not true

→ The law doesn't take in to account various factors like self current density, mech. strength, Corona losses

→ The conductor size determined by this law may not always be practicable because it may be to smu for the true uncertainty of current.

→ Interest & depreciation on the capital outlay can't be determine accurately

Economic choice of transmission voltage.

The transmission voltage for which the cost of conductor, cost of insulators, transformers, switch gear and other terminal apparatus is minimum is called economical transmission voltage.

→ The economic voltage betⁿ lines in 3-phase AC system is

$$V = 5.5\sqrt{0.62L + \frac{3P}{150}}$$

where,

V = is the line voltage in kV

P = maxᵐ kW per phase to be delivered to single cut.

L = Distance of transmission line in km.

6-1-2016

CORONA

→ When the applied voltage ~~excites~~ exceeds a certain value called critical disruptive voltage, the conductor are surrounded by a faint violet glow called corona.

→ The phenomenon of corona is accompanied by a hissing sound production of ozone, power loss and radio interference.

→ The higher the voltage is raised the greater are the sound and the power loss.

→ The phenomenon of violate glow, hissing noise and the production of ozone gas in an overhead transmission line is known as Corona.

→ If the conductors are smooth the Corona glow will be uniform througout of the conductor.

Factor affecting corona

a) Atmosphere.

ii) Conductor size.

3) spacing betn the conductors

4) line voltage

Critical Disruptive voltage

→ It is the minimum phase nutral voltage at which Corona occurs.

$$\text{C.D.V},\ V_c = m_0 g_0 \delta r \log_e \frac{d}{r} \ \text{KV/phase}.$$

m_0 = Irregularity factor

where, m_0 = 1 for smoth conductors

= 0.98 to 0.92 (for darty Conductor)

= 0.87 to 0.8 (for stranded ,,)

δ = air density factor.

$= \frac{3.92b}{273+t}$

g_0 = potential gradiant

The value of g_0 is directly proportional to air density

Visual critical voltage

→ It is the minimum phase nutral voltage at which corona glow appears all along the conductors.

→

$$V_v = m_v g_0 \delta r \left[\frac{1+0.3}{\sqrt{\delta r}}\right]$$

Power loss due to corona

Formation of corona is always accompanied by energy loss which is dissipated in the form of light, heat, sound & chemical action.

→ The power loss due to corona is given by

$$P = 242.2\left(\frac{f+25}{\delta}\right)\sqrt{\frac{r}{d}} \times 10^{-5} \text{ kW/km/phase}$$

where f is the frequency in hertz

V is the phase nutral voltage.

$$P = 242.2\left(\frac{f+25}{\delta}\right)\sqrt{\frac{r}{d}}\,(V-V_c) \times 10^{-5} \text{ kW/km/phase}$$

V_c = disruptive voltage (rms per phase

ADVANTAGES OF CORONA. 7-1-2016.

Due to corona formation the air surrounding the conductor becoms conducting and hence virtual diameter of the conductor is increased. The increase diameter reduces the electro static stresses betn the conductors
→ corona reduces the effects of ~~traingent~~ sients produced by surges

Disadvantages

→ Corona is accompanied by loss of energy.
→ This effects in transmission efficiency of the line
→ ozone is produced by corona therefore ~~Corrosion~~ Corrosion of the conductors may occur due to chemical action.
→ The current drawn by the line due to corona is non sinusoidal and hence non-sinusoidal voltage occurs in the line.

methods of reducing ~~current~~ corona :-

1→ By increasing conductor size

→ By increasing conductor size the voltage at which corona occurs is raised and hence corona effects are reduced.

→

2) By increasing spacing.

→ By increasing the spacing betⁿ conductors the voltage at which corona occurs is raised and hence the corona effect can be neglected.

Problem's

Q) A 3-phase line has conductors 2 cm in diameter spaced equilaterally one meter appart if the dielectric strength of air is 30 kV/cm find the disruptive critical voltage for the line?

Take air density factor $\sigma = .952$ and irregularity factor $m_0 = 0.9$.

Solⁿ

Given :- | find :-
3-phase line. | disruptive voltage.

(g_0) diel. strength = $\frac{30 \text{ kV/cm}}{\sqrt{2}} = 22.21$

(d) spacing = 1 m. = 100 cm

(r) = 1 cm = 2×10^{-2} m.

① Critical Disruptive voltage →

$$V_c = m_0 g_0 \sigma r \log_e \frac{d}{r}$$

$$= \frac{0.9 \times 30}{\sqrt{2}} \times 0.952 \times 1 \times \log \frac{100}{1}$$

$$= 0.9 \times 22.21 \times 0.952 \log_e \frac{100}{1} = 83.68 \text{ kV/phase}$$

② line voltage = $83.68 \times \sqrt{3} = 144.93$

CH-3 DESIGN OF OVER HEAD LINE.

Main component of over head lines

conductor which carry

Conductor which carry electric power from sending end station to receiving end station.

① support's

support's which may be poles or tower to keep the conductor's at suitable level above the ground.

③ Insulator's

Insulator's which are attach to support and insulate the conductors from the ground.

④ ~~Cross arms~~.

Cross arms which provide support to the insulators.

⑤ Miscellaneous Item's

miscellaneous items are phase plate, danger plates, lightning arrestor, wires etc.

conductor's materials.

The conductor is one of the important iteams, so the proper choice of material and size of the conductor is an considerable importance

The conductor material used for transmission & distribution should have.

(1) high electrical conductivity

(2) high tensile stress. to with stand mechanical stress

(3) low cost so that it can be used for long distances.

(4) low specific gravity

The most commonly used conductors material are copper, aluminium, steel ~~cote~~ coating aluminium, Cadmium copper, galvanised steel

Line supports

The supporting structure for over head line conductors are various type of poles and towers called line supports

→ The line supports most have the following properties. are (1) high mechanic strength to ~~wh~~ with stand the weight of conductors.

(2) light in weigh with out the loss of mechanical strength

(3) chief in cost and economical to mentain

(4) Longer life

(5) Easy accessibility of conductor for mentains

The line supports used for transmission and distribution of electric power are of various type.

① wooden poles
② steel poles
③ RCC poles
④ lattice steel towers

Insulators. 08-01-2016

The over head line conductors should be supported on the poles or towers in such a way that current from the conductor do not flow to earth through supports.
Line conductors must be properly insulated from supports. this is achive by sequring line conductors to support with the help of insulator.

The insulator provide necessary insulation betn the line conductors & support and thus prevent any linkage from conductors to earth.

→ The insulators should have the following property

1) high mechanical strength to withstand conduct load, wind load.
2) High electrical resistance in order to avoide linkage current to earth.
3) High relative permitivity of insulator material so that dielectric strength is high
4) The insulator material should be free from impurities and cracks otherwise the permitivity
[illegible]

5) High ratio of puncture strength to flash over, the most commonly used material for insulators of overhead line is porcelain, steatite, glass are also used

Types of insulators

1. Pin type insulators.
2. Suspension " "
3. Strain " "
4. Shackle " "

Causes of insulator failure

→ Insulators are required to withstand both mechanical and electrical stress. The latter type is primarily due to line voltage and may cause breakdown of insulators. The electrical breakdown of insulator can occur either by flash over or puncture.

In flash over an arc occurs betn the line conductor and the arc and the discharge jumps across the air gap. In case of flash over the insulator will continue to act in its proper capacity unless extreme heat produced by the ~~a~~ arc destroys the insulator

* safety factor of insulator = $\frac{\text{Puncture strength}}{\text{flash over voltage}}$

Merits of suspension type insulators.

→ suspension type insulators are low cost than pin type insulators for voltages beyond 33 KV.

→ The ~~[struck-through]~~ desired no. of disc can be connected in series. If any one disc is damage the damaged disc can be replaced

→ It provides greater flexibility to the line.

→ The suspension type insulators are generally used with steel towers. As the conductor hangs bellow the earth cross arm of the tower,

Therefore this arrangement provide partial protection from lighting

Sag in overhead line   19-01-2016

The difference in level betn point of supports and the lowest point on the conductor is called sag.

The lowest point on the conductor is 'O' and the sag is 'S'. The following point may be noted.

* when the conductor is suspended betn 2 supports at the same level it takes the shape of a parabulla

* The tension at any point on the conductor acts tangentially

* Thus tension To at the lowes point 'O' acts horizontally

* The horizontal component of the tension is constant through out the length of the wire

* The tension at supports is approximately equal to the horizontal tension acting at any

point on the wire.

Calculation of sag

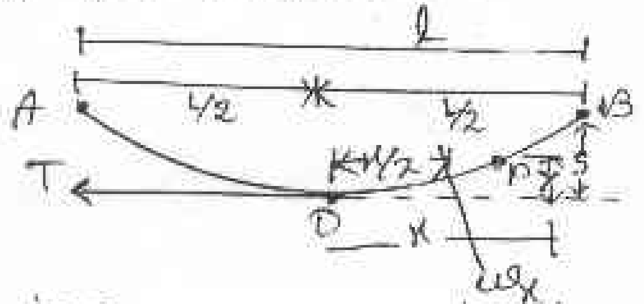
→ low conductor tension and minimum sag are not possible
→ It is because low sag means a tight wire and high tension.

→ We will now calculate sag and tension of a conductor when.
1 → supports are equal levels.
2 → " " different "

I. when supports are equal levels

Consider a conductor betⁿ two equilevel supports A & B. with 'O' as the lowest point

Let,
l, is the length of the span
w, weight of unit length of conductor.
T, Tension of the conductor.



Let us Consider a point 'p' on the conductor.
Let the co-ordinate of point 'p' be x & y.

