B.E.

Fifth Semester Examination, May-2008

Power Systems-I (EE-315-E)

Note : Attempt any five questions. All questions carry equal marks.

Q. 1. (a) What are functions of a substation ? What are the different types of substation ? Write short notes on them. 10

Ans. Functions of Substation : The main functions of substation are :

(i) To receive energy transmitted at high voltage from the generating stations.

(ii) To reduce the voltage to a value appropriate for local distribution.

(iii) To provide facilities for switching

Additional functions :

(iv) They provide points where safety devices may be installed to disconnect equipment or circuit in the event of fault.

(v) Some substations are simply switching stations where different connections between various transmission lines are made, others are connecting susbstation which cannot either A.C. to D.C. or vica-versa.

Classification of Substations :

(a) According to Service :

(i) Transformer substations
  - (i) Transmission and primary substations
  - (ii) Sub-transmission and secondary sub-stations
  - (iii) Distribution substations

(ii) Industrial substations

(iii) Switching substations

(iv) Power factor correction or synchronous substations

(v) Frequency charger substations

(vi) Connecting substations

(b) According to Design :

(i) Indoor type substation

(ii) Outdoor substations :
  - (i) Pole mounted substations
  - (ii) Foundation mounted substations

Indoor Substation : According to construction indoor distribution transformer substations and high voltage switch boards are futher subdivided as follows :

(i) Substation of integrally built type.

(ii) Substation of the composite built up type.

(iii) Unit type factory fabricated substation and metal clay switch boards.

Q. 1. (b) What are the factors considered for the selection of site of an outdoor 11/0.4 KV substation. Describe advantages and disadvantages of an outdoor substation over an indoor type. 10

Ans. While selecting the sites for substation the following factors should be given due considerations :

(i) Nearness to load centres of distribution areas.

(ii) Availability of land.

(iii) Cost of land.

(iv) Local zoning laws.

(v) Future load growth.

Advantages and Disadvantages of Outdoor Substation over an Indoor Substation :

Advantages :

(i) Fault location is easier since all the equipment is within view.

(ii) The time required to erect such substation is less.

(iii) The extension of the installation is easier.

(iv) The smaller amount of building material is required.

(v) Switch gear installation cost is low.

(vi) There is practically no danger of a fault which appears at one point being carried over to another point in the installation because the apparatus of the adjoining connections can be spaced liberally, without any appreciable increase in costs.

Disadvantages :

(i) More space required.

(ii) The various switching operations with the insulators, as well as supervision and maintenance of the apparatus are to be performed in the open air during all kinds of weather.

(iii) The influence of rapid fluctuator is ambient temperature and dust and dirt deposits upon the outdoor substation equipment makes it necessary to install apparatus specially designed for outdoor service and, therefore, more costly.

Q. 2. (a) Explain the difference between radial distribution system and ring main distribution system. **6**

Ans. Radial Distribution System : Distribution networks are of two types, radial or interconnected. Radial network leaves the station and passes through the network area with no normal connection to any other supply. This is typical of long rural lines with isolated load areas. The radial distribution system is cheapest to build and is widely used in sparsely populated areas The radial system has only one power source for a group of customers. A power failure, short circuit or a down powerline would interrupt power in the entire line which must be fixed before power can be restored. The figure shows the radial distribution system.

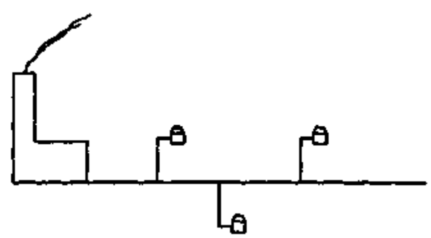


Fig. Radial distribution system

Ring Distribution : (i) A ring distributior is a distributor which is arranged to form a closed circuit and which is fed at one or more than one points.

(ii) For the purpose of calculating voltage distribution, it can be looked upon as consisting of a series of open distributors fed at both ends.

(iii) If the ring ditsributor is fed on one point then, for the purpose of calculation, it is equivalent to a straight distributor fed at both ends with equal voltages.

(iv) By using a ring distributor fed properly, great economy in copper can be affected.

