B.E.

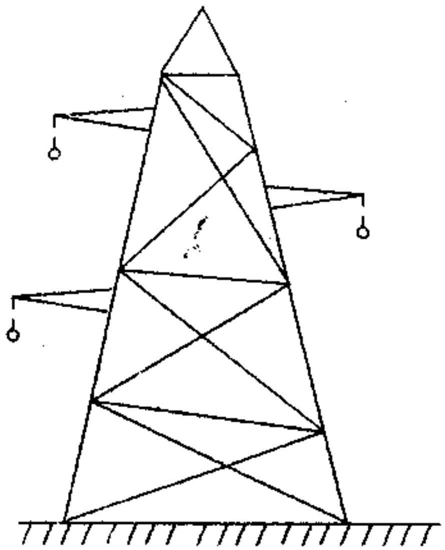
Fifth Semester Examination, 2009-2010

Power Systems-I (EE-315-E)

Note : Attempt any *five* questions.

Q. 1. (a) Give the comparison of outdoor and indoor substations.

Ans. Outdoor & Indoor Substations : For reason of cost & safety it is common to have outdoor sub-stations for 33kV and above. Outdoor sub-stations may be of the low type or the high type. The low type is more usual as it is more convenient to operate and service. In this type the equipment is arranged in one horizontal plane or levels. The setup sub-stations are associated with the generating stations. The generating voltage is limiting to a low value and needs to be stepped due to the transmission voltage so that huge blocks of power can be carried over long distances to the load centres economically. The distribution sub-stations are created where the sub-transmission voltage/primary distribution voltage is stepped down to supply voltage; these sub-stations feed the actual consumers through a network of distributions & service lines. The mining sub-stations, as their name indicates are sub-stations required for very special purposes. They need special design considerations because of the extra precautions for safety needed in the operation of the electric supply. The mobile sub-stations are also of special purpose and designs; they are needed primarily for temporary requirements such as for construction purposes. The cinematography sub-stations are also specific purpose sub-stations and are required to meet special requirements.



Q. 1. (b) Draw the layout of typical 66/11kV substation.

Ans. The economics of generation of electrical energy and the huge demands for power in the modern times require creation of bigger and bigger power houses, may these be hydro-electric, steam or atomic. The power houses may be far away from the load centres as in the case of hydro power houses or they may be in the midst of populated areas as in the case of steam power houses. The transmission network is incitable. Long and high voltage transmission lines are necessary to transmit huge blocks of power from the sources of generation to the load centres, to interconnected power houses for increased reliability of supply, greater system stability and lesser stand by power plant and hence cheaper electric energy. In between the power house and ultimate consumer a number of transformation and switching stations have to be created. These are generally known as sub-stations.

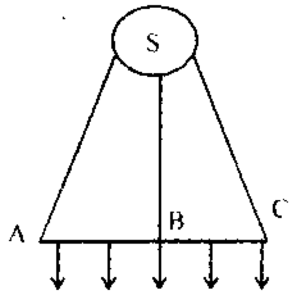
Q. 2. (a) Explain the following systems of distribution :

(i) Radial system

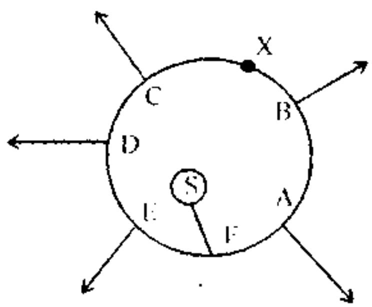
(ii) Ring main system

(iii) Interconnected System

Ans. (i) Radial System : If the distributor is connected to the supply system on one end only the system is a radial system of distribution. It is clear that in such a case the end of the distributor nearest to the generation station would be heavily loaded. With such a system the consumer at the distant end of the distributor would be subject to serious voltage variation as the load on the distributor varies. In addition the consumer is dependent upon a single feeder so that a fault on any feeder or distributor cuts off the supply to the consumers who are on the side of the fault away from the station. This can be remedied to some extent if the distributor is fed at a number of points as shown in fig. In this case three feeders SA, SB and SC from a generating stations are shown feeding a distributor AC at points A, B and C.



(ii) Ring Main System : It employs a feeder which converse the whole area of supply finally retaining to the generation station. The feeder is closed on itself. This arrangement is shown in fig. where the feeder ABCDEFA forms a complete ring. The distributors are connected to A, B, C, D & E. The arrangement is similar to two feeders in parallel on different roots. The advantages of such an arrangement is that it offers a greater reliability of supply. In the event of a fault on any section of the feeder, say at X, the supply to all consumers can continue to be available by isolating the faulty section between B & C.