* The two forces acting on the portion O, p of the conductor are
a) The weight 'wx' of the conductor acting

at a distance $x/2$ from 'O'

ii) The tension acting at 'O'

The equating moments of above two forces about point 'O' we get

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

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

The maximum sag is represented by the value of y at either of supports A & B

At support 'A' = $x = l/2$

and 'y' = S

$\therefore$

$$sag(S) = \frac{w(l/2)^2}{2T}$$

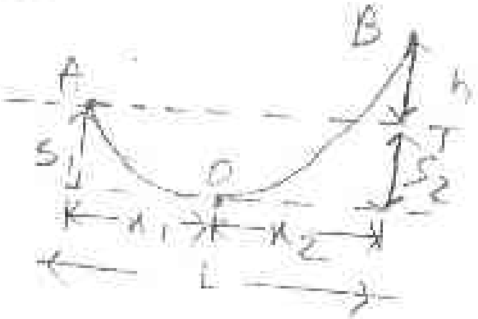
$$Ty = wx \times \frac{x}{2}$$

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

$$S = \frac{w(l/2)^2}{2T} = \frac{wl^2/4}{2T}$$

$$= \frac{wl^2}{8T} = \frac{wl^2}{8T}$$

2. when supports at different level



$$S_1 = \frac{w x_1^2}{2T}$$

$$S_2 = \frac{w x_2^2}{2T}$$

again $x_1 + x_2 = l$

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

where, h is difference in level betn 2 supports

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

$$h = \frac{wL}{2T}(x_2 - x_1)$$

But $S_2 - S_1 = h$

$$x_2 - x_1 = \frac{2Th}{wL}$$

~~$x_1 + x_2$~~ $x_1 + x_2 = l$ — ①

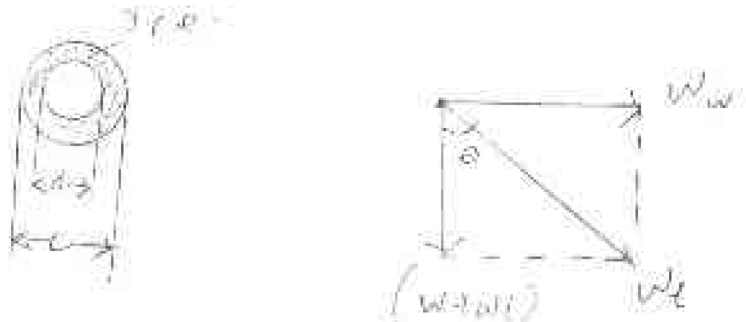
$x_2 - x_1 = \frac{2Th}{wL}$ — ②

on solving equn ① & equn ② we get.

$$x_1 = \frac{L}{2} - \frac{Th}{wL}$$

$$x_2 = \frac{L}{2} + \frac{Th}{wL}$$

Effect of Ice and wind loading 20-1-2016



$$w_t = \sqrt{(w+w_i)^2 + w_w^2}$$

where, w = weight of the conductor per unit length

* w_i = " " " " ice " " "

∴ 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

i.e = wind pressure × $\left[(d+2t) \times 1\right]$

when the conductor has wind & ice loading the following points may be noted.

1→ The conductor sets itself at an angle θ to the vertical

where,

$$\tan\theta = \frac{w_w}{w+w_i}$$

2→

2-> The sag of conductor is given by.

$$\frac{W_t \times l^2}{2T}$$

3-> The vertical sag = $S\cos\theta$

Problem

weight of the conductor 680 kg/km, length of the span 260 m, tension 1550 kg ground clearance required is 10 meters. Calculate the height above the ground at which the conductor should be supported.

Soln

$w = 680$ kg/km $= \frac{680}{1000} = 0.68$ kg/m

$l = 260$m.

$T = 1550$ kg.

$$S = \frac{w(l/2)^2}{2T} = \frac{0.68(260/2)^2}{2 \times 1550} = 3.70\text{ m}$$

Conductors will be supported at height of

$10 + 3.70 = 13.70$ m above the ground

5) (M-12)

span length (l) = 150 m

working tension (T) = 2000 kg.

wind force per meter length (w_w) = 1.5 kg

weight of the conductor per meter length (w) 1.98 kg

calculate the sag (s) = ?

Find the vertical sag = ?

(iii) $S = \frac{w_t (l/2)^2}{2T}$

$= \frac{2.48 (150/2)^2}{2 \times 2000} = 3.48 m$

ii) $w_t = \sqrt{w^2 + w_t^2} = \sqrt{(1.98)^2 + (1.5)^2} = 2.48$ kg.

i) $\tan \theta = \frac{w_w}{w} = \frac{1.5}{1.98} = 0.75$

$\theta = \tan^{-1} 0.75$

$\theta = 36.86°$

CH-3 performance of Transmission lines   21-1-16

classificat of overhead transmission lines

A transmission line has three constants R, L&C Distributed uniformly along the hole length of the line

-> The resistance and inductance form the series impedance.

-> The capacitance existing betn conductors for single phase line or from a conductor to nutral for a three Phase line forms a shunt path throughout the length of the line.

-> The overhead transmission lines are classified as –

a-> short transmission lines

b-> Medium " "

c-> long " "

*(a) short transmission lines :-

The length of the short transm is up to about 50 km and the line voltage is compparitibely load.

-> Due to smaller length and lower voltage the capacitance effect can be small and only resistance & inductance of the line are taken in to account

- Medium transmission line -

The length of the MT L about 50 to 150 km and the line voltage is moderately high / just high. Due to sufficient length and high voltage the effect of capacitance is taken in account

c - Long transmission lines -

The length of the long T.L's is more than 150 km and the line voltage is very high (>100 kV)

voltage Regulation

when a transmission line is carring current there is a voltage drop due to resistance & inductance of the line so the receiving end voltage (V_r) is generally less than sending end voltage (V_s)

* voltage drop = ~~sending end voltage / receiving end voltage = V_s / V_r~~ $V_s - V_r$

and is expressed as a percentage of receiving end voltage V_r and is called voltag regulation.

the difference in voltage at the receiving end of a transmission line betn conditions of no load & full load is called voltage regulation and is expressed as a percentage of the receiving end voltage.

mathematically % voltage regulation

$$= \frac{V_S - V_R}{V_S} \times 100$$

Transmission efficiency.

The ratio of receiving end power to the sending end power of a transmission line is called the transmission efficiency of the line.

* Percentage transmission efficiency

$$\Rightarrow \eta_T = \frac{\text{Receiving end power}}{\text{sending end power}} \times 100$$

$$= \frac{V_R I_R \cos\phi_R}{V_S I_S \cos\phi_S} \times 100$$

where.

V_R, I_R & $\cos\phi_R$ are receiving end voltage.

I_R " " current.

$\cos\phi_R$ " end at power factor.

V_S = sending end voltage.

I_S = " " current.

$\cos\phi_S$ = " end at power factor.

Performance of single phase short transmission lines

Let

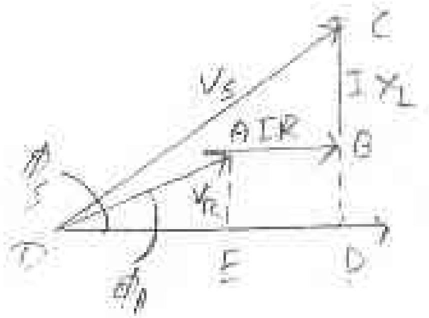
I = load current.

R = Resistance of both conductors.

X_L = Reactance

V_S = sending voltage

V_R = Receiving voltage



The phasor diagram of the line for lagging load power factor is shown in the figure.

From the rightangle traingle, ODC we get

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

$$V_S^2 = (OE + ED)^2 + (DB + CB)^2$$

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

Therefore $V_S = (V_R \cos\phi_R + IR)^2 + (V_R \sin\phi_R + IX_L)^2$

* Percentage voltage regulation $= \frac{V_S - V_R}{V_R} \times 100$

* Sending end power factor $\cos\phi_S = \frac{OD}{OC} = \frac{V_R \cos\phi_R + IR}{V_S}$

* Power delivered $P = VI\cos\phi$

$= V_R I_R \cos\phi_R$

line losses $= I^2R$

Power sent out $=$ ~~P~~ $V_R I R\cos\phi_R + I^2R$.

~~P~~ % transmission ~~P~~ $\eta = \frac{\text{Power deliver}}{\text{Power sent out}} \times 100$

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

soln in complex notation

$\vec{V_S} = \vec{V_R} + \vec{I} \times \vec{Z}$

$= (V_R + j0) + I(\cos\phi_R - j\sin\phi_R)(R + jX_L)$

$= (V_R + IR\cos\phi_R + IX_L\sin\phi_R) + j(IX_L\cos\phi_R - IR\sin\phi_R)$

~~Therefore $V_S =$~~

Therefore $V_S = \sqrt{(V_R + IR\cos\phi_R + IX_L\sin\phi_R)^2 + j(IX_L\cos\phi_R - IR\sin\phi_R)}$

The second term is quit small and can be neglected

Therefore V_S becoms

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

The following points may be noted

i) The approximate formula for V_S gives fairly correct result for laging power factor. However error is caused for leading power factors. Therefore approximate expression for V_S should be used for laging power factor only

e)

A single phase over head transmission line delevers 1100 kW at 33 kV at 0.8 power factor laging the total resistance and inductive reactance of the line are 10 Ω & 15 Ω respectively. Determine.

(1) senting end voltage
(2) senting end power factor
(3) Transmission efficiency.

v.v.v. impotant

Soln

Load power factor $\cos\phi_R = 0.8$ (laging)

Total line impedance $\vec{Z} = R + jX_L$

$= 10 + j15$

Receiving at voltage $V_R = 33000V$

Line current (I) $= \frac{1100 \times 10^3}{V_R \cos\phi_R}$

$= \frac{1100 \times 10^3}{33000 \times 0.8} = 41.66$ A.

22-1-16

$\cos\phi = 0.8 \Rightarrow \phi = \cos^{-1}(0.8) = 36.86$

$\sin\phi = \sin(36.86) = 0.6$

$\vec{V_r} = V_R + j0 = 33,000 \text{ V}$

$\vec{I} = I(\cos\phi_R - j\sin\phi_R)$

$= 41.67(0.8 - j0.6)$

$= 33.336 - j25$

$\vec{V_s} = \vec{V_R} + \vec{I}\,\vec{Z}$

$= 33000 + (33.33 - j25)(10 + j15)$

$= 33000 + 333.3 - j250 + j500 + 375$

$\Rightarrow 33708.3 + j250$

$V_S = \sqrt{(33708.3)^2 + (250)^2} = 33709 \text{ V}$

angle betn $\vec{V_R}$ and $\vec{V_S}$ $= (\alpha) = \tan^{-1}\frac{250}{33708.3} = 0.42^\circ$

$\phi_s = \phi_R + \alpha$

$= 36.86 + 0.42 = 37.28^\circ$

sending end power factor angle $= 37.28^\circ$

$\cos\phi_s = \cos(37.28^\circ)$

$= 0.795$ (lagging)

line losses $= I^2R$

$= (41.67)^2 \times 10 = 17364 \text{ W}$

output $= 1100000 + 17364 \text{ W}$

$= 1117364 \text{ W}$ or 1117.364 kW

Transmission efficiency

$= \frac{1100}{1117.364} \times 100 = 98.44$ %.

(2) An overhead 3ϕ transmission line delivers 5000 kw at 22 kV at 0.8 power factor laging. The resistance and reactance of each conductor is 4Ω & 6 Ω. Determine.

