**Important suggestions to examiners**:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skills)
4) While assessing figures, examiner may give credit for principle components indicated in a figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

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| Q.1 | **Attempt any TEN of the following:** **20 Marks** |
|---|---|
| **a)** | **Write any two advantages of high voltage of Transmission line.** |
| Ans: | **(Any two advantages 1 Mark each ,Total 2 Marks)**<br>**Advantages: (Any two advantages are expected)**<br>1. As Transmission voltage increases, current decreases. **( as I** $\alpha \frac{1}{V}$ **)**<br>2. As current decreases, cross section of conductor decreases. **[as c/s of conductor** $\alpha$ **I]**<br>3. As cross section of conductor decreases, its weight decreases.<br>4. As weight of the conductor decreases, design of tower becomes lighter in weight.<br>5. As current decreases, cross section of bus bar and size of switch gear contact etc. reduces.<br>6. Due to above advantages, Transmission cost per KM decreases<br>7. As transmission voltage increases. A current decreases, so copper losses in transmission line reduces.**(as** $Cu.losses \alpha I^2$ **)**<br>8. As copper losses reduces, transmission efficiency increases **[as Tr.** $\eta_T \alpha \frac{1}{Cu.loss}$ **]** |

| | |
|---|---|
| | 9. As current reduces, voltage drop in transmission line reduces. **[ as Voltage drop** $\alpha$ **I** $\alpha \frac{1}{V}$ **]**<br>10. As voltage drop in transmission reduces, voltage regulation becomes better (improved).<br>11. As efficiency and regulation of transmission line gets improved, so performance of transmission line increases<br>12. As transmission voltage increases power handling capacity of transmission line increases (as P $\alpha$ $V^2$) |
| **b)** | **State standard voltage in India for the following : (i) Generation Voltage (ii) Primary Transmission Voltage** |
| Ans: | **i. Generation Voltage :** 3.3KV, 6.6KV,11KV and 17.5 KV **( 1 Mark)**<br>**ii. Primary Transmission voltage :-** 220 KV, 400KV, 765 KV (750 KV) **( 1 Mark)** |
| **c)** | **State the necessity of transmission of electricity. (any two reason)** |
| Ans: | **(1 Mark to each reason, Total 2 Marks)**<br>**Because of following points there is necessity of transmission of power:**<br>**(Any two reasons are expected )**<br>1. Electrical load on power system is not concentrated at one place but it is widely spread.<br>2. Load points are located away from generating station.<br>3. Due to limitation of site selection criteria of major generating Station (HPP, TPP & NPP) are located far away from load centers and hence the electricity need to transmit from generating stations to the point of actual utilization of it (consumers) for this purpose transmission electricity is necessary. |
| **d)** | **State long form of : (i) AAC (ii) AAAC** |
| Ans: | **Long form of :** **( Each long form 1 Mark : Total 2 Marks)**<br>**(i) AAC :** All Aluminum Conductor<br>**(ii) AAAC :** All Aluminum Alloy Conductor |

**e) State effect of line parameter on performance of transmission line.**

Ans: **Following are the effect of line parameter on performance of transmission line:**

**(2 Marks)**

1. Due to resistance (R), voltage drop in transmission line & copper losses in transmission line produces.
2. Due to inductance (L) voltage drop in transmission line produces.
3. Capacitor (C) draws charging current through transmission line. This charging current produces additional copper losses & voltage drop in transmission line.

**Effect: -** Due to above reasons, transmission line efficiency, voltage regulation & also power factor of transmission line gets affected.