(iii) Interconnected Systems : The current distribution in such a network may be easily obtained either by applying Kirchhoff's laws or considering the network first without the interconnector. then applying Thevenin's theorem & finding the distribution of current with interconnector. In some cases superposition principle. circulating current method or Milliman's theorem may also be usefully employed.

Q. 2. (b) A 250m, 2-wire distributor feed from one end is loaded uniformly at the rate of 1.6 A/metric. The resistance of each conductor is 0.0002Ω per metre. Find the voltage necessary at feed point to maintain 250V :

(i) at far end

(ii) at the mid point of distribution.

Ans. Let D be the point of minimum potential and let x be the current flowing towards this point from end A. Then current supplied from end B is (40 - x) amp. If r is the resistance of the distributor drop in length

$$AD = (20 + x)r60 + xr40$$

Also drop in length

$$BD = \frac{(1.5) \times r \times 250^2}{2} + (40 - x) r\, 350$$

Since feeding points A & B are at the same potential.

$$(20 + x)60 + 40x = \frac{1.5 \times 250^2}{2} + (40 - x)350 \quad \text{where } x = 132.61\text{ A}$$

In other words D is not the point of minimum potential. The current supplied to the distributed load from end

$$A = 132.61 - 40 = 92.61 \text{ Amp.}$$

So, the point of minimum potential occurs at F where its distance from

$$A = 60 + 40 + 100 + \frac{92.61}{1.50}$$

$$= 261.74 \text{ meters}$$

Potential at point F

$$= 250 - \left[152.61 \times 60 + 132.61 \times 40 + 92.61 \times 100 + 90.61 \times \frac{61.74}{2}\right] \times \frac{0.05 \times 2}{1000}$$

Check potential of point F from end B

$$= 250 - \frac{[(375 - 92.61)(250 - 61.74)]}{2} \times \frac{0.10}{1000}$$

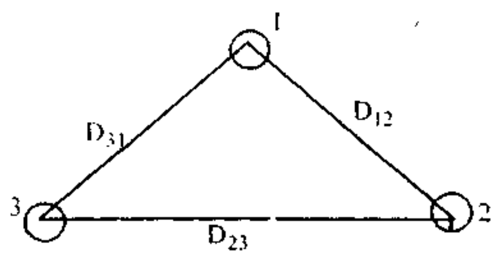
$$= 250 - \frac{282.39}{2} \times 188.26 \times 10^{-4}$$

$$= 250 - 2.65$$

$$= 247.35 \text{ volts.}$$

Q. 3. (a) Derive the expression for inductance of a 3-phase overhead line. With unsymmetrical spacing.

Ans. Expression for Inductance of a 3-Phase Overhead Line with Unsymmetrical Spacing :



For a transposed line as conductor will occupy position 1, 2 and 3 each for one third of its length similarly conductors b & c will occupy all these positions each for one third of their lengths. Let us calculate ψ_{a_1}, ψ_{a_2}, ψ_{a_3}. Where these quantities denote the flux linkages of a conductor a in positions 1, 2, and 3 respectively.

$$\psi_{a_1} = 2\times10^{7}\left[I_a \ln\frac{1}{r'} + I_b \ln\frac{1}{D_{12}} + I_c \ln\frac{1}{D_{31}}\right]$$

$$\psi_{a_2} = 2\times10^{-7}\left[I_a \ln\frac{1}{r'} + I_b \ln\frac{1}{D_{23}} + I_c \ln\frac{1}{D_{12}}\right]$$

$$\psi_{a_3} = 2\times10^{-7}\left[I_a \ln\frac{1}{r'} + I_b \ln\frac{1}{D_{31}} + I_c \ln\frac{1}{D_{23}}\right]$$

Thus, average flux linkages of conductor a.

$$\psi_a = \frac{\psi_{a_1} + \psi_{a_2} + \psi_{a_3}}{3}$$

$$= 2\times10^{-7}\left[I_a \ln\frac{1}{r'} + \frac{1}{3} I_b \ln\frac{1}{D_{12}D_{23}D_{31}} + \frac{1}{3} I_c \ln\frac{1}{D_{12}D_{23}D_{31}}\right]$$

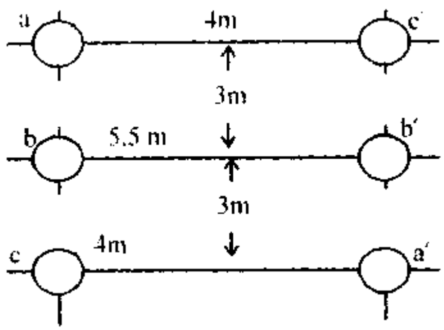
$$= 2\times10^{-7}\left[I_a \ln\frac{1}{r'} + I_b \ln\frac{1}{\sqrt[3]{D_{12}D_{23}D_{31}}} + I_c \ln\frac{1}{\sqrt[3]{D_{12}D_{23}D_{31}}}\right]$$