1. sendingend voltage.
2. percentage Regulation.
3. Transmission efficiency

Sol^n

load powerfactor $\cos\phi_R = 0.8$

Vidul $V_L = 22$ kV $= 22000$

$V_R = \frac{V_L}{\sqrt{3}} = \frac{22000}{\sqrt{3}} = 12701$ V.

$\vec{Z} = R + jX_L$

$= 4 + j6$

Line current $I = \frac{P}{V\cos\phi} = \frac{5000 \times 10^3}{3 \times 12700 \times 0.8} = 164.04$ A

$\cos\phi = 0.8 \Rightarrow \phi = \cos^{-1}(0.8) = 36.86$

$\sin\phi = \sin(36.86) = 0.6$

$\vec{V_R} = V_R + j0 = 12700$

$\vec{I} = I(\cos\phi_R - j\sin\phi_R)$

$= 164.04(0.8 - j0.6)$

$= 131.2 - j98.4$

$\vec{V_S} = \vec{V_R} + \vec{I}\vec{Z}$

$= 12700 + (131.2 - j98.4)(4 + j6)$

$= 12700 + 524.8 + j787.2 - j393.6 + 590.4$

$= 13815.2 + j393.6$

Internal

Answer any two

1) (a) what is thermal eff. & over all eff. (2)

b) why surge tank is provided in hydroelectric power station.

c) Draw the schematic arrangement of thermal power station.

2) (a) what is corona.

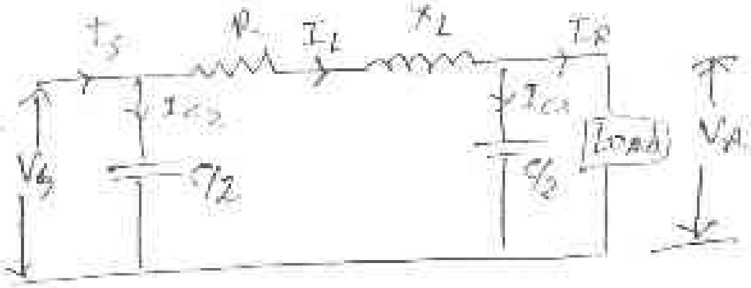
b) what are the factor affecting corona

c) Derive the sag when the support are in equal level

3) (a) Explain the principle of working of a nuclear power plant

b) Draw and explain the lay out of transmission and distribution scheme

c) Derive the expression for kelviens law for economic size of conductors.



Let I_R is the load current

R is the resistance

X_L inductive reactance

C capacitance

$\cos\phi_R$ receiving end power factor

V_S sending end voltage

we know,

$$\vec{V_R} = V_R + j0$$

load current $\vec{I_R} = I_R(\cos\phi_R \; j\sin\phi_R)$

charging current at load end $\vec{I_{C_1}} = j\omega C/2 \; \vec{V_R}$

line current $\vec{I_L} = \vec{I_R} + \vec{I_{C_1}}$

sending end voltage, $\vec{V_S} = \vec{V_R} + \vec{I_L} \times \vec{Z}$

i.e. $\vec{V_R} + \vec{I_L}(R + jX_L)$

charging current at the sending end $I_{C_2} = j\omega C/2 \times \vec{V_S}$

$$= j(\pi f)C \times \vec{V_S} = j\pi f C \vec{V_S}$$

sending end current $= \vec{I_L} + \vec{I_{C_2}}$

→ In this method the capacitance of each conductor is divided in to two half

1) one half present at the sendingend.

and the other half at the receivingend.

2 The capacitance at the sending end has no effect on the line draw.

Problem

A three phase 50 herth 150 km line has a resistance, inductive reactance and capacitive sub admittance of 0.1 Ω, 0.5 Ω & 3.10^{-6} S per km per phase if the line delevers 50 MW at 110 kV and 0.8 powerfactor laging. Determine the sending end voltage and current assume a nominal π cct for the line

Ans

Soln

Total resistance per phase $= 0.1 \times 150 = 15$ Ω

Total reactance per phase $= 0.5 \times 150 = 75$ Ω

Capacitive admittance $= 3 \times 10^{-6} \times 150 = 45 \times 10^{-5}$ S

Receivingend voltage per phase $V_R = \frac{110}{\sqrt{3}} = 63.508$ kV or 63508 V.

Load current $I_R = \frac{P}{\sqrt{3} V_L I_L \cos\phi} = \frac{50 \times 10^6}{\sqrt{3} \cdot 110 \times 10^3 \times 0.8} = 328.03$ A

$\cos \phi_R = 0.8$

$\Rightarrow \phi_R = \cos^{-1}(0.8)$

$\Rightarrow \phi_R = 36.86$

$\sin \phi_R = \sin 36.86 = 0.59 \sim 0.6$

$V_R' = V_R + I_0$

$= 63508\ V$

$\vec{I_R} = I_R(\cos\phi_R - j\sin\phi_R)$

$= 328.03(0.8 - j0.6)$

$= 262.4 - j196.82$

Charging current at load end $\vec{I_{C_1}} = \vec{V_R}\, j\frac{Y}{2}$

$= 63508\ j\frac{4.5\times10^{-5}}{2} = j14.3$

Line current, $\vec{I_L} = \vec{I_R} + \vec{I_{C_1}}$

$= 262.4 - j196.82 + j14.3$

$= 262.4 - j182.52$

Sending voltage, $\vec{V_S} = \vec{V_R} + \vec{I_L}\,\vec{Z}$

$= 63508 + (262.4 - j182.52)\times(15 + j75)$

$= 63,508 + 3936 + j19680 - j2737.5 - j^2 13687.5$

$= 63,508 + 3936 + j19680 - j2737.5 + 13687.5 \quad [\because j^2 = -1]$

$= 81131.5 + j16942.5$

$V_S = \sqrt{a^2 + b^2}$

$= \sqrt{(81131.5)^2 + (16942.5)^2}$

$= 82881.65$ Ans

Line to line sending voltage

$= \sqrt{3}\times 82881.65 = 143555.22,\ V_1 = 143.55\ kV$

Charging current at sending end. $I_{C_2} = \vec{V_s} \frac{jY}{2}$

$8131.5 + j16942.5 \times j \frac{457 \times 10^{-5}}{2}$

$= -3.81 + j18.25$

2.2.2016

Sending end current, $\vec{I_s} = \vec{I_L} + \vec{I_{C_2}}$

$= (262.4 - j182.52) + (-3.81 + j18.25)$

$= 258.59 - j164.27$

Therefore the magnitude sending end current =

$= \sqrt{a^2 + b^2}$

$= \sqrt{(258.59)^2 + (j164.27)^2}$

$= 306.35$ A Ans

The angle

$= \tan^{-1}(306.35) = 89.81$

VV.V.V.V. ipot

Q) A 100 km long 3phase 50 Hz transmission line has the following line constant resistance per phase per km = 0.01 Ω, reactance per φ per km = 0.5 Ω, susceptance per phase per km = 10×10^{-6} S

if the line supplyes load of 20 mw at 0.9 power factor lagging at 66 kV at the receiving end, calculate by nominal π method

(1) sendingend powerfactor, $\cos \phi_s$

(2) regulation

(3) Transmission efficiencity

Ans

Resistance per phase

= 100 × 0.1 = 10 Ω

Reactance per phase

= 100 × 0.5 = 50 Ω

total

suspentance per phase

= 100 × 10 × 10⁻⁶ = 10⁻³ S

Receivingend voltage phase = $\frac{66 \times 10^{-3}}{\sqrt{3}}$ = 1000

= 3810.5 V.

load current $I_a = \frac{20 \times 10^6}{\sqrt{3} \times 66 \times 10^3}$ = [illegible] = 195 A

$\cos \phi_R = 0.9$

$\Rightarrow \phi_R = \cos^{-1} 0.9 = 25.84$

$\sin \phi_R = \sin(25.84) = 0.435$

$I_L =$

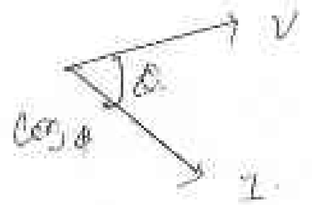
CHAPTER-7

3.2.16

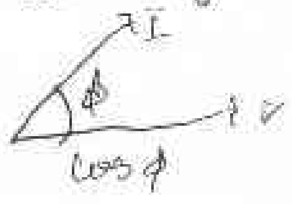
Power factor improvement.

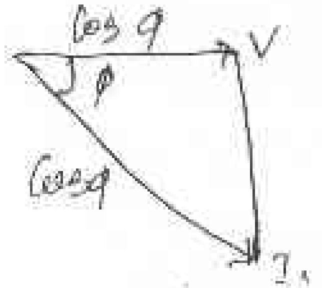
Power factor

The cosine of the angle betn voltage and current in an A.C ckt is known as power factor.
The term cosϕ is called the power factor of the ckt. if the ckt is inductive the current lages behind the voltage and the power factor is refer to as lagging.



However in capacitive ckt the current leads the voltage and the power factor is said to be leading





The current 'I' can be resolved in to two rectangular component.

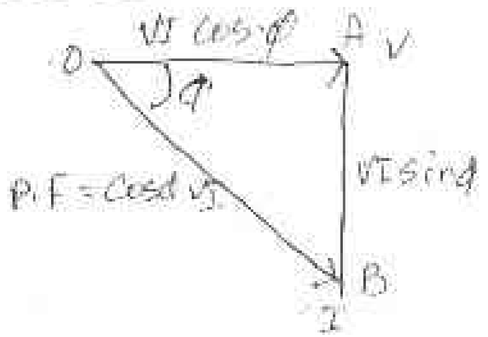
(a) I cosϕ in phase with voltage (v)
(b) I sinϕ - 90 out of phase voltage

→ The component I cos ϕ is known as active or wattful component
→ The component I sinϕ is called the reactive or wattless

→ If the reactive component is small the phase angle ϕ is small and hence $\cos\phi$ will be high and vice versa.

→ The value of power factor can never be more than unity.

→ Power traingle



→ OA VI cos ϕ and represent in active power in watts or kW.

→ AB = VI sin ϕ and represent in reactive power in VAR and kVAR

→ OB = VI and represent the apparent power in VA or kVA.

The following points may be noted.

→ $OB^2 = OA^2 + AB^2$

or

Apparent power^2 = active power^2 + reactive power^2

→ power factor, $\cos\phi = \frac{b}{h}$

$$\cos\phi = \frac{OA}{OB} = \frac{\text{Active Power}}{\text{Reactive Power}}.$$

Thus the power factor of a cut is the ratio of active power to apparent power

→ kVAR = kVA sin ϕ

→ power factor $\cos\phi$ = cosine of the angle betn V & I

→ Power factor $= \frac{R}{Z} = \frac{\text{Resistance}}{\text{impedance}}$

Power factor $= \frac{VI\cos\phi}{VI} = \frac{\text{active power}}{\text{apparent power}}$

D.A. of low power factor :-

→ large kVA rating of equipment.