**f) State any two HVDC transmission line in India.**

Ans: **HVDC transmission line in India:** **( Any Two Expected: 1 Mark each : Total : 2 Marks)**

| S.N. | From | To | Voltage |
|---|---|---|---|
| 1 | Rihand (U.P) (from 1990) | Dadri | ± 500 KV (bipolar) |
| 2 | Talcher- is the biggest HVDC transmission passes through Orissa (A.P) Tamilnadu & Karnataka | Kolar | ± 500 KV (bipolar) |
| 3 | Chandrapur- Padghe (Maharashtra) in Western Region | Padghe (Maharashtra) | ± 500 KV (bipolar) |
| 4 | Bersoor (M.P.) | Lower Sileru (Arunachal | 100KV |

| | | | |
|---|---|---|---|
| | | Pradesh) | |
| 5 | Connecting Northern region (Sasaram-Pusawali) | Eastern Region | 140KV |
| 6 | Connecting Northern region (Vindhyachal) | Western Region | 70KV |
| 7 | Connecting Southern region (Chandrapur) | Western Region | 140KV |
| 8 | Connecting Southern region(Vizag- Gajuwaka) | Eastern Region | 140KV |

**g) State the classification of substation according to the method of construction.**

Ans: **( Only Four Name of substation expected 1/2 Mark each : Total : 2 Marks)**

**Classification of Substation According to Method of Construction:-**

1. Indoor Substation
2. Outdoor Substation
3. Gas insulated Substation
4. Underground Substation
5. Pole mounted substation
6. Plinth Substation
7. Compact/prefabricated substation

**h) Why radial distribution system used for short distance ?**

Ans: **Because of following disadvantages radial distribution system is not used for long distance: (Only two points are expected) ( 2 Marks)**

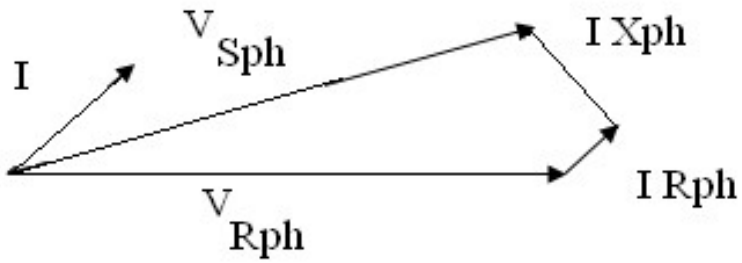
Since there is only one feeder to DTC feed at one point so,

1) There is no reliability to maintain supply at the time of fault on incoming feeder.

2) There is no reliability to maintain supply at the time of maintenance of incoming

| | |
|---|---|
| | feeder.<br>3) If the system is used for long distance then it takes more time for fault finding & repairing<br>Hence radial distribution system is used for short distance. |
| **i)** | **State four requirements of a distribution system.** |
| Ans: | **Following requirements of a distribution system.**<br>**( Only Four requirement expected 1/2 Mark each : Total : 2 Marks)**<br>1. Layout should be simple in design.<br>2. It should have less initial cost<br>3. The distribution system should have minimum distribution losses.<br>4. Voltage drop in distribution system should be less and within permissible limit (± 6%).<br>5. From safety point of view distribution system should maintain proper clearances.<br>6. The rating of distribution transformer & cross section of conductor should be proportional to result of load densities present & future.<br>7. Power should be available to consumers whenever needed.<br>8. A steady, non-fluctuating, quality supply (Pure sine wave) should be available to consumers.<br>9. Distribution system should not be over loaded.<br>10. Distribution system should have high reliability to maintain supply.<br>11. Distribution system lay out should not affect the appearance of locality.<br>12. Before installation of distribution system proposed widening of the road in the near future are to be kept in mind<br>13. It should have low, easy, less costly & less time consuming maintenance.<br>14. Fault on nearest distribution system should not affect stability of existing distribution system.<br>15. Time required for completion of work should be less. |

| | |
|---|---|
| **j)** | **Draw a vector diagram at leading power factor in transmission line. State its effect on regulation.** |
| Ans: | **Vector diagram at leading power factor in transmission line:** **( 1 Mark)** |




**OR Equivalent Figure**

**Effect on regulation:** **( 1 Mark)**

At Leading PF Receiving voltage is more than Sending end hence regulation is negative.

| | |
|---|---|
| **k)** | **State desirable properties of Cable. (any four)** |
| Ans: | **Following are the main properties of cables:** |

**( Any Four Properties expected: 1/2 Mark each : Total 2 Marks)**

**1. Stranded Conductor:**

The conductor used for cable should be stranded specially for large size of cable because,

- To increase the flexibility of cable
- For easy handling of cable
- For easy storage cable.