But since $(I_b + I_c) = -I_a$

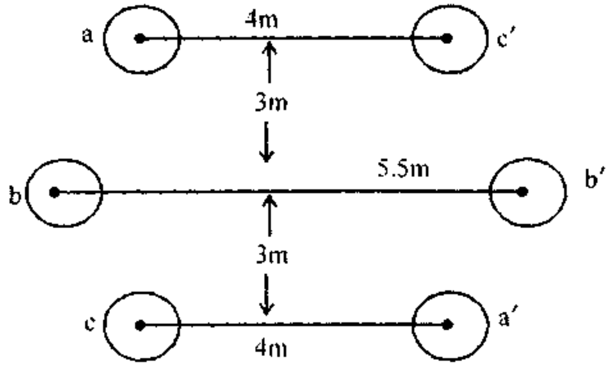
$$\psi_a = 2\times10^{-7}\left[I_a \ln\frac{\sqrt[3]{D_{12}D_{23}D_{31}}}{r'}\right] \text{wb} - \text{T / meter}$$

$$L_a = 2\times10^{-7} \ln\frac{\sqrt[3]{D_{12}D_{23}D_{31}}}{r'} \text{ H / m}$$ **Ans.**

Q. 3. (b) Find the inductance per phase per km of double circuit, 3-phase line. The conductors are transposed and are of radius 0.75 cm each. The phase sequence is ABC.



Ans.



CMR of conductor $r' = 7.5\,mm$

Distance a to b $= \sqrt{3^2 + 0.5^2} = 3.04\,m$

Distance a to b' $= \sqrt{3^2 + 5.5^2} = 6.27\,m$

Distance a to a' $= \sqrt{6^2 + 5^2} = 7.81\,m$

$$D_s = 3\sqrt{D_{S_1} * D_{S_2} * D_{S_3}}$$

Also D_S is the same for all the phases.

$$D_{S_1} = 4\sqrt{D_{aa}\,D_{aa'}\,D_{a'a'}\,D_{a'a}} = \sqrt{4.67 \times 10^{-3} \times 7.81}$$

$$D_{S_2} = 4\sqrt{\left(4.67 \times 10^{-3}\right)^2 \times 6^2} = \sqrt{4.67 \times 10^{-3} \times 6}$$

$$D_{S_3} = 4\sqrt{\left(4.67 \times 10^{-3}\right)^2 \times (7.81)^2} = \sqrt{4.67 \times 10^{-3} \times 7.81}$$

$$D_S = \left(4.67 \times 10^{-3}\right)^{1/2} \times (7.81 \times 6 \times 7.81)^{1/6} = 0.1825\,m$$

Degree or $(D_m) = 3\sqrt{D_{AB} D_{BC} D_{CA}}$ where D_{AB}, D_{BC}, D_{CA} are mutual GMDs.

$$D_{AB} = 4\sqrt{D_{ab} D_{ab'} D_{a'b} D_{a'b'}}$$

$$= 4\sqrt{3.04 \times 6.27 \times 6.27 \times 3.04} = \sqrt{3.04 \times 6.27}$$

$$= 4.36\,m = D_{BC}$$

$$D_{CA} = 4\sqrt{D_{ca} D_{ca'} D_{c'a} D_{c'a'}}$$

$$= 4\sqrt{6^2 \times 5^2} = \sqrt{30} = 5.48\,m$$

Degree $(\text{or } D_m) = 3\sqrt{4.36 \times 4.36 \times 5.48} = 4.7\,m$

Inductance per phase $= 0.2 \ln \frac{D_{eq}}{D_s}$

$$= 0.2 \ln \frac{4.71}{0.1825}$$

$$= 0.65 \text{ mH / km}$$ **Ans.**

Q. 4. (a) Explain the effect of load power factor on regulation and efficiency of a transmission line.

Ans. Regulation : In a short line if the load is thrown off there will be no appreciable. IR and IX voltage drops so that receiving end voltage would be equal to the sending end voltage under these conditions.