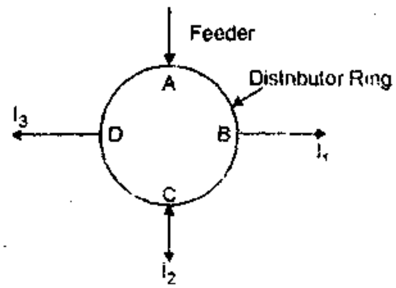
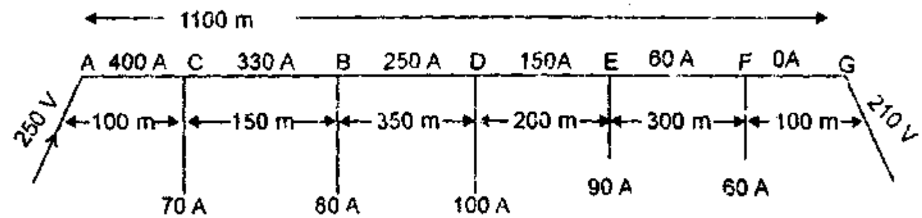


Fig. Ring Distributors/mains

Q. 2. (b) A 2 wire distribution AG, 1,200 metres long is fed at A at 250V. Loads of 80, 70, 100, 90 and 60A are tapped from points B, C, D, E and F whose distances from A are 250, 100, 600, 800 and 1100



metres respectively. If the voltage at G is 210 V, find the resistance per metre of the distributor. **10**

Ans.

Current in section $I_{AC} = 70 + 80 + 100 + 90 + 60 = 400$ A

Current in section $I_{CB} = 80 + 100 + 90 + 60 = 330$ A

Current in section $I_{BD} = 100 + 90 + 60 = 250$ A

Current in section $I_{DE} = 90 + 60 = 150$ A

Current in section $I_{EF} = 60 = 60$ A

The resistance per metres of the distributor

For $AC = R_{AC} \times r$

$CB = R_{CB} \times r$

$BD = R_{BD} \times r$

$DE = R_{DE} \times r$

$EF = R_{EF} \times r$

$FG = R_{FG} \times r$

Hence $V_B = V_A -$ (Voltage drops in the various sections)

& $V_A - V_B = (I_{AC} \times R_{AC} \times r) + (I_{CB} \times R_{CB} \times r) + (I_{BD} \times R_{BD} \times r)$

$$+ (I_{DE} \times R_{DE} \times r) + (I_{EF} \times R_{EF} \times r) + (I_{GF} \times R_{GF} \times r)$$

$$250 - 210 = 400 \times 100r + 330 \times 150r + 250 \times 350r + 150 \times 200r + 60 \times 300r + 0$$

$$40 = 225000r$$

Hence
$$r = \frac{40}{225000} = 0.000177$$
$$= 0.17 \times 10^{-3}\ \Omega/m$$

Q. 2. (c) What is the difference between a feeder and a distributor ? **4**

Ans. Feeder : It is a conductor which connects the substation to the area where power is to be distributed :

(i) Current through it remains same.

(ii) Current carrying capacity is the main consideration in the design.

Distributor : Distributor is a conductor from which tapings are taken for supply to the consumers.

(i) Current is not constant.

(ii) Voltage drop along its length is main consideration.

Q. 3. (a) Derive an expression for inductance of a transmission line per km per conductor. **8**

Ans. The inductance of a circuit is defined as the flux linkages per unit current, it is expressed in henry. (H).

i.e.,
$$L = \frac{\Psi}{I}\ H \qquad \text{...... (1)}$$

Where, L = inductance of circuit
Ψ = flux linkages
I = current (amperes)

$$\Psi = LI\ \text{Wb-T} \qquad \text{...... (2)}$$

If current is alternating, the above equation can be written as,

$$\lambda = LI \qquad \text{...... (3)}$$

λ & I are the rms values of flux linkages and current respectively, these are in phase.

Mutual inductance between 2 circuits is flux linkages of one circuit per unit current in other circuit.

$$M_{12} = \frac{\lambda_{12}}{I_2}\ H \qquad \text{...... (4)}$$

Where, I_2 = current
λ_{12} = flux linkage with circuit 1
M_{12} = mutual inductance

(i) Two parallel conductors of a transmission line form a rectangular loop of one turn. The changing flux in the line links the loop and hence the line has inductance.

(ii) Inductance is uniformaly distributed along the length of the line, for convenience it is taken to be lumped.

Q. 3. (b) Write short notes on : **12**

(i) Bundled conductor
(ii) Skin effect in a T. L.
(iii) Transposition of conductors.

Ans. (i) Bundled Conductor : These are the conductors made of thin wires of small cross-section and bundled together. They are flexible, not rigid, coiled easily.

(i) It is made by twisting the wires, called strands, together to form layers.

(ii) Wires of each layer are laid in helical fashion round the preceding layer called stranding.

(iii) Stranding is done in opposite directions for successive layers.