**2. Annealed Conductor:**

Annealed conductor should be used to become conductor soft.

**3. Tinned conductor:-**

Tinned conductor should be used so that conductor will not stick with insulation.

**3. Cross Section Of Conductor:**

Cross Section Of Conductor should be proportional to magnitude of current.

**4. Insulation Thickness:**

The insulation thickness provided to cable should be proportional to magnitude of voltage. To give high degree of safety and reliability.

Thickness of insulation α Magnitude of voltage

**5. Mechanical Protection:**

Especially underground cable should be provided with mechanical protection (armouring). So that it will withstand against rough handling and mechanical injury.

**6. Life:**

The material used for cable should have long life.

**l) State any four Trade name of ACSR conductor.**

Ans: **Trade name of ACSR conductor:**

**( Only Four Trade Name expected 1/2 Mark each : Total : 2 Marks)**

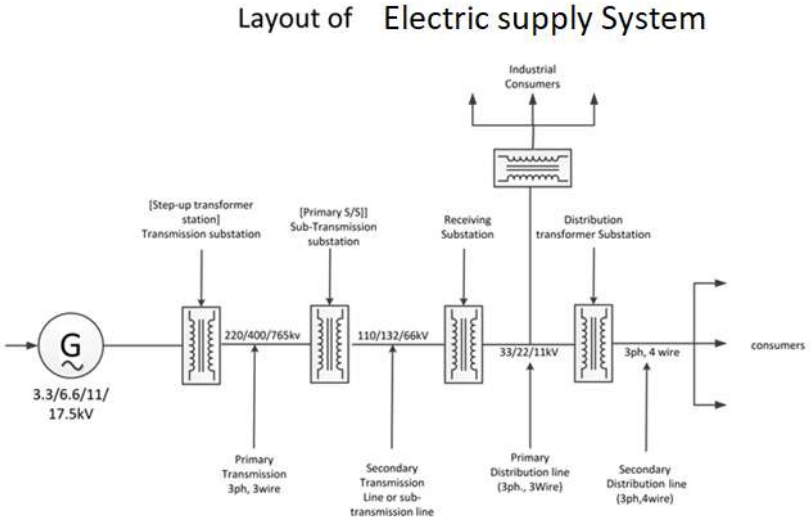
| S.No | Brand/Trade name | Current rating in air Amp | S. No | Brand/Trade name | Current rating in air Amp |
|---|---|---|---|---|---|
| 1 | Mole | 40 A | **16** | **Tiger** | **265 A** |
| **2** | **Squirrel** | **76 A** | 17 | Wolf | 305 A |
| 3 | Gopher | 85 A | 18 | Lynx | 335 A |
| **4** | **Weasel** | **95 A** | **19** | **Panther** | **370A** |
| **5** | **Ferret** | **115 A** | **20** | **Lion** | **405 A** |

| | | | | | |
|---|---|---|---|---|---|
| **6** | **Rabbit** | **135 A** | 21 | Bear | 430 A |
| **7** | **Mink** | **165 A** | 22 | Goat | 495 A |
| **8** | **Horse** | **185 A** | **23** | **Sheep** | **554 A** |
| 9 | Beaver | 176 A | 24 | Koo Doo | 575 A |
| **10** | **Raccoon** | **180 A** | 25 | Deer | 590 A |
| 11 | Otter | 185 A | **26** | **Zebra** | **610 A** |
| **12** | **Cat** | **195 A** | 27 | Elk | 630 A |
| **13** | **Dog** | **205 A** | **28** | **Camel** | **825 A** |
| 14 | Leopard | 275 A | **29** | **Moose** | **665 A** |
| 15 | Coyote | 260 A | | | |