Thus, for a short line, % age regulation

$$= \frac{E_S - E_r}{E_r} \times 100\%$$

From fig. we may write $E_s^2 = [E_r \cos\phi_r + IR]^2 + [E_r \sin\phi_r + IX]^2$

$$= E_r^2 \left[\cos^2\phi_r + \frac{2IR}{E_r}\cos\phi_r + \sin^2\phi + \frac{2IX}{E_r}\sin\phi_r + I^2\frac{(R^2 + X^2)}{E_r^2} \right]$$

However considering that $I^2(R^2 + X^2)/E_r^2$ is small in comparison with other terms.

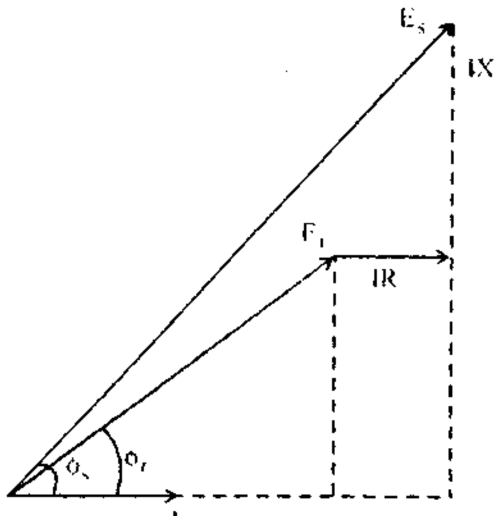


Fig. Phase Diagram of a Short Line

$$E_S \simeq E_r \sqrt{\left[1 + \frac{2IR}{E_r}\cos\phi_r + \frac{2IX}{E_r}\sin\phi_r\right]}$$

$$E_S \simeq E_r\left[1+\frac{IR}{E_r}\cos\phi_r+\frac{IX}{E_r}\sin\phi_r\right]$$

So that % age regulation $\left(\frac{E_s - E_r}{E_r}\right)$

$$\simeq \frac{IR\cos\phi_r + IX\sin\phi_r}{E_r}\times 100\%$$

Normally the load is lagging and % regulation is positive as evident from the above equation. In case the load is of leading power factor, ϕ_r is –ve and thus the expression for regulation becomes,

$$\%\text{ regulation} \simeq \frac{IR\cos\phi_r - IX\sin\phi_r}{E_r}\times 100$$

Voltage regulation is zero when, $IR\cos\phi_r = IX\sin\phi_r$

i.e., $\tan\phi_r = \frac{R}{X}$

$$\phi_r(\text{leading}) = \frac{\pi}{2}-\theta$$

The efficiency of lines is defined as,

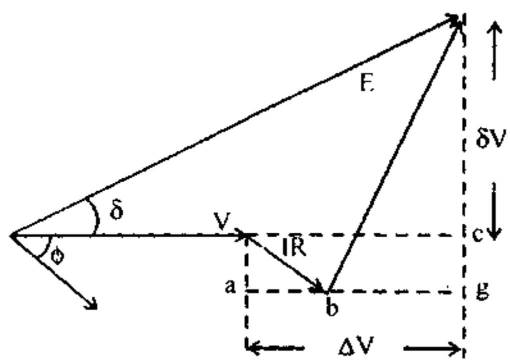
$$\%\text{ efficiency} = \frac{\text{Power delivered at the receiving end}}{\text{Power sent from the sending end}}\times 100$$

$$\%\text{ efficiency} = \frac{\text{Power delivered at the receiving end}}{\text{Power delivered at the receiving end + losses}}\times 100$$

The end of the line where load is connected is called the receiving end and where source of supply is connected is called the sending end.

Q. 4. (b) Using rigorous method, derive the expression f-r sending end voltage and current f-r a long transmission line.

Ans.



In a simple transmission network, the sending end voltage (E), the receiving end voltage (V) and power angle (δ) are inter-related. From the phasor diagram (Fig.) it is evident that,

$$E^2 = (V + \Delta V)^2 + \delta V^2$$

$$= (V + RI\cos\phi + XI\sin\phi)^2 + (XI\cos\phi - RI\sin\phi)^2$$

$$\therefore \quad E^2 = \left(V + \frac{RP}{V} + \frac{XQ}{V}\right)^2 + \left(\frac{XP}{V} - \frac{PQ}{V}\right)^2 \qquad ...(i)$$

$$\left[\because I\cos\phi = \frac{P}{V} \text{ and } I\sin\phi = \frac{Q}{V}\right]$$

Thus,

$$\Delta V = \frac{RP + QX}{V} \qquad ...(ii)$$

&

$$\delta V = \frac{XP - RQ}{V} \qquad ...(iii)$$

Assuming $\delta V << (V + \Delta V)$,

$$E^2 = \left(V + \frac{RP + QX}{V}\right)^2$$

&

$$E - V = \frac{RP + QX}{V} = \Delta V \qquad ...(iv)$$

Hence, the arithmetic difference between the voltages is approximately given by $\left(\frac{RP + XQ}{V}\right)$.