(iv) Standard strand ing consists of 6 wires around one wire, then 12 wires around the previous 6, then 18 wires around 12, then 24 wires around 18 and so on. No. of layers depends on no. of wires. Center wire is not counted as a layer. Instead of single, 3 or 4 standard wires may also be put in the centre over them layers may be formed.

(v) No. of wire in n^{m} layer from centre = 6n

(vi) Total no. of wires in standard conductor having 'n' layer $= 1 + 3n(1 + n)$

(vii) Diameter over n^{m} layer in cm $= (1 + 2n)d$

(ii) Skin Effect : Direct currents distribute themselves uniformly over the cross-section of the conductor and therefore use the centre of conductor just as effectively as they use periphery. Alternating currents, owing to inductance effects within the conductors, crowd toward the outside of the conductor. This behaviour is skin effect. It raises the apparent resistance of the conductor, because power loss varies as the current and higher density of current flowing near the skin of the conductor produces more power loss than the lower density of current flowing through the centre of the conductor.

(i) Resistivity remains unchanged.

(ii) Total resistance increases with frequency and diameter.

(iii) Reduces the amount of current carried by the centre portion of the conductor, hollow conductors are employed to use them more efficiently.

(iv) Aluminium cable steel inforced [ACSR] is used more.

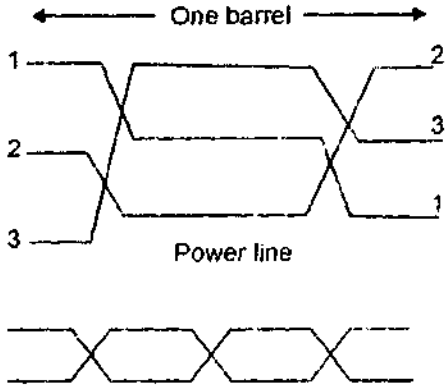
(v) ACSR offers large surface area available for cooling.

(vi) Skin effect is negligible when supply frequency is low (< 50Hz) and conductor diameter is small (< 1 cm).

(iii) Transposition of Conductors : To reduce the induced voltages due to electromagnetic and electrostatic induction the conductors of both the power line and communication line are regularly transposed. Transition balances the capacitance of line i.e., electrostatically induced voltages balance out in the length of a complete set of transposition called barrel. Due to cancellation of fluxes electro magnetically induced emfs get diminished. This does not apply to zero sequence currents. The induced voltages can be kept down to a low value by proper co-ordination of power and communication lines. Each power line conductor occupies all the three possible positions for $\frac{1}{3}$ rd length in one barrel.

Power line & communication line transposed.

Transposition does not offer a complete solution because a large emf is induced. Due to perfect transposition, no voltage between the two wires of the circuit may exist. This requires that communication line insulation must be so arranged that it can withstand such a voltage. In case of electrostatic charging it may become necessary to isolate telephone apparatus from the telephone line completely by means of highly insulated transformers.



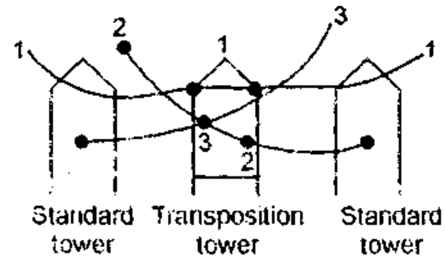


Fig.Transposition

Fig. Power line & Communication line transposed.

Q. 4. (a) A 3 ph, 50 Hz, 300 km long transmission line has the following parameters $r = 0.15\Omega/km$, $X = 0.5\Omega/km$, $y = 3 \times 10^{-6}$ ℧/km. If the line is nominal π determine.

(i) ABCD constants of the line (derive the formula used)

(ii) Power at unity power factor if voltage at each end is maintained at 220KV.

(iii) The sending end voltage required if a load of 200MW at 0.85 lagging p.f. is to be delivered with V_R at 220KV. **20**

Ans. Given $r = 0.15\ \Omega/km$

$X = 0.5\ \Omega/km$

$Y = 3 \times 10^{-6}\ \Omega/km$

3ϕ, 50 Hz

$L = 300$ km

Series impedance $Z = 0.15 + j0.5 = 0.52 \angle 73°$

$Y = j3 \times 10^{-6} = 3 \times 10^{-6}$ ℧ /km

(i) A, B, C, D constants for nominal π line method

$$A = D = \left[1 + \frac{1}{2} YZ\right] = 1 + \frac{1}{2}(3 \times 10^{-6} \angle 90° \times 0.52 \angle 73°)$$