→ Greater conductor size

→ large copper losses

→ Poor voltage regulation.

→ Reduce handling capacity of system.

Causes of low power factor. 4·2·16

* most of the AC motors are induction type which have low lagging power factor. These motors work at power factor which is extremly ~~sm~~ small at light load and raises to 0.8 or 0.9 at full load.

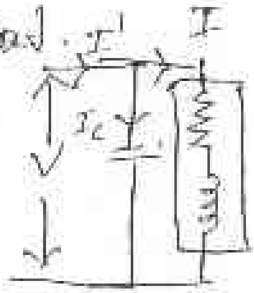
* Arcs lamps, electric discharge lamps industrial furnaces operate at low power factor

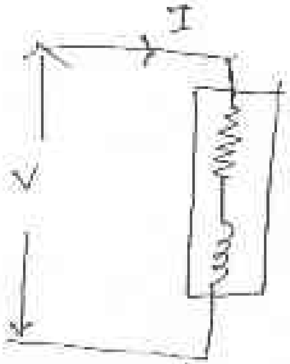
* The load on power system is varying. During low load period, supply voltage is increased which increases magnetisation current.

This results in decreased powerfactor. 4.2.16

Power factor Improvement

In order to improve the power factor, some device having leading power should be connected in parallel with the load. one of such devices is a capacitor. The capacitor draws a leading current and partly or completely nutralizes the lagging reactive component of total load current. This ~~raises~~ reses the powerfactor of the load.





Power factor improvement equipment.

The power factor can be ~~improvement~~ by the following equipments

1. static capacitor
2. Synchronous Condensers
3. phase advancers

1. static capacitor.

The power factor Can be improved by Connecting capacitors in parallel with the equipment operating at lagging powerfactor. The capacitor (static capacitor) draws a leading current and partly & completly nutralizes the lagging reactive component of load current

Advantages

They have low losses.

* required little mentenance.

* can be easily installed.

* can work under ordinary atmospheric conditions

Disadvantages.

* short service like

* Easily daymased

* If capacitor is daymased the repair is uneconomical

2 synchronous Condenser.

A synchronous motor takes a leading current when over excited and behaives as a capacitor. An over excited synchronous motor running on no load is called synchronous condenser.

Advantages.

* By varing the field excitation, the magnitude of the current drawn by the motor can be changed.

* The motor windings have high thermal stability to short cut currents.

* fault can be remove easily

Disadvantages :- * There are considerable losses in motor. mentenance cost is high

* It produces noise

* As synchronous motor has no starting torque,

an axulary equipment has to be provided

phase ~~advance~~ advanser

phase advanser as use to improve power factor of induction motor. If exciting ampere turns can be provided from sum other AC sources the stator winding is relieved of exciting current and the power factor of the motor can be increased.

Advantages.

* lagging KVAR drawn by the motor are reduc

* It can be used ~~wh~~ where the use of synchronous motor is unadmissible

Disadvantages.

They are not economical for motors bellow 200H

09-02-2016

11-02-2016.

Important terms & factor:-

1: Connected load.

It is the sum of continious ratings of all the equipments connected to the supply system.

2. Max^m demand.

* It is the greatest demand of load on the power station during a given period.

* The station must be capable of meeting the max^m demand.

* The max^m demand is generally less than

the connected load.

3. Demand factor.

It is the ratio of max^m demand on the power station to it's connected load

$$\text{Demand factor} = \frac{\text{Max}^m \text{ demand}}{\text{Connected load}}$$

* The value of demand factor is usually less than one because the max^m demand is less than connected load.

* The knowledg of demand factor is vital in determining the capacity of plant equipment

1. Average load.

The average of loads occuring on the power station in a given period is called average load or average demand

2. ~~Deary average load.~~

Number (of) unit.

$$\text{Daily avera lo} = \frac{\text{number of units generated in a day}}{\text{24 hour}}$$

~~monthly of load~~ = ~~no of unit generated~~ / 3

no. of day ~~in a month × 30 day~~.

$$\text{onthly average load} = \frac{\text{no of units generated in a month}}{\text{no of days} \times 24 \text{ in month}}.$$

Yearly avarage load

$$= \frac{\text{no. of unit generated in a year.}}{\text{8760 hour.}}$$

Load factor.

It is the ratio of average load to the max^m demand during a given period.

$$L.F = \frac{\text{Avarage load.}}{\text{max}^m \text{ demand.}}$$

* load factor is alway less then one because avarage load is smaller than max^m demand.
* It is used to determine the overall cost per unit generated.

Diversity factor

The ratio the some of individual max^m demand to the max^m demand on the power station is known as diversity factor

$$\text{Diversity factor} = \frac{\text{some of individual max}^m \text{ demands.}}{\text{max}^m \text{ demand on power station.}}$$

* The max^m demand on the power station is always less than the some of individual max demands

plant capacity factor.

It is the ratio of actual energy produced to the max^m energy that could have bein produced during a given period.

plant capacity factor = $\frac{\text{Actual energy produced}}{\text{Max}^m \text{ energy that could have bein produced}}$

* i.e = average demand by plant capacity

* Anual plant capacity factor = $\frac{\text{Anual kwh o/p}}{\text{plant capacity} \times 8760}$

* The plant capacity factor is an indication of the resurve capacitive plant.

Resurve capacity = plant capacity − max^m demand

plant use factor.

It is the ratio of kwh generated to the product of plant capacity and the no of hours for which the plant was in operation

plant use factor = $\frac{\text{o/p in kwh}}{\text{plant capacity} \times \text{hours of use}}$

Load Curve:

15-02-2016

The curve sweeing the variation of load on the Power station with respect to time is called a a load curve

The load on a power station varies from time to time. The load variation during the whole day are recordedly half hourly or hourly and are ploted in a graph against the time the curve obtained is known as daly load curve.

The monthly load curve can be obtained from the daly load curve of that month

The early load curve is obtained by considering the monthly load curve of that particular year. The early load curve is generally used to determine the anual load factor.

Importance

The daly load curve has a greate importance in generation as they give the following information.

→ The dayly load curve shows the variation of the load or the power station during differe hours of the day

→ The area under the dayly load curve gives the no. of units generated in the day.

- units generated per day.

= area (in kwh) under dayly load curve

→ The highst point on the dayly load curve represents the max^m demand on that day.

→ The area under the dayly load curve divided by the total no. of hour gives the average load on that day.

→ The ratio of the area under the load curve to the total area of rectangular in which it is Contain gives the load factor

$$\text{load factor} = \frac{\text{average load.}}{\text{max}^m \text{ demand.}}$$

→ The load curve helps in selecting the size and number of generating units

→ The load curve helps in preparing the operation schedule of the station

⑤) max^m demand = 100 mW

anual load factor = 40% = 0.4

Calculate energy generated in a year.

Sol^n

Energy generated per year.

= max^m demand × load factor × hour in a year.

$100 \times 10^6 \times 0.4 \times 8760 = 3.50 \times 10^{11}$

⑥) Connected load = 43 mW.

max^m demand = 20 mW

units generated = 61.5×10^6 per annum.

① Calculate demand factor.

② Load factor.

Sol^n

① demand factor = $\frac{max^m \text{ demand}}{\text{Connected load}}$

$\frac{20}{43} = 0.465$

② Load factor = $\frac{\text{load}}{max^m \text{ demand}}$

avarage load = $\frac{\text{unit generated}}{\text{no. of hours in year}} = \frac{61.5 \times 10^6}{8760}$

= 7020 mW

load factor = $\frac{7020}{20 \times 10^6} \times 100 = 0.035\%$ =

CH-

23-02-2016

Distribution system.

* The part of power station which distribute electrical power for local use for local use is called as distribution system

* It generally consists of feeders, distributers, service mains

Feeder.

A feeder is a conductor which connects the substation to the area where power is to be distributade.

Generally no tappings are taken from the feeder so that current in it remains the same

Distributer.

A distributer is a conductor from which tappings are taken for supply of consumer

* The current through a distributer is not constant because tappings are taken at various places

Service main.

A service mains is generally a small cable which connects the distributers to the consumer terminals

Classification of distribution.

A distribution system can be classified according to

1- The nature of current.
2- types of construction.
3- scheme of connection

1- Nature of current.

According to the ~~nation~~ nature of current distribution system can be classified ~~into~~ as AC distribution system & DC dist. system.

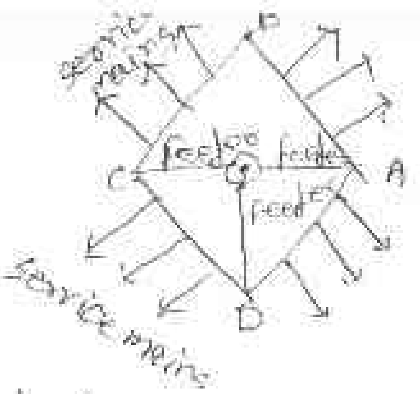
* It is universally adopted for distion of electrical power

2- Types of construction.

According to the type of construction distribution system can be classified as overhead & under ground distribution system.

3- Scheme of connection.

According to the scheme of connection the dist. system can be classified as radial system, ring main system & interconnected system.



AC Distribution.

The AC dist. system is classified in to.
① Primary distribution system
② secondary " "

1- Primary Distribution system.

It is the part of AC distribution system which operates at voltage some what higher than general utilization and handles large electrical energy.

* The voltage used for primary distribution depend upon the amount of power to be fed and the distance of substation.

* The most commonly used primary distribution voltage are 11 KV, 33 KV & 6.6 KV

* Primary distribution is carried out by 3 phase 3 wire system.

2- secondary distribution system.

It is a part of AC distribution system system which includes voltages at which the ultimate consumer utilizes the electrical energy delivered

The secondary distribution employs 400/230 V 3 phase 4 wire system

<u>DC Distribution.</u>

for certain applications DC supply is absolutely necessary for this purpose AC power is converted into DC power by rectifier, rotary converter and motor generator sets.