Assuming line resistance R = O,

$$E - V = \frac{XQ}{V}$$

Thus, it reveals that the voltage depends mainly on reactive power (Q). The angle of transmission (power angle δ) is governed by real power (P) and is obtained from

$$\delta = \sin^{-1}\left(\frac{\delta V}{E}\right) \qquad ...(v)$$

Where R is assumed to be O and E is specified, from equation.

$$V = \sqrt{\left[\left(E - \frac{QX}{E}\right)^2 + \left(\frac{PX}{E}\right)^2\right]} \qquad ...(vi)$$

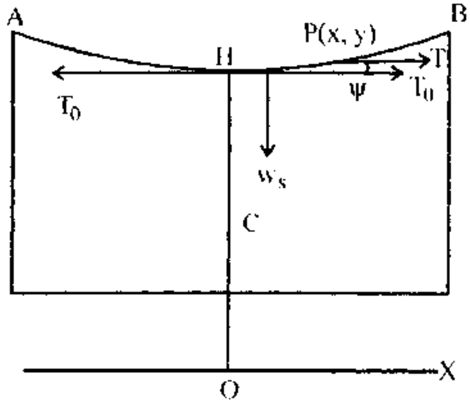
Q. 5. (a) What is sag in overhead lines? Discuss the disadvantages of too small or too large sag on a line.

Ans. Let the conductor be strung between the supports A and B (Fig.) and l is the distance between the support, w the weight per unit length of the wire, T_0 the tension in the wire at the lowest point H of the wire in kg and OX and OY are the axes drawn from the origin O. The location of O is C units below the lowest point H such that $T_0 = wC$ or $C = T_0 / w$. ψ is the angle substended by T with the horizontal axis. Consider the equilibrium of the small length S of the wire upto point P(x, y). Three forces are acting on this length of the wire :

(i) The horizontal tension $T_0 = wC$,

(ii) The vertical weight ws.

(ii) The tension T.



From fig., it is clear that

$$T\cos\psi = T_0 = wC \qquad ...(i)$$

& $$T\sin\psi = w_s \qquad ...(ii)$$

& from equation (i) and (ii)

$$\tan\psi = \frac{dy}{dx} = \frac{w_s}{wC} = \frac{s}{C} \qquad ...(iii)$$

Now for a differential length

Or $$ds = \sqrt{ds^2 + dy^2} \qquad ...(iv)$$

$$\frac{ds}{dx} = \sqrt{1 + \left(\frac{dy}{dx}\right)^2} \qquad ...(v)$$

Substituting for $\frac{dy}{dx}$ from equation (iii) into (v)

$$\frac{ds}{dx} = \sqrt{1 + \frac{s^2}{c^2}} = \frac{\sqrt{c^2 + s^2}}{c}$$

Or $$\frac{cds}{\sqrt{c^2 + s^2}} = dx$$

Let $s = c\sinh\theta$, $ds = c\cosh\theta\, d\theta$ ...(vi)

$$\frac{c.c\cosh\theta d\theta}{c\cosh\theta} = dx$$

Or $c.d\theta = dx$

Or $c.\theta = x + A$

Now for $x = 0, s = 0$. $\therefore$ $\theta = 0$

Substituting for x and θ in the equation above,

$$O = A$$

$$c\theta = x$$

Or $$\theta = \frac{x}{c}$$

From equation (vi) $$\theta = \sinh^{-1}\frac{s}{c}$$

$\therefore$ $$\sinh^{-1}\frac{s}{c} = \frac{x}{c}$$

Or $$\frac{s}{c} = \sinh\frac{x}{c}$$

Or $$s = c\sinh\frac{x}{c} \quad \text{...(vii)}$$

Now from equations (vi) and (vii),

$$\frac{dy}{dx} = \sinh\frac{x}{c}$$

$$dy = \sinh\frac{x}{c}dx$$

$$y = c\cosh\frac{x}{c} + B \quad \text{...(viii)}$$

From fig., $x = 0, y = c$

Substituting this condition in equation (viii) for evaluating B,

$$c = c + B$$

$\therefore$ $$B = 0$$

$$y = c\cosh\frac{x}{c} \quad \text{...(ix)}$$

Equations (vii) and (ix) represent a catenary and they give the relationships between the length of the wire measured from the lowest point H and the vertical height of any point P(x, y) as measured above the origin O respectively in terms of the distance x as measured from O along OX. Expanding the terms $\sinh x/c$ and $\cosh x/c$, the equations (vii) and (ix) becomes,

$$s = c.\frac{x}{c} + \frac{x^3}{3!c^3} + \frac{x^5}{5!c^5} + \ldots\ldots \quad \ldots(x)$$

$$y = c.1 + \frac{x^2}{2!c^2} + \frac{x^4}{4!c^4} + \ldots\ldots.. \quad ..(xi)$$