$$= 1 + \frac{1}{2}(3 \times 10^{-6} e^{j90°} \times 0.52 e^{j73°})$$

$$= 1 + \frac{1}{2}(1.56 \times 10^{-6} e^{j163°})$$

$$= 1 + 0.78 \times 10^{-6} e^{j163°}$$

$$= 1.78 \times 10^{-6} e^{j163°}$$

$$B = Z\ \Omega$$

$$= 0.52 \angle 73° = 0.52 e^{j73°}$$

$$C = Y\left\{1 + \frac{1}{4} YZ\right\} ℧ = 3 \times 10^{-6} \angle 90° \left[1 + \frac{1}{4}(3 \times 10^{-6} \angle 90°)(0.52 \angle 73°)\right]$$

$$= \left[1.38\, e^{j163^\circ}\right]$$

(ii) V_R = receiving end phase voltage $= \frac{220}{\sqrt{3}} = 127$ KV

V_S = sending end phase voltage $= \frac{220}{\sqrt{3}} = 127$ KV

Power P = V1 cos ϕ $\quad \cos\phi_R = 1$

Hence $\quad P = V_R I_R = \frac{V_R^2}{Z}$

$$P = \frac{127 \times 1000}{0.15 + j0.5} = \frac{127000}{0.5Z \angle 73^\circ}$$

$$= (127000\, e^{i0})\,(0.52\, e^{-i73})$$

$$= 66040\, e^{-i73}$$

$$= 66 \times 10^{-3}\, e^{-i73}$$

(iii) Power at receiving end $= 200$MW

Receiving end phasor voltage $\quad V_R = \frac{220KV}{\sqrt{3}} = 127$ KV

Power factor $\quad \cos\phi_R = 0.85$

Receiving end current $\quad I_R = \frac{200 \times 10^3}{\sqrt{3} \times 220 \times 0.85} = \frac{200 \times 10^3}{317.9} = 0.62 \times 10^3$

$$= 629 \text{ A}$$

Sending end voltage $\quad V_s = A\bar{V}_R + B\bar{I}_R$

Where, $\bar{V}R = 127(1 + j0)$

$= 127 < 0^\circ$ KV, $I_R = 629 <$, $\bar{I}R = .00158, = 1.5 \times 10^{-2}$

$$= \left[1.78 \times 10^{-6}\, e^{i163} \times 127\, e^{i0}\right] + \left[1.38\, e^{i163} \times 1.5 \times 10^{-3}\, e^{i0}\right]$$

$$= \left[2.26 \times 10^{-4}\, e^{i163}\right] + \left[2.07 \times 10^{-3}\, e^{i163}\right]$$

$$= (2.26 \times 10^{-4}\, e^{i163} + 20.7 \times 10^{-4}\, e^{i163})$$

$$= 22.96 \times 10^{-4}\, e^{i163}$$

Q. 5. (a) Obtain an expression for sag of a T. L. supported by towers of different heights at the ends. Explain how the effect of wind and ice can be included in sag calculations of transmission line ?

Ans. SAG at Unequal Height : Consider an overhead line AOB supported over the supports A and B, at unequal levels. 'O' is the lowest point.

Let, l = span length

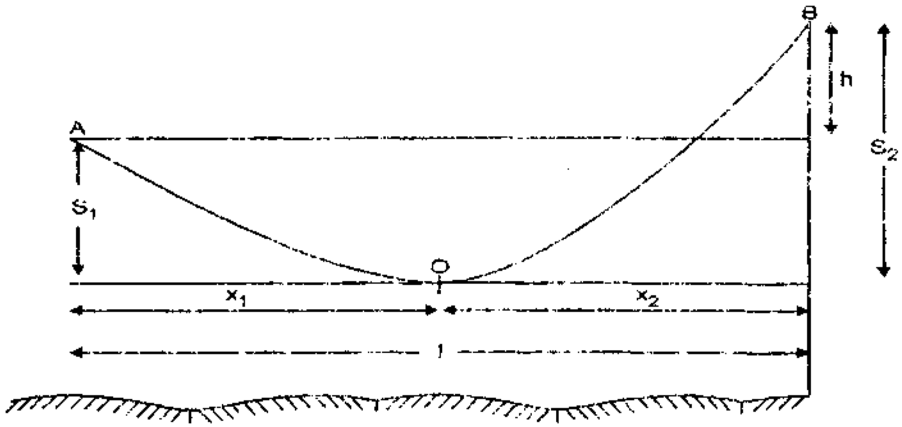
h = difference in levels between two supports

x_1 = distance of support A from O

x_2 = distance of support A from O

w = weight/length of conductor

T = tension in conductor.