* The DC supply from the substation may be obtained in the form of two wire, 3 wire for distribution

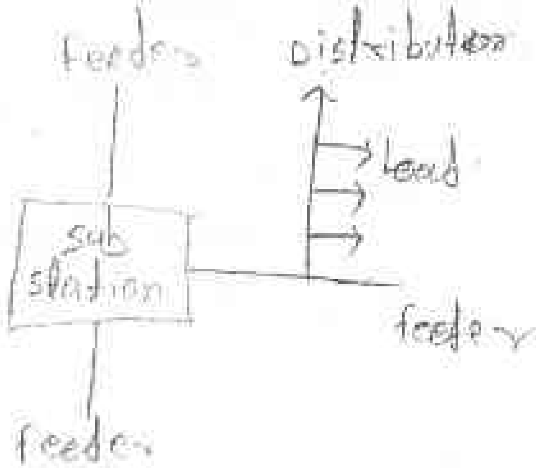
<u>Connection schemes of Distribution system.</u>

25-02-2011

* All distribution of electrical energy is done by constant voltage system. The following distribution ckt are generally used-

① Radial system →

In this system separate feeders radiate from a single substation and feed the distributors at one end only



The radial system is employed only when power is generated at low voltage and the sub station is located at the centre of the load

* This is the simplest distribution cut and has lowest initial cost

Disadvantages -

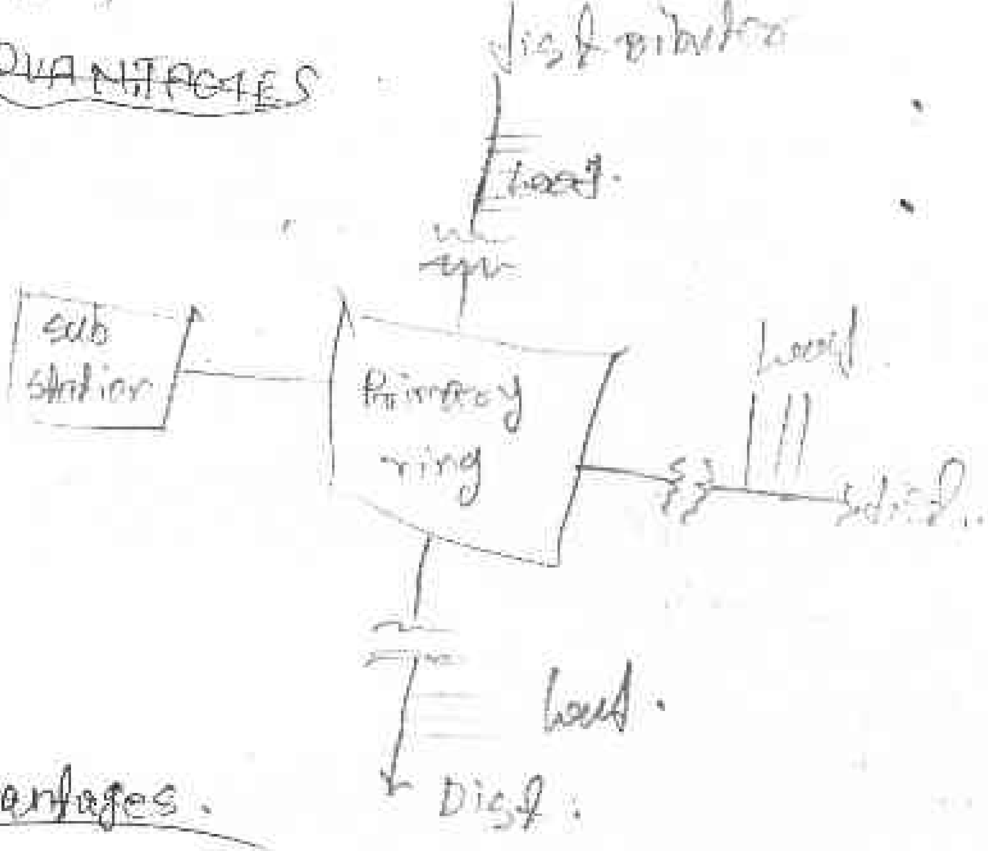
* The end of the distributor nearer to the feed point will be heavyly loaded.
* The cosumers are dependents on a single feeder and a single distributor. Any fult on the feeder or distributor cuts off supply to the consumer
* The consumers at distant end of the distributor, there would be serious voltage ~~fluctuation~~ fluctuations when the load on the changes

Note - Due to this disadvantages this system is used for short distances only

Ring main system.

* In this system the primeries of distribution transformer form a loop. The loop out starts from the substaions bus bars, makes a loop through the area to be serves and returns to the sub-station

ADVANTAGES



advantages.

: There are less valtage flucduation and Consumine terminal

* The system is very relayble as each distributor is faid by two feeders. In the even of fult of the feeders the Continiouty of supply is maintained

Inter Connected system.

when the feeder ring is energiesed from more than two generating system or substation then it is called inter connected system.

Advantages.

* It increases the system relaibility.
* It reduces reserve power capacity & increase efficiency of the system.

Requiredment of a Distribution system.

* Proper voltage
* Availability of power on demand.
* Reliability.

~~DC distribution.~~

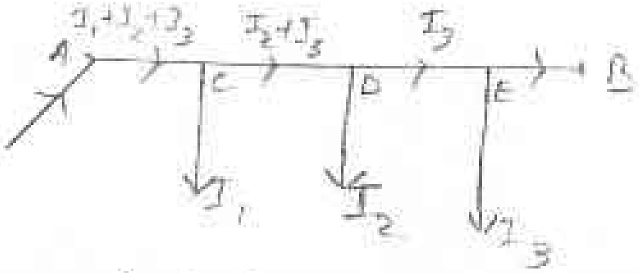
~~Types of DC Distributors.~~

~~→ Distributor fed at one end.~~

DC distribution.

Types of distribution:

1) Distributor feed at one end:



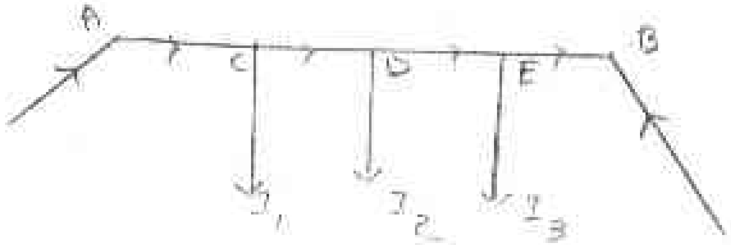
* In this type of feeding the distributor is connected to the supply at one end and loads are taken at differents along the length of the distributor.
* It is also called singly fed distributor.

Disadvantages.

* The current in various sections goes on decreasing
* The voltage across the load goes on decreasing
* In case of a fault the whole distributor is disconnected from the supply mains. Therefore continuity of supply is interactade.

2) Dis.

2) Distributor feed at both end :-



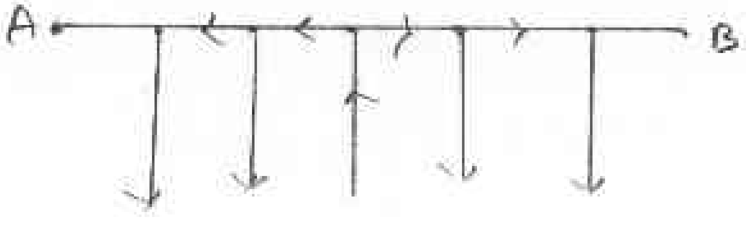
? In this type of feeding the distributor is Connected to the supply mains at both end & loads are tapped off at different points along the distributor

ADVANTGA.

* If a fult occurs, the continutiy of supply is maintain from other feeding point

* The area of X-section required for a doubly feed distributor is much less than that of a single feed distributor

3) Distributor feed at a center :-

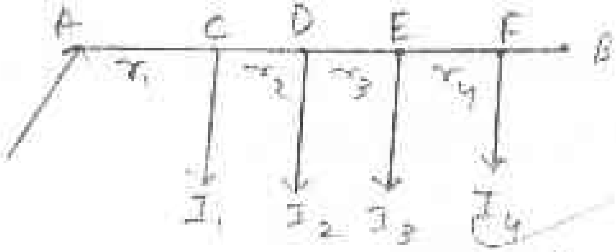


* In this type of feeding the centre of the distributor is connected to the supply mains

(v) Ring mains —

* In this type of the distributor is in the form of a closed ring. The distributor ring may be fed at one or more than one point

DC distributor fed at one end.



Let

r_1, r_2, r_3, r_4 be the resistances of both wires of the section A&C, C&D, D&E, E&F, F&B

Current fed from point A $= I_1 + I_2 + I_3 + I_4$

Current in section A&C $= I_1 + I_2 + I_3 + I_4$

" " " C&D $= I_2 + I_3 + I_4$

" " " D&E $= I_3 + I_4$

" " " EF $= I_4$

Voltage drop in section A&C $= r_1 (I_1 + I_2 + I_3 + I_4)$

" " " " C&D $= r_2 (I_2 + I_3 + I_4)$

" " " " D&E $= r_3 (I_3 + I_4)$

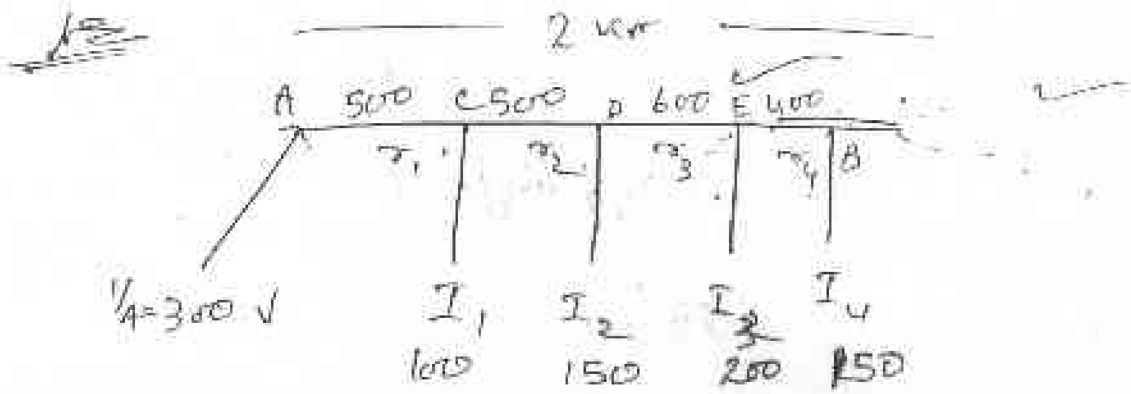
" " " " E&F $= r_4 (I_4)$

Total voltage drop of the distributors.

$$r_1(I_1+I_2+I_3+I_4)+r_2(I_2+I_3+I_4)+r_3(I_3+I_4)+r_4(I_4)$$

Q) A two wire DC distributor cable A.B is 2 km long & supplyes loads of 100A, 150 A, 200A & 50 A situated 500 m, 1000 m, 1600 m & 2000 m from the feding point A. Eeach conductor has a resistance of 0.01 Ω per 1000 km calculate P.D at each load point if a P.D of 300 V is maintend at point A.