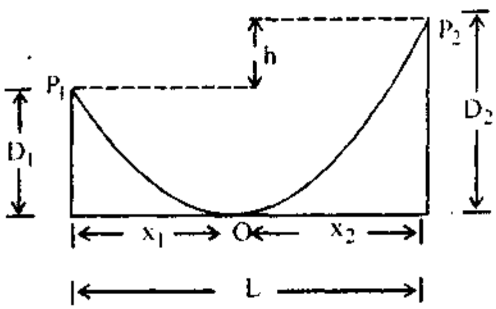
These expressions can be approximated by taking the first two terms in case the span length is not large as compared with c. After approximations the equation (x) and (xi) can be rewritten as,

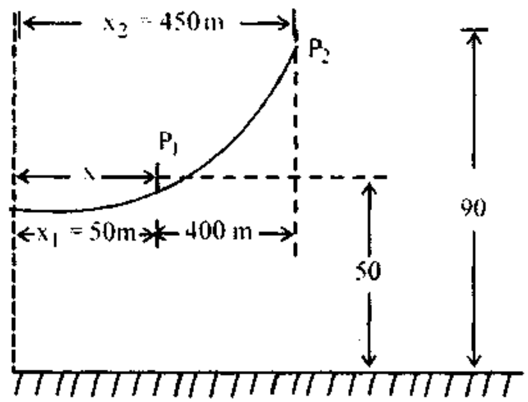
$$s = x + \frac{x^3}{6c^2} \quad \ldots(xii)$$

$$y = c + \frac{x^2}{2c} \quad \ldots(xiii)$$

Q. 5. (b) An overhead transmission line at a river crossing is supported from two towers at heights of 40 m and 90 m above water level, the horizontal distance between the towers is 400 m. If maximum allowable tension is 2000 kg, find the clearance between the conductor and water at a point midway between the towers. Weight of conductor is 1 kg/m.

Ans.





$$x_2 = \frac{l}{2} + \frac{Th}{wl} \quad \text{and} \quad x_1 = \frac{l}{2} - \frac{Th}{wl}$$

Substituting the given values,

$$x_2 = \frac{400}{2} + \frac{2000 \times 50}{1 \times 400} = 200 + 250 = 450\,m$$

$$x_1 = 200 - 250 = -50\,m$$

The negative value of x_1 shows that P_1 is on the same side of O as P_2.

Fig. is drawn, we find that

$$P = 50 + \frac{400}{2} = 50 + 200 = 250\,m \text{ from } O = x$$

The height of P above O is

$$D = \frac{wr_0^2}{2T} = \frac{1 \times (250)^2}{2 \times 2000} = 15.625\,m$$

Height of P_2 above O is $$D_2 = \frac{wx_2^2}{2T}$$

$$= \frac{1 \times (450)^2}{2 \times 2000} = 50.625\,m$$

Which shows that mid point is $50.675 - 15.625 = 35$ m below P_2 and is therefore $90 - 35 = 55\,m$ above water.

Alternatively we could have calculated the height of P_1 above O. Denoting the same by D_1.

$$D_1 = \frac{\omega x_1^2}{2T} = \frac{1 \times (50)^2}{2 \times 2000} = 0.625\,m$$

Thus, the mid point is $15.625 - 0.625 = 15$ m above P_1, the latter being 50m above water. So, that P is $50 + 15 = 65\,m$ above water.

Q. 6. (a) Explain the methods of improving string efficiency.

Ans. Methods of Improving String Efficiency :

(i) Making ratio of capacity to earth/capacity per insulator as small as possible. A long cross-arm help to some extent but the limitations of cost & strength of towers makes $\frac{1}{10}$ as the maximum practical limit.

(ii) Correct Grading of the Various Capacitances : Suppose the mutual capacitance of the lowest unit is increased progressively decreasing this figure as to P unit is approached. This will result in reduction of voltage across the line unit since the voltage for a given current is inversely proportional to the capacitance. To carry out capacitance grading, as the method is known is very inconvenient in practice because it implies all insulators in the string to be different from one another. Alternatively capacity to earth of the bottom units could be increased (by fitting sheets metal caps or rings in intimate contact with porcelain). The method of capacitance grading is only suitable for every high voltage systems say 200 kV and above.