$$x_1 + x_2 = l \qquad \text{......... (1)}$$

$$s_2 - s_1 = \frac{wx_2^2}{2T} - \frac{wx_1^2}{2T} = \frac{w}{2T}(x_2^2 - x_1^2)$$

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

From equation (1) $\quad s_2 - s_1 = \frac{wl}{2T}(x_2 - x_1)$

But $\quad s_2 - s_1 = h$

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

$$(x_2 - x_1) = \frac{2Th}{wl} \qquad \text{........ (2)}$$

Add equations (1) & (2)

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

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

$$x_1 = l - \left[\frac{l}{2} + \frac{Th}{wl}\right]$$

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

Effect of Wind & Ice on Sag : Conductor may be coated with ice and subjected to wind load simultaneously. Under such condition weight of conductor, together with weight of ice acts vertically downwards while winds act in horizontal direction.

Resultant weight/mt

$$w_r = \sqrt{(w_c + w_i)^2 + (w_w)^2} \quad \text{......... (1)}$$

$$w_c = \text{wt/length}$$

$$= \text{density} \times \text{vol/length}$$

$$w_i = \text{weight of ice/length}$$

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

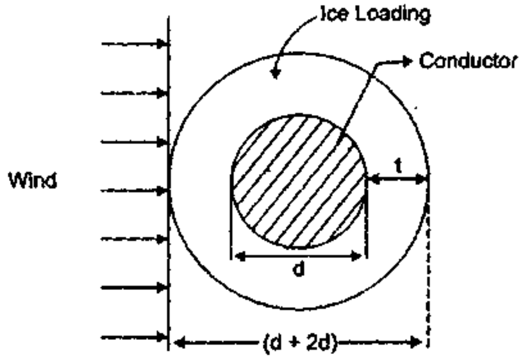
$$w_w = \text{wind force/length}$$

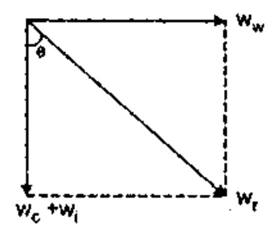
$$= \text{wind pressure/area} \times \text{projected area/length}$$

$$= P \times \left[(d + 2t) \times 1\right] \quad \text{and}$$

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

$$\text{Slont sag 'S'} = \frac{wrl^2}{8T}; \text{ vertical sag} = s\cos\theta$$





Q. 5. (b) Write a short note on vibration dampers. **5**

Ans. Vibrations may be of 3 types :

(i) Simple

(ii) Aeoline

(iii) Galloping

(i) Simple : Simple swing of conductor in the horizontal plane due to simple wind deflection is harmless.

(ii) Aeoline : Low amplitude and high frequency.

Dampers : Vibration problem has been solved by it.

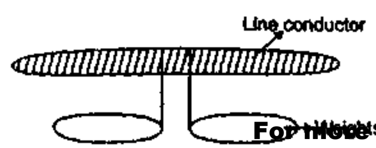


Figure shows stock bridge damper an extremely simple, but effective device for supressing high frequency vibration. It consists of two weights attached to a piece of stranded cable 30cm to 50cm long which is clamped to line conductor. Energy of vibration is absorbed by standed cable & is damped out rapidly.

(iii) Galloping : Low frequency (1/4 to 1.5 C/S) and high amplitude (6 mt).

These are dampened by making the conductor circular. For stranded conductor PVC tape is wrapped to make the conductor circular. This method is useful when there is no sleet formation on the conductor.

Q. 6. (a) Name and explain the different types of insulators used in transmission & distribution system.

Ans. (i) Rubber :

(i) Relative permittivity is between 2 & 3.

(ii) Dielectric strength is 30KV/mm.

(iii) Temperature is 60° − 70°C.

(iv) Absorbs moisture readily.

(ii) Vulcansied India Rubber (VIR) :

(i) Greater mechanical strength

(ii) Dielectric strength is 15 KV/mm

(iii) Low melting point

(iv) Sulphur reacts easily.

(iii) Impregnated Paper :

(i) Low cost

(ii) Low capacitance

(iii) High dielectric strengh

(iv) Higher insulation resistance.

(iv) Varnished Cambric :

(i) Dielectric strength 4KV/mm

(ii) Permittivity = 2.5 to 3.8

(iii) Do not require scaling.

(v) Polyvinyl Chlorine :

(i) Dielectric strength 17KV/mm

(ii) Dielectric constant of 5

(iii) Temperature rating is 75°C.