**Q.2** **Attempt any FOUR of the following :** **16 Marks**

**a)** **Draw single line diagram of an Electric supply system.**

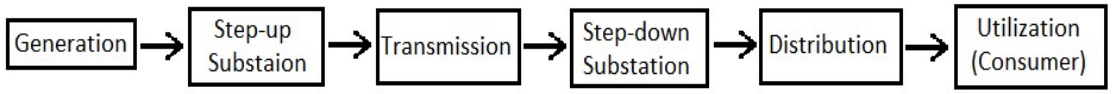
**Ans:** **Single line diagram of an Electric supply system:** **( 4 Marks)**




**OR Equivalent Figure**

**OR**

Block diagram of Power System




**b) State the advantage and disadvantages of stranded conductors.**

**Ans: Advantage and disadvantages of stranded conductors**

- **Advantages of Stranded Conductors:-**

**( Any Three Point Expected : 1 Mark each: Total 3 Marks)**

1. Conductor becomes flexible.
2. Its weight reduces.
3. Easy for handling.
4. Easy to store & transport.
5. Skin effect reduces.

- **Disadvantages of Stranded Conductors:-** **(1 Mark)**

1. Due to stranding of conductor its resistance increases slightly about 2%.

**c) A string of three unit suspension insulator observed to have voltage distribution on top disc 9 kV. middle disc 12 kV. Find (i) Line voltage (ii) String efficiency**

Ans: $V_1$= 9KV, $V_2$= 12KV **(Give stepwise Marks as mention below)**

**Ratio of capacitance 'k':-**

$$V_2 = V_1 (1+ m)$$
$$\therefore \quad 12 = 9 (1+ m)$$
$$\therefore \quad 12 = 9+ 9m$$

12- 9 = 9m ∴ 3 = 9m

**k = m = 0.333**---------- **(1/2 Mark)**

$V_3 = V_1 (m^2 + 3m + 1)$

$= 9 [(0.333)^2 + (3 \times 0.333) + 1]$

**$V_3$ = 18.981 KV** ---------- **(1/2 Mark)**

∴ **Voltage across string =** Vph = $V_1 + V_2 + V_3$

= 9+12+18.981

= 39.981 KV ---------- **(1/2 Mark)**

**i) The line voltage:** $V_L = \sqrt{3}\, V_{ph}$

$V_L = \sqrt{3} \times 39.981$

**$V_L$ = 69.249 KV**---------- **(1 Mark)**

**ii) String efficiency:-**

String $\eta\% \equiv \frac{Vph}{\eta \times V_3} \times 100$ ---------- **(1/2 Mark)**

String $\eta\% \equiv \frac{39.981}{3 \times 18.981} \times 100$

String $\eta\%$ **= 70.21%.** ---------- **(1 Mark)**

**d) Draw a neat labelled diagram of the following : (i) Pin type (ii) Strain type insulator**

Ans: **i) Neat labelled diagram of Pin type Insulator :** **( 2 Marks)**

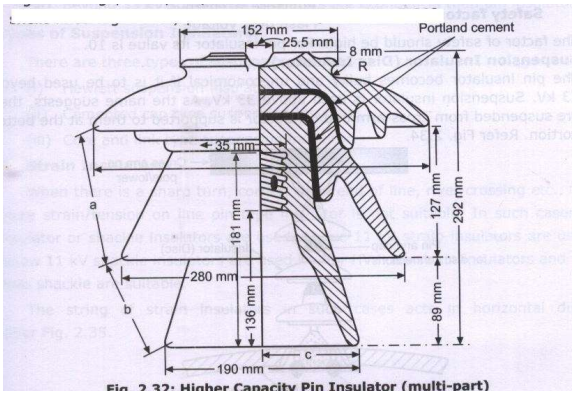
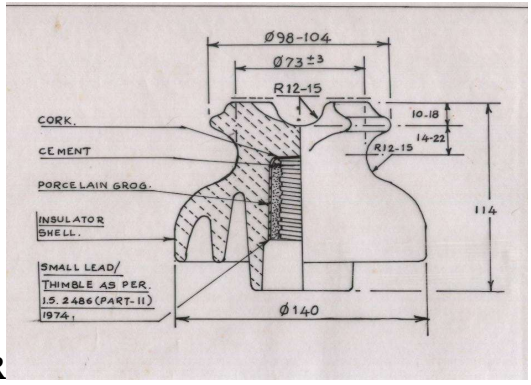