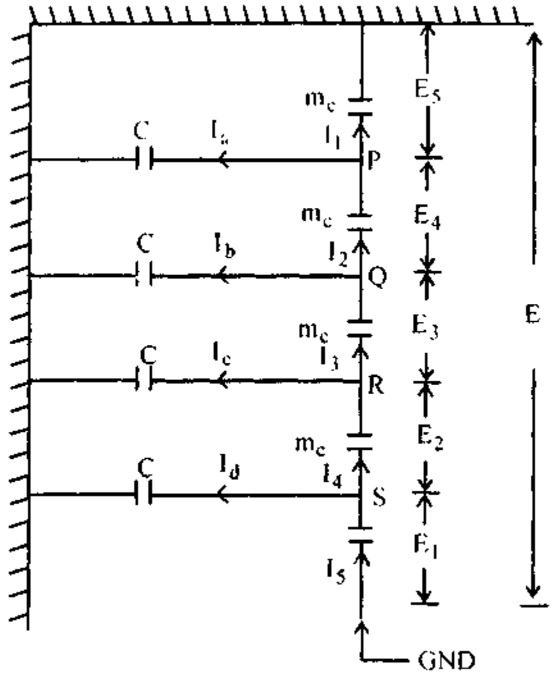
(iii) Static Shielding : This makes the use of guard ring (a large metal ring surrounding the bottom unit and connected to the metal work at the bottom of this unit). This ring screens the lower units (decreasing their earth capacitances) and introduces a number of capacitances between the line and the insulator caps. These capacitances are greater for the lower units and thus voltage across those units is reduced (An equal distribution of voltage is not possibly by this method). The guard ring when used along with an arcing horn fixed at the top end of the string also serves the purpose of an arcing shield and protects the insulator string from damage due to over voltage on the system.

Q. 6. (b) A string of 4 insulators has self-capacitance equal to 4 times the pin to earth capacitance calculate :

(i) The voltage distribution across various units as a percentage of total voltage across the string

(ii) String efficiency.

Ans.



Let capacitance to earth be C and mutual capacitance be m C.

Then $m = 6$

At P, $CE_5 + mCE_5 = mCE_4$

Or $(1+m)E_5 = mE_4$

$$E_4 = E_5\left(1+\frac{1}{m}\right)$$

At Q, $C(E_4 + E_5) + mCE_4 = mCE_3$

$$E_4 + E_5 + mE_4 = mE_3$$

$$\left(1+\frac{1}{m}\right)E_5 + E_5 + (1+m)E_5 = mE_3$$

$$E_3 = E_5\left[\frac{1}{m} + \frac{1}{m^2} + \frac{1}{m} + 1 + \frac{1}{m}\right]$$

$$= E_5\left[1+\frac{3}{m}+\frac{1}{m^2}\right]$$

Similarly it can be found that

$$E_2 = E_5\left[1+\frac{6}{m}+\frac{5}{m^2}+\frac{1}{m^3}\right]$$

$$E_1 = E_5\left[1+\frac{10}{m}+\frac{15}{m^2}+\frac{7}{m^2}+\frac{1}{m^4}\right]$$

Remembering that m = 6 and $E_5 + E_4 + E_3 + E_2 + E_1 = 100\%$

It can be worked out to see that

$$E_5 = 11.15\%$$

$$E_4 = 13.1\%,\ E_3 = 17.1\%,\ E_2 = 23.85\% \text{ and } E_1 = 34.85\%$$

$$\text{String efficiency } = \frac{100}{5\times 3485} = 58\%$$

Q. 7. (a) Write a brief note on oil filled cables.

Ans. Oil Filled Cables : Single phase oil filled cables are common in high voltage systems through 3 core oil filled cables also exist. A single phase oil filled cable consists of a concentric stranded. Conductor built around an open helical core that serves as channel for the oil flow. The cable is kept constantly supplied with low viscosity minerals oil. The cable is insulated & sheathed in the same manner as the solid type cables. The ducts within the core are connected to oil reservoirs and hence expansion or contraction of the oil in the cables do not produce any void.

The three core oil filled cables may be of conventional circular design or may be flat type. The flat side are reinforced with metallic tapes and binding wires. Pumps are used to maintain specified oil pressure and it should not fall below $22 KN/m^2$. Oil filled cables can sustain voltage stress upto 130 kV/cm.

Q. 7. (b) A 66kV single core lead sheathed cable is graded by using two dielectrics of relative permittivity 5 and 3 respectively thickness of each being 1 cm. The core diameter is 2 cm. Determine the maximum stress in the two dielectrics.