(vi) Gutta Percha :

(i) Non-hygroscopic

(ii) Cannot withstand even medium voltages.

Q. 6. (b) Define string η. Calculate its value for a string of 3 insulator units if the capacitance of each unit to earth and line be 20% and 5% of the self capacitance of the unit. Derive the formula used.

Ans. String Efficiency : String efficiency is a measure of the utilization of material in the string and is defined as

$$\text{String efficiency} = \frac{\text{Voltage Across String}}{\eta \times \text{Voltage across the unit adjacent to line}}$$

Where, n = no. of insulators in a string.

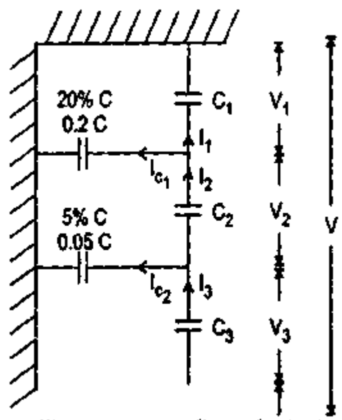
String efficiency is also defined as

$$\text{String } \eta = \frac{\text{SOV for the string}}{n \times \text{SOV of one disc}}$$

Given

Let, $$m = \frac{\text{Capacitance per insulator}}{\text{Capacitance to ground}} = \frac{m_C}{C}$$

Where, $C_1 = C_2 = C_3 = m_C$



Let V be the operating voltage (line to ground) and V_1, V_2 and V_3 the voltage drop across the units.

$$V = V_1 + V_2 + V_3$$

From frequency we can write

$$I_2 = I_1 + I_{C_1}$$

Wheres, $20\% \, C = \frac{C}{5} = 0.2\,C$, $5\% \, C = \frac{C}{20} = 0.05\,C$

$$\omega_m CV_2 = \omega_m CV_1 + \omega_C V_1 \qquad (\omega = \text{Supply angular frequency})$$

& $$V_2 = V_1 \left[\frac{1+m}{m}\right] = V_1 \left[1 + \frac{1}{m}\right]$$

& $$I_3 = I_2 + I_{C_2}$$

$$\omega_m CV_3 = \omega_m CV_2 + \omega_C (V_1 + V_2)$$

Hence $$V_3 = V_1 \left[\frac{m^2 + 3m + 1}{m^2}\right] = V_1 \left[1 + \frac{3}{m} + \frac{1}{m^2}\right]$$

Now m = 3.

Hence $$V_2 = V_1 \left[1 + \frac{1}{3}\right] = \frac{4}{3} V_1 = 1.33\, V_1$$

$$V_3 = V_1\left[1 + \frac{3'}{3} + \frac{1}{9}\right] = \frac{18+1}{9}V_1 = \frac{19}{9}V_1$$

$$V_3 = 2.11\ V_1$$

Hence $$V = V_1 + V_2 + V_3 = V_1 + 1.33V_1 + 2.11\ V_1$$

$$V = 4.44\ V_1$$

$$\text{String efficiency} = \frac{V}{n \times V_3} = \frac{4.44\ V_1}{3 \times 2.11\ V_1}$$

$$= \frac{4.44}{6.33} = 0.7014$$

& $$\eta = 70.14\%$$

Q. 7. (a) What are types of HV and LV cables ? Explain. 10

Ans. LV Cables :

(i) For voltage below 1KV

(ii) Insulation may consist of paper impregnated with oil.

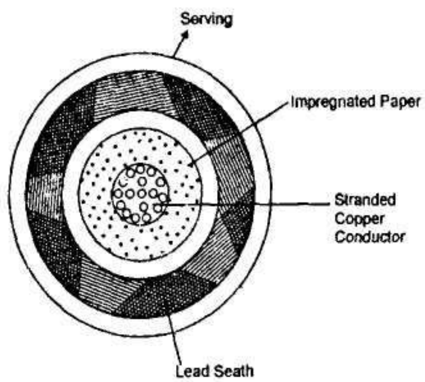
(iii) Resin used to prevent drainage.

(iv) Varnished cambric used for insulation.

(v) Petrolium jelly is provided between layers that allows cable to bend.

(vi) Bitumen treated with sulphur and vegetable oil is used as insulators.

(vii) Lead covered cables are used in house wiring, service mains etc.



→ Consist of circular core of tinned stranded copper insulated by layer of impregnated paper

→ Lead sheath prevents entry of moisture

→ Serving protect sheath from corrosion.