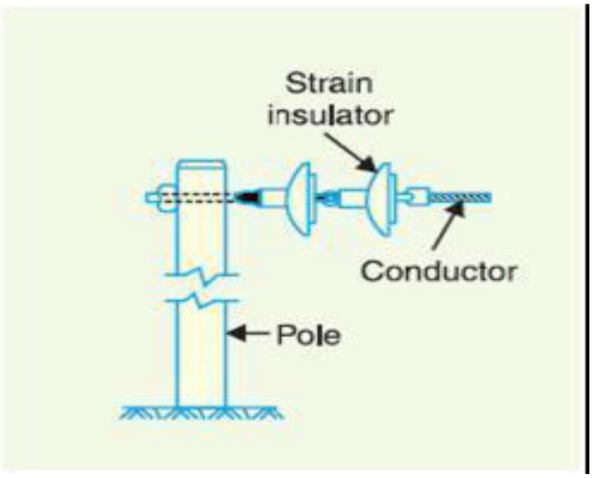
Fig. 2.32: Higher Capacity Pin Insulator (multi-part)

**OR**




**OR Equivalent Figure**

**ii) Neat labelled diagram of Strain type Insulator :** **( 2 Marks)**




**or equivalent Figure**

**e) State and explain any one method for improving string efficiency**

Ans: **The Methods of Improving String Efficiency:-**

**( Methods : 2 Mark & Any one explanation: 2 Marks : Total 4 Marks)**

1) By reducing value of 'm' or ('k') by using longer cross arm.
2) By Making of 'm' or ('k') equal to zero
3) By grading Insulator.
4) By Using guard ring.

**Explanation:-**

**1) By reducing value of 'm' or ('k') by using longer cross arm:-**

Fig:-

The value of 'm' can be decreased by reducing value of shunt capacitance ($C_1$) since m = $C_1/C$.

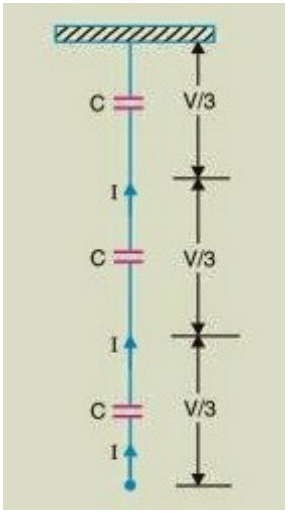
In order to reduce value shunt capacitance ($C_1$) distance of string of insulator from tower must be increased. i.e. by using longer cross arm. Due to this value of shunt capacitance ($C_1$) reduces.

Therefore value of m reduces Since ($m = \frac{C_1}{C}$) As value of 'm' reduces there will be more uniform voltage distribution along a string of suspension insulator. In this way string efficiency increases.

**Limitation:**

In practice there is limitation to increase length of cross arm as cost of tower increases. In practice m= 0.1 is the limit which can be achieved by this method.

**2) By Making of 'm' or ('k') equal to zero:-**




**or equivalent Figure**

If an insulating material or any non conducting material of high strength is used for connection between two disc insulators in a string instead of using steel part.

Than value of Shunt Capacitance (C1) becomes Zero,(Capacitance will not form) therefore value of 'm' becomes zero (since m = $C_1/C$) So string efficiency becomes 100%.