Sol:



Current in sec. A&C = 100 + 150 + 200 + 50 = 500

C&D = 150 + 200 + 250 = 400

D&E = 200 + 50 = 250 A.

EB = 50 A.

Resistance in sec. AC = 500 = $\frac{0.01}{1000} \times 500 = 0.005\ \Omega$

$V_C = V_A - I_{AC} \times R_{AC} = 300 - (500 \times 0.005) = 297.5\ V$

" " sec CD = 0.005 Ω

$V_D = 297.5 - (400 \times 0.005) = 295.5\ V$

DE = 0.006Ω

$V_E = 295.5 - (250 \times 0.006) = 293.5$

EB = 0.004 Ω.

$V_B = 293.5 (50 \times 0.004) = 293.3$ v.

EC 27-02-2016.

1) (a) At what condition the η of a T-F is max^n

b) Derive the emf equ^n of a single phase T-F with usuall notation.

(c) The no load current of a TF is 4A and 0.25 power factor when supplied at 250 v at 50 Hz The no. of turns the primary winding is 200 Calculate,

(1) flux in the Core

(2) Core loss

(2) (a) In DC shunt motor if the field terminals are reversed then what happes to its speed

b) Derive torque equ^n of a DC motor with usual notation

(c) The i/p to a 230 v of DC shunt motor is 11 kw no load current is ~~[illegible]~~ 5 A., no load speed

1150 RPM armature resistance 0.15 Ω & shunt field resistance is 110 Ω. Calculate.

1. The torque develope.
2. The speed at full load.

5)(a) write two important causes for which DC shunt generator may not build up it's voltage

(b) Derive the emf equ^n of a DC generator.

(c) A 25 KW 250V DC shunt generator as an armature & field resistance of 0.6 Ω and 100 Ω respectively. Determine total armature power developed when running

1. As a generator delevery 25 KW o/p
2. As a motor taking 25 KW i/p.

Ans Resistance per wire

1000 m = 0.01 Ω

Total resistance = 2 × 0.01 Ω

1000 m = 0.02 Ω.

Current in section AC = 100 + 150 + 200 + 50 = 500 A.

" " " CD = 400 A

" " " DE = 250 A

" " " EB = 50 A.

Resistance is sec. AC $= \frac{0.02}{1000} \times 500 = 0.01\Omega$.

" " " CD $= 0.01$

DE $= 0.012$

EB $= 0.008\Omega$.

$V_C = V_A - (500 \times 0.01) = 300 - 5 = 295$

$V_D = V_C - (400 \times 0.01) = 295 - 4 = 291\ V$

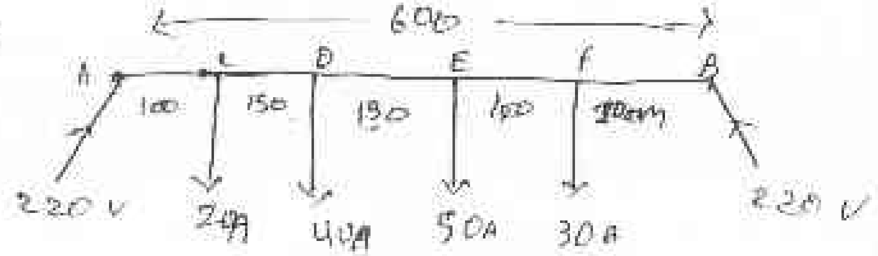
$V_E = V_D - (250 \times 0.012) = 291 - 3 = 288\ V$.

$V_B = V_E - (50 \times 0.008) = 288 - 0.4 = 287.6\ V$.

Distributor fed at both ends.

→ Two ends fed with equal voltages.

A two wire DC street mains AB 600 m long is fed from both the ends at 220 V. load of 20, 40, 50, 30 A are taped at distance at 100 m, 250 m, 400 m, 500 m. If the area of x-section of distributor conductor is 1 cm² find the minimum consumer voltage. Take $\rho = 1.7 \times 10^{-6}\ \Omega$ cm



Sol^n

Current in sec. AC $= (I_A - 20)$ A.

" " CD $= (I_A - 60)$ A

" " EF $= (I_A - 110)$ A.

" " FB $= (I_A - 140)$ A.

we know that

$R = \rho \frac{l}{a}$

$l = 1m = 100\ cm$

$\rho = 1.7 \times 10^{-6}\ \Omega\ cm$

$a = 1\ cm^2$

$R = 1.7 \times 10^{-6} \Omega \times \frac{100\ cm}{1\ cm^2}$

$= 1.7 \times 10^{-4}$

Total resistance $= 2 \times 1.7 \times 10^{-4}$

$= 3.4 \times 10^{-4}\ \Omega$

$AC = 3.4 \times 10^{-2}\ \Omega = 0.034$

$CD = (3.4 \times 10^{-4} \times 150) = 0.051$

$DE = (3.4 \times 10^{-4} \times 150) = 0.051$

$EF =$ [illegible] $3.4 \times 10^{-2} = 0.034$

$FB = 3.4 \times 10^{-2}\ \Omega = 0.034$

$V_B = V_A - I_A(0.034) - (I_A - 20)0.051 - (I_A - 60)0.051 - (I_A - 110)$
$0.0034 - (I_A - 140)0.034$

$V_B = V_A - I_A [0.034 + 20 \times 0.051 + 60 \times 0.05 + 110 \times 0.034$
$+ 140 \times 0.034]$

$\Rightarrow 220 - I_A (12.554)$

$0.204\ I_A$ [illegible] $= 12.55 \Rightarrow I_A = \frac{12.55}{0.204} =$ [illegible] 61.51

V_E Current $AC = I_A = 61.51$ A. 27-02-2016.

$CD = I_A - 20 = 61.51 - 20 = 41.51$

$DE = 61.51 - 60 = 1.51$

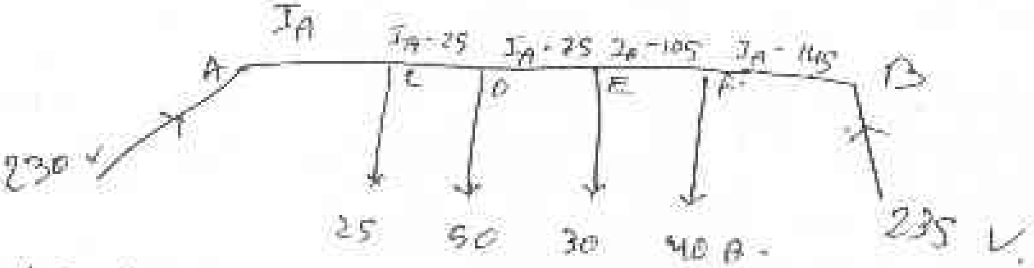
$ED = 61.51 - 110 = -48.49$

$FB = 61.51 - 140 = -78.49$

$V_E = V_A - (0.034)(61.7) - (0.051)(41.7) - (0.057)(.7)$

$= 220 - 4.31$

$= 215.69$ A.



$R = 0.6\Omega / 1000$ m

Resistance for sec. $AC = \frac{0.6}{1000} \times 50 = 0.03\Omega$.

" " " $CD = \frac{0.6}{40} = 0.015\Omega$

$DE = 0.015$

$EF = 0.03$

$FB = 0.03$

~~Voltage at ... $(I_A - 25)$~~

~~$V_B = V_A - I_A(...)$~~

$I_A = 33.34$ A.

current at section AC = 33.34
〃 〃 〃 CD = 8.34 A.
〃 〃 〃 DE = I_B - ~~75~~ = -41.66
EF = I_A - 105 = -71.66 A.
FB = -111.66 A.

$$V_B = 230 - (33.34)(0.03) - (8.34)(0.015)$$
$$= 228.875\ V.$$

~~Total power loss~~

~~$I_A^2 R = (33.34)^2 \times 0.03 + (8.34)^2 + ...$~~

AC Distribution.

03-03-2016.

AC distribution calculation differ from those of DC distribution in the following respect —

* In case of DC system the voltage drop is due to resisistance only. How ever in AC system in depends on inductance, resistance & capacitance.
* In DC system the addition and subtraction of voltages and current are done numerically. But in case of AC system it is done vectorically.
* In DC system the power factor is not taken in to account.
* But in an AC system the power factor is taken in to account.

Method of solving AC distribution problem.

In AC distribution calculation, power factor of various load current have to be considered since current will be the vector sum & not the arithmetic sum. the power of load current may be given —

1: with the respect to ~~sendi~~ receiving or sending end voltage

2: " " " load voltage it self

Power factor refer to ~~secondary~~ receiving end voltage.

Let's consider an AC distributer AC will concentrated load of I_1 & I_2 tapped off at point B & C respectively. Taking the receiving end voltage V_C as the reference vector. Let lagging power factor at B & C be $\cos\phi_1$ & $\cos\phi_2$ with rc. to V_B

Let, R_1, X_1 & R_2, X_2 = be the resistance & reactance of section AB & BC respectively.

Impedance of se. AB, $\vec{Z}_{AB} = R_1 + jX_1$

" " " BC, $\vec{Z}_{BC} = R_2 + jX_2$

load current at point B, $\vec{I_1} = I_1(\cos\phi_1 - j\sin\phi_1)$

" " " " C, $\vec{I_2} = I_2(\cos\phi_2 - j\sin\phi_2)$

current in sec BC, $\vec{I_{BC}} = \vec{I_2} = I_2(\cos\phi_2 - j\sin\phi_2)$

" " " AB, $\vec{I_{AB}} = \vec{I_1} + \vec{I_2} = I_1(\cos\phi_1 - j\sin\phi_1) + I_2(\cos\phi_2 - j\sin\phi_2)$

voltage drop is sec. BC, $\vec{V_{BC}} = \vec{I_2}\ \vec{Z_{BC}}$

$= \vec{I_2}(\cos\phi_2 - j\sin\phi_2)(R_2 + jX_2)$

" " " " " AB, $\vec{V_{AB}} = (\vec{I_1} + \vec{I_2})\ \vec{Z_{AB}}$

sending end voltage, $\vec{V_A} = \vec{V_C} + \vec{V_{BC}} + \vec{V_{AB}}$

" " current, $\vec{I_A} = \vec{I_1} + \vec{I_2}$.

2) Power factors Refer to respective load voltages.