Advantages :

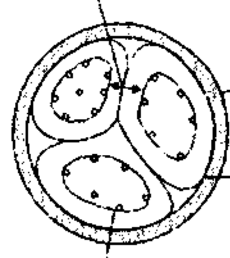
(i) Simple in construction.

(ii) Availability of large copper section.

HV Cables :

(i) Multi core cables and of belt type.

(ii) Belt type cable consist of either circular shaped or oval shaped cores of stranded copper or aluminium conductors wrapped by impregrated paper. Another layer of paper tape called paper belt is wound round the grouped insulated cores. The gap is filled with fibrous insulating material. The cores are stranded. The belt is covered with lead sheath to protect cable against entry of moisture and mechanical injury.



Q. 7. (b) A 66KV, single core metal sheathed cable is to be graded by metallic intersheath. Calculate diameter of intersheath and voltage to obtain minimum overall cable diameter. Maximum voltage gradient is 60KV/cm. **10**

Ans.

r = radius

r_1 = inside radius of intersheath

R = outside radius of intersheath

V_1 = Voltage at which intersheath is maintains

V = Voltage at which conductor is maintains

g_{max} = maximum strength at r

$$r_1 = 2.718\, r \quad \text{......... (1)}$$

$$g_{max} = \frac{V - V_1}{r \ln (r_1/r)} \quad \text{......... (2)}$$

$$g_{max} = \frac{V_1}{r \ln (R/r_1)} \quad \text{(at intersheath surface)} \quad \text{......... (3)}$$

From equations (1) & (2)

$$g_{max} = \frac{V - V_1}{r \ln (r_1/r)} = \frac{2.718\,(V - V_1)}{r_1 \ln (r_1/r)}$$

$$r_1 = \frac{2.718\,(V - V_1)}{g_{max}} \quad \text{......... (4)}$$

Put the value of r_1 in equation (3), we have

$$g_{max} = \frac{V_1}{r_1 \ln (R/r_1)}$$

Solving

$$R g_{max} = 2.718\,(V - V_1)\, e^{[V_1/2.718\,(V - V_1)]} \quad \text{......... (5)}$$

g_{max} & V are constant

For max R, $\frac{\partial R}{\partial V_1} = 0$

$$\frac{\partial R}{\partial r} = \frac{2.718}{g_{max}} \frac{\partial}{\partial r} \left[(V - V_1)\, e^{[V_1/2.718\,(V - V_1)]} \right] = 0$$

Solving, we get $\frac{V}{2.718\,(V - V_1)} = 1$

$$V = 2.718\,(V - V_1)$$

$$V = 2.718V - 2.718\,V_1$$

$$V_1 = \frac{1.718}{2.718} = 0.632\text{ V} \qquad \text{........ (6)}$$

From equation (2) $g_{max} = \frac{V - V_1}{r \ln (r_1/r)} = \frac{V - V_1}{r \ln (2.718)}$

$$= \frac{V - V_1}{r}$$

$$r = \frac{V - V_1}{g_{max}} = \frac{V - 0.632\text{ V}}{g_{max}} = \frac{0.368}{g_{max}}$$

From equation (4) $r_1 = \frac{2.718\,(V - V_1)}{g_{max}} = \frac{2.718\,(V - 0.632V)}{g_{max}}$

$$r_1 = \frac{V}{g_{max}}$$

From equation (5) $R = \frac{2.718\,(V - V_1)}{g_{max}} e^{[V_1/2.718\,(V - V_1)]}$

$$= \frac{2.718 \times 0.368V}{g_{max}} e^{V_1/V}$$

$$= \frac{V}{g_{max}} e^{0.632} = 1.88 \frac{V}{g_{max}}$$

We have $V_1 = 0.632V = 0.632 \times 66$
$= 41.712$ KV to neutral

Ans.

$$r = 0.736 \frac{V}{g_{max}} = 0.736 \times \frac{66}{60}$$

$= 0.8096$ cm. **Ans.**

$$r_1 = \frac{V}{g_{max}} = \frac{66}{60} = 1.1\text{ cm.}$$ **Ans.**

$$R_1 = 1.88 \times \frac{66}{60} = 2.068\text{ cm.}$$ **Ans.**

Q. 8. Write short notes on the following : 20

(i) Phenomenon of corona

(ii) Methods of reducing corona loss

(iii) HVDC power transmission

(iv) HVDC links and its types

Ans. (i) Phenomenon of Corona : Phenomenon of appearance of violet luminous glow and production of hissing noise and ozone gas in an overhead transmission line is called corona.

(i) Violet luminous glow appear around conductor
(ii) Hissing noise produced
(iii) Ozone gas produced
(iv) Power loss occur.