**3) By grading Insulator :-**

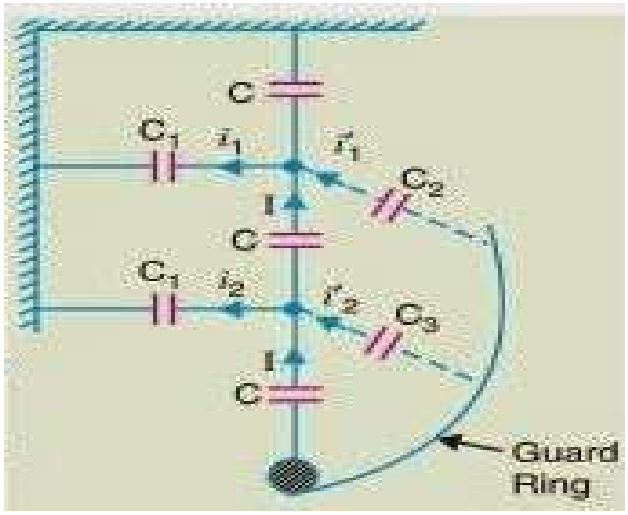
In this method, disc insulators of different dimensions are so selected that each disc has different capacitance. The assembly in the string of suspension insulator is made in such a way that the top unit insulator has fewer dimensions. (Less capacitance) ($C \alpha$ A) and dimensions of insulators progressively goes on increasing i.e. bottom unit has maximum capacitance due to large dimensions of insulators.

(Since Q=C/V i.e. **V** is inversely proportional to capacitance So as **A** Increases **C** increases therefore voltage decreases)

In this way it equalizer potential distribution across the string and therefore increases string efficiency.

This method has disadvantages that it requires disc insulator of different dimensions in one string of suspension insulator. Practically it is not possible to obtain such ration. But very high voltage transmission line (1200KV). This method is used.

**4) By Using guard ring :-**




**or equivalent Figure**

Guard ring is a metal ring electrically connected to conductor and surrounding the bottom insulator.

Due to guard ring leakage current through all discs in a string is same.

So, we will get uniform voltage distribution along the string of suspension insulator, In this way string efficiency increases.

**f)** **Compare EHVAC and HVDC transmission line on given points :**
**(i) Number of conductors for double circuit. (ii) Capital cost of sub-station (iii) Skin effect (iv) Proximity effect (v) Ferranti effect (vi) Corona loss (vii) Copper loss (viii) String efficiency**

Ans: **Comparison EHVAC and HVDC transmission line:**

**( Each point expected: 1/2 each : Total 4 Marks)**

| S.No | Points | EHVAC | HVDC |
|---|---|---|---|
| 1 | Number of conductors for double circuit | Six conductors (R,Y,B & R,Y,B) | Two conductors.& Ground is used as a return path |
| 2 | Capital cost of S/S | Less | More |
| 3 | Skin effect | Present | Absent |
| 4 | Proximity effect | Present | Absent |
| 5 | Ferranti effect | Present | Absent |
| 6 | Corona losses | More | Less |
| 7 | Copper loss | More | Less |
| 8 | String efficiency | Less than 100 % | 100 % |