Let,

ϕ_1 be the phase angle betn V_B & I_1 and ϕ_2 is the phase angle betn V_C & I_2

voltage drop in section $BC = \vec{I_2}\ \vec{Z_{BC}}$

" at point, C $= \vec{V_C}$ + drop in sec. BC

~~voltage at~~ $= V_B \angle\alpha$

Now $\vec{I_1} = I_1\angle -\phi_1$ with respect to voltage V_B

$\vec{I_1} = I_1\angle -(\phi_1 - \alpha)$ with respect to voltage V_C

$\vec{I_1} = I_1[\cos(\phi_1 - \alpha) - j\sin(\phi_1 - \alpha)]$

$\vec{I_{AB}} = \vec{I_1} + \vec{I_2}$

voltage drop in sec. AB $= \vec{I_{AB}}\ \vec{Z_{AB}}$

∴ voltage at point A = V_C + drop in BC + drop in sec AB

CHAPTER-

03.03.2016

UNDER GROUND CABLE

An under ground cable accentiary consist of one or more conductor covered with suitable insulation and surrounded by protecting cover.

* A cable must fulfill the necessary requirements —

i-> It should be sinned stranded copper or aluminium of high conductivety

ii-> The conductor size should be such that the cable carries the current with out over heating and causes voltage drop with in limits

iii-> The cable must have ~~proper~~ thicuness of insulation in order to give high safety and relability

iv-> The cable must be provided with suitable protection so that it may with stand the rough use in laying heat.

-> The materials uses for the manufaturing of the cables should be compled chemical & phisical stability

Construction of cable.

A) ~~Coarse or~~ Cores or Conductor :-

A cable may have one or more than one core depending up on the type of service

→ ~~The cond~~

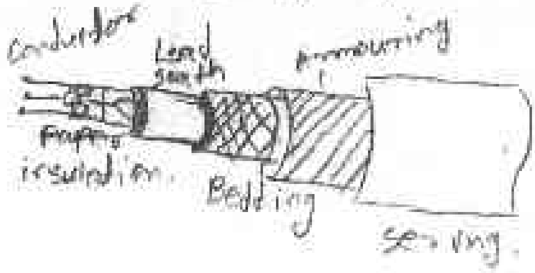
B) Insulation :-

Eeach core is provided with suitable thickness of insulation depending upon the voltage to be with stood by the cable.

Ex - pape, wood, rubber

C) Metalic sheath :-

In order to protect the cable from moisture, gasses or other daymasing liquid in the soil and atmosphere a metalic sheath is provided over the insulation.



Bedding.

~~In order~~ to over the metalic sheath is applied a layer of bedding which consist of material like Jute. The purpose of bedding is to protect the metalic sheath from ~~corrosione~~ corrosion.

Armouring over the bedding

- Armouring is provided. to protect the cable from mechanical injury.
- It consist of one or two layes of galvanised steel wire or steel tape.

Serving.

In order to protect the amouring from the atmospheric condition a layer of material like. Jute. is provided over the armouric. this is caled serving.

Insulating materials for Cable.

a) rubber
b) Vulcanised india rubber (VIR)
c) Inpregnated paper
d) Varnished cambric
e) polyvinyl chlorid. (PVC)

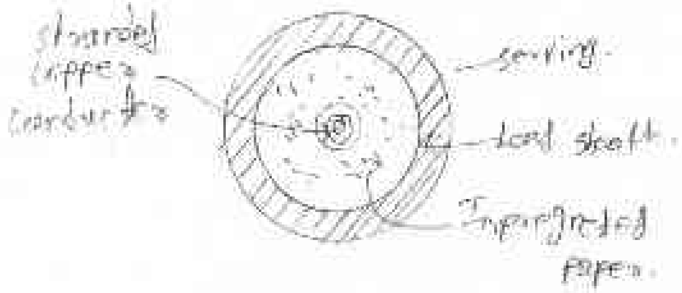
classifications of Cable

04-03-2016

The cables can be classified as follows -

1) low tension (LT) cables, range 1000 V.
2) High tension (HT) " " 11000/11 KV
3) Super tension (ST) " " 22 kV/33 kV.
4) Extra high tension (EHT) " " 33 kV/66 kV.
5) Extra super voltage (ESV) " beyond 132 kV.

2. Low Tension Cable (LT)



It consists of one circular core of tinned stranded copper insulated by Impregnated paper the insulation is surrounded by lead sheath. Finally serving is provided over lead sheath to Protect the lead sheath from corrosion.

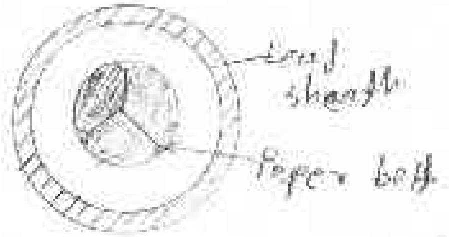
2. HT cable.

under ground cables are generally required to delever 3ϕ power for the purpose either 3 core Cable or 3 single core cables may be used.

The following types of Cable are generally used for ~~are generally used~~ 3ϕ service

1- Belted. cable up to 11kV.
2- Screeled " " " 22kV/66kV.
3- pressure " beyond 66 kV.

Belted Cables.



These Cables are used for voltages up to 22 kV.
These Core are insulated by each other by layers of impregneted paper. An other layer of Impregnetet Paper tape, called paper belt is wound round the Cores

→ The belted types cables is suitable for law and medium voltages

laying of under ground cable:

* Direct laying:- This method of laying under ground cables is simple and cheap.

→ In this method is trench about 1.5m deep and 2.5 cm wide is dug The trench is coverd with a layer of sand and the cable is laid over the sand belt. The sand privents the entry of moisture from the ground

Advantages.

It is simple and less costly.

→ It gives the best conditions for dissipating the heat generated in the cables.

→ It is clean and safe method. and free from external disturbances.

Disadvantages.

The maintainance cost is very hig.

→ Localization of fult is difficult

→ It can't be used in congested area because excavation is expensive and in convenient.

→ The alteration in the cable network is difficult.

Draw In system.

In this method ~~Ground~~ conduit or duct of glased stone or cast iron or concrit are laid in the ground. with main holes The cables are than pulled in to position from main hole.

Advantages.

Repairs, alterations or addition to the cable network can be made with out opening the ground.

* As the cables are not armoured, there fore joint becoms ant maintainace cost is reduced.

* There are very less chancess of fult occurence due to strong mechanical protection

Disadvantages.

→ The initial cost is very high

* The current carring capacity of the cables is reduced

Solid system.

* In this method of laying the cable is laid in open pipes or through dug out in earth along the cable route

Disadvantages.

→ It is more expensive
→ It required scheled labor.
→ Due to poor heat dissipation the current carring capacity is reduce

Types of cable fult.

The following are the fult most lightly to occur in underground cable

1- open cut fult :-

when there is a brake in the conductor of a cable it is called an open cut fult.

* The ~~ocf~~ open cut fult can be cheited by a megger

2- short cut fult.

when two conductors of a multi core cable from in elettrical contact with each other due to insulation falure it is called short cut fault.

for this purpose the 2 terminals of the megger are connected to any two conductors

3- Earth fault.

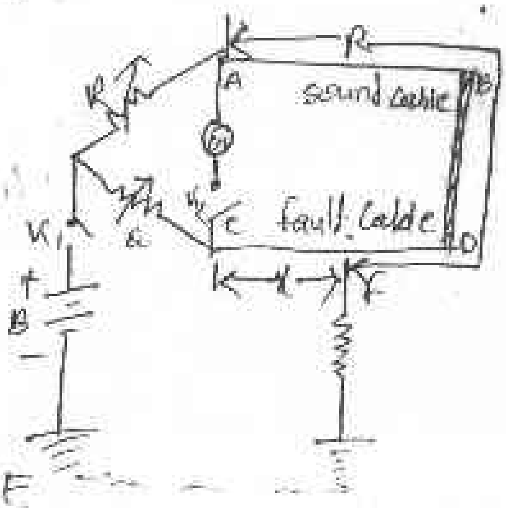
when the conductor of a cable comes in contact with earth it is called earth fault or ground fault. To identify this fault one terminal of the megger is connected to the conductor and the other terminal to the earth

Loop test for location of fault.

In under ground cables.

I- Murray loop test:

i) Earth fault.



Let R = resistance of the conductor loop up to the fault from the test end

x = resistance of the other length of the loop.

In the balanced position of the bridge,

we have $\frac{P}{Q} = \frac{R}{X} \Rightarrow \frac{P}{Q}+1 = \frac{R}{X}+1$

$$\Rightarrow \frac{P+Q}{Q} = \frac{R+X}{X}$$

If, r is the resistance of the each cable the

$R + X = 2r$

$$\Rightarrow \frac{P+Q}{Q} = \frac{2r}{X}$$

$$\Rightarrow X = \frac{Q}{P+Q} \times 2r.$$

If l is the length of each cable, then resista[nce] per meter length of cable

$= r/l$

∴ distance of fault from test end.

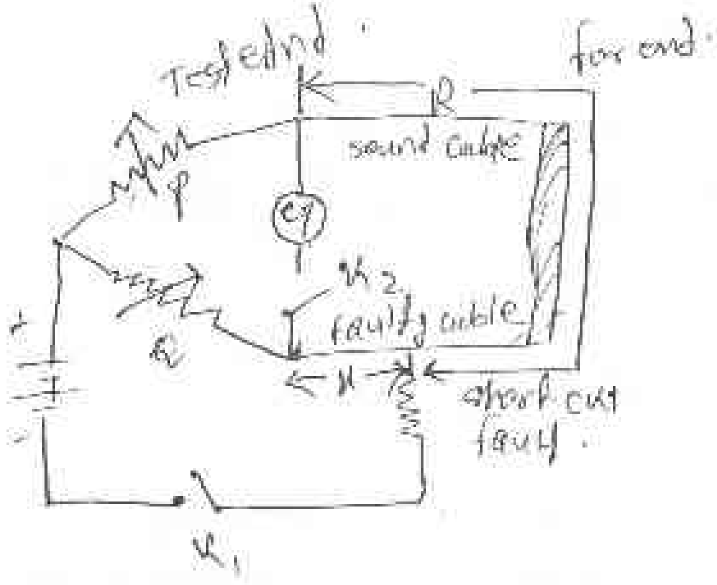
$$d = \frac{X}{r/l} = \frac{Q}{P+Q} \times 2r \times \frac{l}{r}.$$

$$= \frac{Q}{P+Q} \times 2l$$

$$= \frac{Q}{P+Q} \times \text{loop length}$$

08-03-2016

(ii) short circuit fault. 95-03-2016.



$$\frac{P}{Q} = \frac{R}{X}$$

$$\Rightarrow \frac{P}{Q} + 1 = \frac{R}{X} + 1$$

$$\Rightarrow \frac{P+Q}{Q} = \frac{R+X}{X}$$

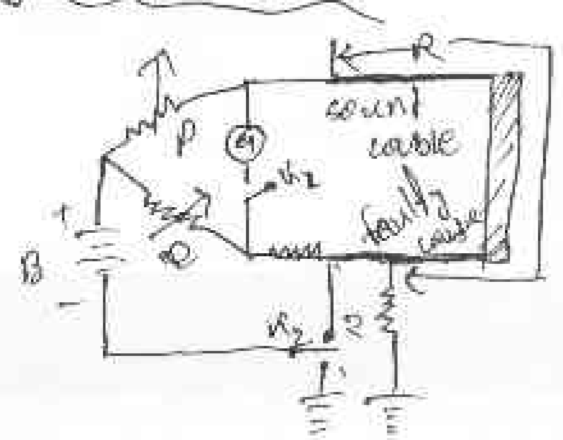
$$\Rightarrow \frac{P+Q}{Q} = \frac{2r}{X}$$

$$\Rightarrow X = \frac{Q}{P+Q}(2r)$$

$$\Rightarrow \frac{Q}{P}$$ (loop length) in meters.