Phenomenon is the ionization of air surrounding the power conductor. When the potential difference between the conductors is increased the gradient around the surface of conductor increases the free electrons will move with certain velocity depending on strength of field. These electrons will have collision with molecules and increase the no. of electrons. This will lead to avalanche of electrons. Eventually there will be ionisation of air surrounding the conductor. If spacing is less than 15 times diameter of conductor flash over occurs before corona phenomenon. This corona is much evident in power lines of 100KV and above.

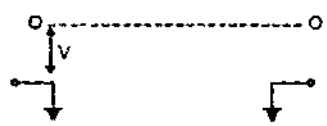
(ii) Methods of Reducing Corona Loss :

(i) By using large diameter conductor.
(ii) By using hollow conductors.
(iii) By using bundled conductors.

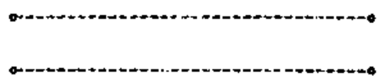
(iii) HVDC Power Transmission : Developments in the design of mercury arc rectifier and SCR have made HVDC transmission all the more feasible and attractive, though generation and distribution still continue to be carried out by AC.

Classification :

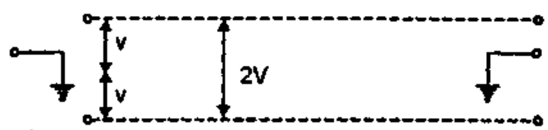
(i) Two pole, one wire system



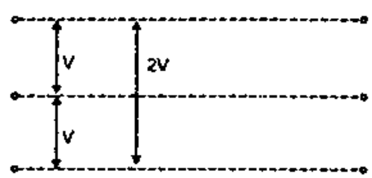
(ii) Two pole two wire system



(iii) Three pole two wire



(iv) Three pole three wire



Advantages :

(i) Cheaper
(ii) Require less insulation
(iii) Sheath loss negligible
(iv) High current carrying capacity
(v) Less corona loss.

Disadvantages :

(i) Distortion in waveform

(ii) Non-availability of reliable DC circuit breakers.

Applications :

(i) Testing HVAC cables of long lengths

(ii) Electrostatic precipitation

(iii) Communication system

(iv) Medical equipments (X-rays).

(iv) HVDC Links & Types : The DC links can be classified into the following types :

(a) Monopolar Links : It has only one energized conductor normally of negative polarity and uses ground or sea water as the return path. It may be noted that earth has much lower resistance to DC as compared to AC.

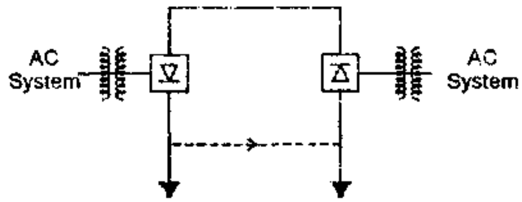


Fig. (a) Monopolar links

(b) Bipolar Link : The link has two conductors, one positive and the other negative potential of the same magnitude. At each terminal, two converter of equal rated voltages are connected in series on the DC side. The neutral points are grounded at one or both ends.

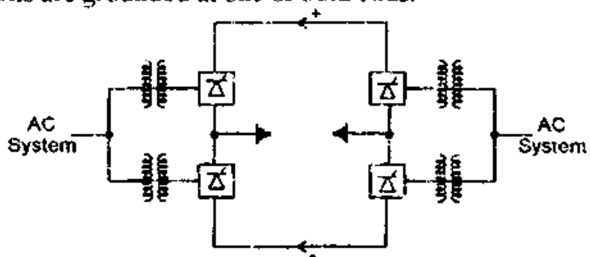


Fig. (b) Bipolor link

(c) Homopolar Link : A monopolar link has two or more conductors, all having the same polarity (usually negative) as the corona loss and radio interference get reduced and it always operates with ground as the return. If one of the conductors develops a fault, the converter equipment can be reconnected so that the healthy conductor can supply more than 50% of the rated power.

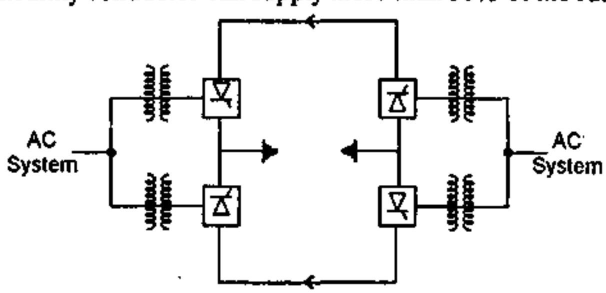


Fig. (c) Homopolor