Ans. Maximum stress,

$$E_{max} = \frac{V}{r\ln\left(\frac{R}{r}\right)}$$

$$= \frac{\left(\frac{66}{\sqrt{3}}\right)}{\left[1.25\ln\left(\frac{1.75}{1.25}\right)\right]}$$

$$= \frac{38.10}{1.25 \ln[1.4]}$$

$$= \frac{30.48}{\ln(1.4)}$$

$$= 90.58 \, kV / cm(rms)$$ **Ans.**

Q. 8. (a) Explain the advantages and limitations of H.V.D.C. transmission system.

Ans. Advantages and Limitations of H.V. D.C. Transmission System : The limitations of use of high voltage AC transmission of bulk power over long distance invite the attention of transmission of high voltage DC for long length on line.

Advantages :

(i) These systems are eonomical for transmitting bulk power over long distances say above 550 km.

(ii) A DC transmission lines does not have any stability problem in itself and hence a synchronous operations of transmission link along with the connected machines is possible.

(iii) There is no charging current in DC transmission systems and hence line length limitation does not arise moreover cables in dc system thus do not suffer from high dielectric loss also in DC system the skin effect is low & hence the current density in the dc transmission line can be higher.

(iv) There is greater power transmission per conductor and the dc line is cheaper as it requires two conductors instead of three and hence cost on insulator and towers are less.

(v) Each conductor in DC line can be operated as an independent circuit.

(vi) Requirement of right of way is less than corresponding AC line.

(vii) The voltage regulation problems are less serious in DC system as in DC line at steady state reactance drop does not exist.

(viii) In HVDC systems the corona loss is much lower as compared to AC system also radio interference of HVDC lines is lesser.

(ix) The line construction is simpler & ground return is possible by using single conductor in HVDC transmission.

(x) Line loss is lesser in DC transmission.

(xi) The interconnection of AC grids through AC lines increase the fault level where as interconnection of AC grids with DC links does not increases fault level to that extent.

Q. 8. (b) Explain various factors which affect corona loss.

Ans. Factors Affecting Corona Losses :

(i) Effect of Frequency : Corona loss is directly proportional to system frequency.

(ii) Effect of System Voltage : As the electric field increases with greater potential differences. Hence corona loss increases with higher system voltage in steep way.

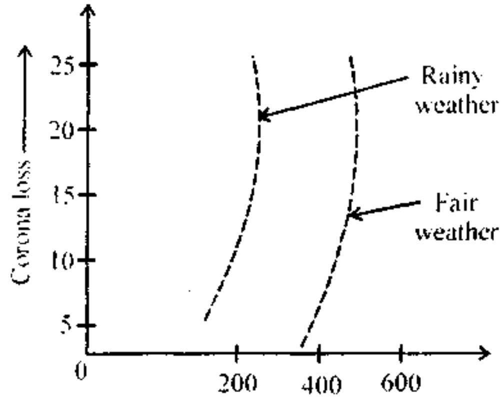
(iii) Effect of Conductivity of Air : The conductivity of air increases if number of ions in air increases during rain and thunder storm ion content in the air enhances & thus corona loss becomes high during bad weather conditions.

(iv) Effect of Conductor Diameter : The electric field intensity reduces if the conductor radius increases hence with greater conductor diameter efi reduces resulting in lower corona loss.

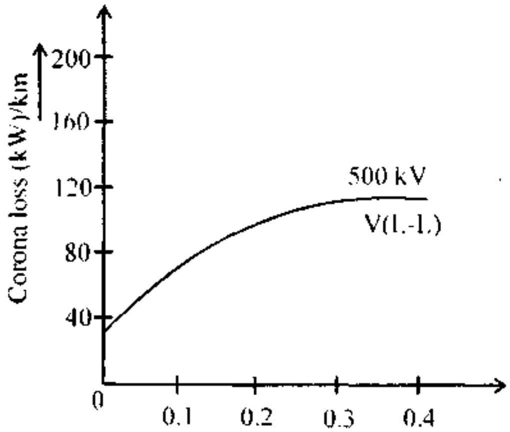
(v) Effect of Load Current : Flow of load current increases the temperature of the conductor thus, it prevents deposition of dew or snow on conductors surface. This reduces corona loss.

(vi) Effect of Conductors Surface : Roughness of the conductors surface results in field distortion & gives rise to high potential gradient causing high corona loss stranding of conductors increases corona loss.

(vii) Effect of Atmospheric Condition : Rain drop & dust deposition increase the corona lose particularly local corona discharges, if the density of air decreases corona loss increases.



Line Voltage



RateRain Cent/hr