Thus the position of the located.

Varley loop test.



$$\frac{P}{Q} = \frac{R}{X+S_1} \quad (\text{Add } 1)$$

$$\Rightarrow \frac{P}{Q} + 1 = \frac{R}{X+S_1} + 1$$

$$\Rightarrow \frac{P+Q}{Q} = \frac{R+X+S_1}{X+S_1}$$

$$\Rightarrow x = \frac{Q(R+X) - PS_1}{P+Q} \quad \text{--- (1)}$$

It is happen, when K_2 is ~~throgh~~ wn to posn (1)

K_2 is thrown to posn (2)

$$\frac{P}{Q} = \frac{R+X}{S_2} \quad \text{--- 1}$$

$$\Rightarrow (R+X)Q = PS_2 \quad \text{--- (2)}$$

~~$X = \frac{PS_2}{}$~~

from equn 1 & 2, we get.

$$x = \frac{P(S_2 - S_1)}{P+Q}$$

since the values of P Q S_1 & S_2 are known, the value of x can be determine

Loop resistance, $R+X$

$$= \frac{P}{Q} S_2$$

if ~~R~~ is the resistance is the cable per meter length the distance of the ~~from~~ fault from the test ...

$\therefore d = \frac{x}{r}$ m

Q) murray loop test is perform on a faulty cable 300 m long. At balance, the resistance connected to the faulty core was set at 15 Ω and the resistance of the resistor connected to the sound core was 45 Ω. Calculate the distance of the fault from the test end

Ans

$P = 45\ \Omega$

$Q = 15\ \Omega$

$r = 300$ m

we know that

$$\text{distance, } d = \frac{Q}{P+Q}(2r)$$

$$= \frac{15}{45+15}(2 \times 300) = 150 \text{ m.}$$

Q) In a test by murray loop for ground fault on 500 m cable. having a resistance of 1.6 Ω/km the faulty cable is loop with a sound cable of the same length and area of cross-section. If the ratio of the other two arms of the testing network at balance is 3:1, find the distance of the fault from the testing end. of the cable.

BM

Given

$r = 500$

$\frac{p}{q} = \frac{3}{p}$

so $\frac{p+1}{q} = 3+1$

$\Rightarrow \frac{p+q}{q} = 4$

so $d = \frac{q}{p+q}(2r)$

$\Rightarrow d = \frac{1}{4} \times 2 \times 500$ $\left[\frac{p+q}{q} = 4, \text{ so } \frac{q}{p+q} = \frac{1}{4}\right.$

$= 250$ m

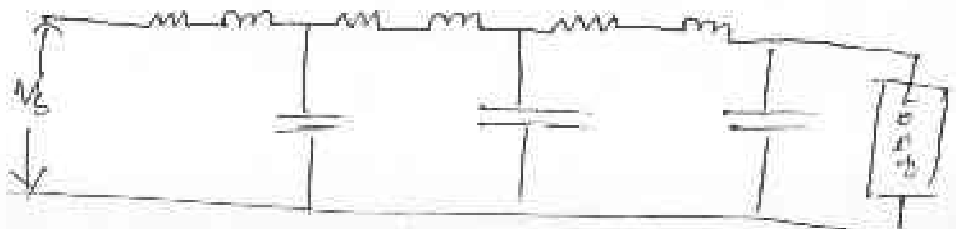
5-3-16.

Chapter-5

Extra high voltage EHV Transmission lines.

Generally the voltages of 300 KV - 765 KV are considered as extra high voltage transmission line.

* Generally E.H.V AC lines are selected for long distances 250 km or above and high power of 500 mega watt & above



Line diagram of E.H.V Transmission line

surge impedance $Z = \sqrt{\frac{L}{C}}\ \Omega$

Surge impedance is the square root of the ratio of the line inductance and the line capacitance.

Reasons for adoption of EHV Transmission line.

for a given amount of power to be transmitted over a given distance, the transmission efficiency increases as the transmission voltage is increases

* In the EHV lines the per unit resistance drop decreases and volume of the conductor material decreases

* The line installation Cost per mw per km decreases with increased in voltage

* The power transmitting capacity of a transmission line at the EHV range increases suddenly as the transmission Capacity in proportional to the square of the transmission voltage.

Surge impedance loading.

If the surge impedance in equal to the load impedance then it is called surge impedance loading.

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

where Z_c = surge impedance.

Problems Involve in E.H.V transmission line:

(i) Coronal ~~loss~~ & radio-interference:

→ The corona loss in EHV transmission line is more and hence grately interference with T.V. and radio signals.

* To reduce the corona loss the spacing betn the conductor are increased. hence the cost of support will be increased.

* The diameter of the conductor increases by using hollow conductor but the manufacturing on hollow conductor is very difficult.

B. Line support.

EHV lines have large mechanical loading in tower

* The transmission tower will febricated steel members are mostly being used

* The cost of steel tower varies from 30% to 30% of the total cost of the line for voltages up to 500 kV

* The ~~terrific~~ wind pressure during storms & cyclones causes heavy daymase to towers, conductor and insulators.

c. Erection difficulty.

The erection of EHV line possess the wide range requiring extremely high standard and mainshive.

Insulation requirement.

The magnitude of voltage surges determines the required line insulation level

* This surges may be due to internal causes (switching operation) or due to external causes (lighting)

e. power station & sub-station equipment.

* The design and manufacturing of power sub-station equipment also under goes so revolutionary changes occurs

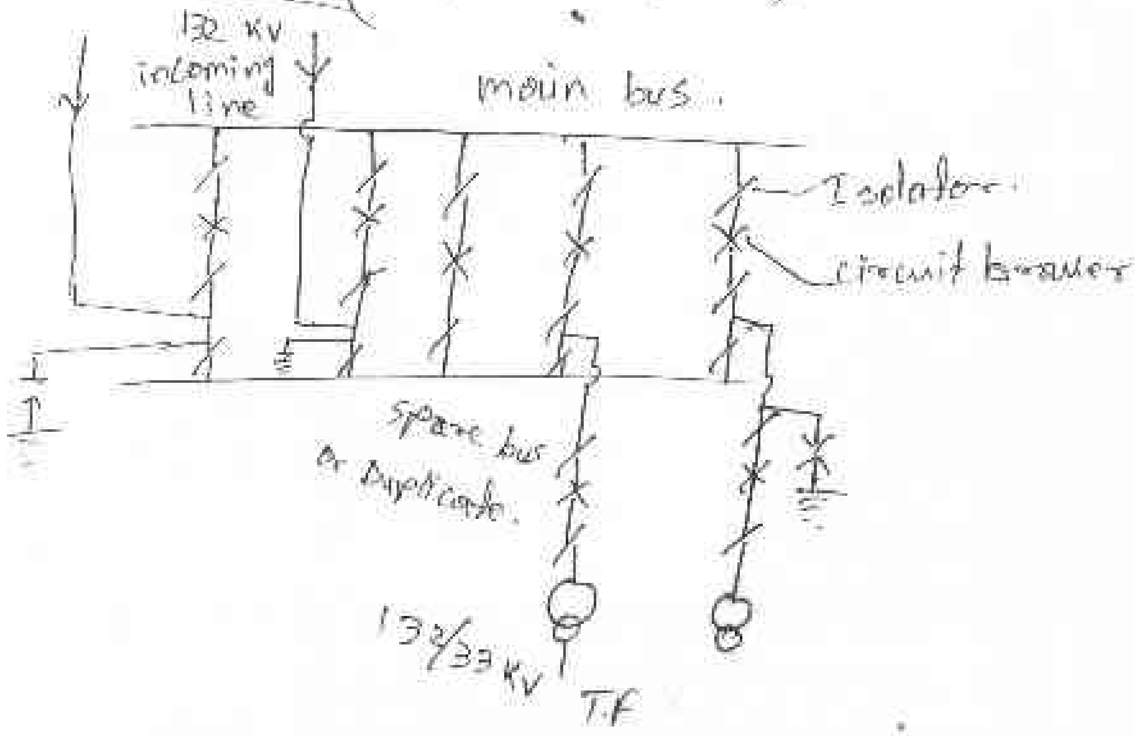
High Voltage DC transmission Line.

The principle of HV DC transmission system consist of one rectifier station at the sending end side and one invater station at the receiving end side.

* The two stations are inter connected by a DC Transmission line.

* The varing the firing angle of the thyristor in the Converter the DC o/p voltage magnitude is controlled.

Lay out of E.H.T sub station. (132/33 or 132/66 KV)



Substation Earthing.

The peeks of the earthing system includes a metalic solid Conductor betn earthed points and the underground earth mate

→ The earth points are held near earth potential by low resistance Conductor Connection with earth mate called the earthing gride.

→ several identical earth electrods at driven vertically in to the soil and welded to the earthing rods of the under ground mesh

→ Earthing ~~Com~~ Connections are galvanised steel strips or electrolytic copper flats or flexible cable

The substation earthing system is provided for the following purposes.

1. savety of operational and maintainance staff
2. Discharge of electrical charges to the grand
3. Electromagnetic interface.

Earthing of Transmission line.

In transmission line as conductor placed on top of the tower having comparatively smaller diameter than other conductors (line conductor) is provide for earthis purpose, this conductor is know as
→ This earthing conductor.

⇒ Purpose of Earthing -

- To ensure that no current carrying conductor raise to a greater potential that it's design insulation

→ To ensure that the potential of non-current carrying metal work doesn't raise to a value such that a person may get shock on touching it

Short type.

1) what is sub-station & types ?

2)

1 kwh = 860 kcal