**Q.3** **Attempt any FOUR of the following :** **16 Marks**

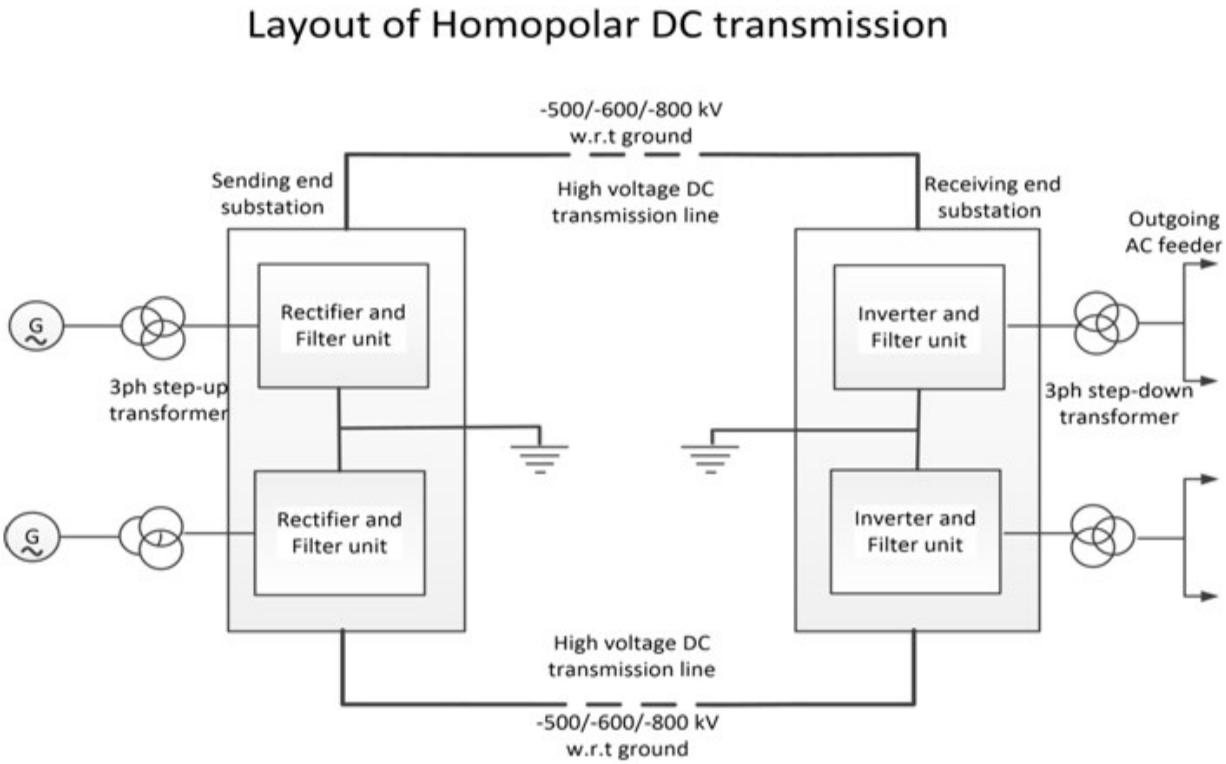
**a)** **Under which conditions Ferranti effect occurs, state any four conditions. What is Ferranti effect?**

Ans: **Under Following conditions Ferranti effect occurs:**

**( Any Four condition expected: 1/2 Mark each : Total : 2 Marks)**

1. When there is no load on transmission line ($I_L = 0$)
2. When There is no load at receiving sub-station or Lightly loaded
3. When there is sudden load thrown OFF.
4. When there is sudden load shading.
5. When Transmission line is open circuited due to load failure.

| | |
|---|---|
| | **Ferranti effect :** **( 2 Marks)**<br>Under any one condition, it is found that receiving end voltage ($V_R$) is found to be greater than sending end voltage ($V_S$). This phenomenon is known as Ferranti effect. |
| **b)** | **State any four factors which affects Corona. State two points how Corona effect can be reduced.** |
| Ans: | **The Following Factors affecting corona:-**<br>**( Any Four Factors expected: 1/2 Mark each : Total : 2 Marks)**<br>**1. Magnitude of Voltage :**<br>If voltage across two conductors is greater than 30 KV/cm, i.e. breakdown voltage of air than corona formation starts. Corona will not start if voltage is below 30 KV/cm<br>**2. Distance between two conductor:**<br>If spacing between two conductors is very large as compare to their diameter than there is no possibility of corona formation. Because value of voltage at which corona occurs increases.<br>**3. Size of conductor:**<br>If size (Cross section) of conductor is more, than magnitude of voltage required to occur the corona increases.<br>**4. Condition of conductor & Hardware:**<br>Rough and irregular surface of conductor and hardware will give more corona than solid, smooth body conductor & hardware.<br>**5. Atmospheric Condition:**<br>As corona takes place due to ionization of air so it depends on condition of air so for dry air formation of corona occurs late than in wet air (damp atmosphere condition/ rainy season/thunderstorms/fog air becomes more conductivity)<br>6. Effect of supply Frequency: Corona loss varies directly as the supply frequency |

| | |
|---|---|
| | 7. Effect of density of air: Corona loss increases with the decrease in the density of air (The corona loss of transmission line passing through hilly area is higher than that of a similar line in plain due to reduced value of air density at high level /altitude)<br><br>**As Following points Corona effect can be reduced:**<br>**( Any Two Point expected: 1 Mark each : Total : 2 Marks)**<br>1. By increasing distance between two conductor i.e. by using longer cross arm.<br>2. By using larger size(diameter) of conductor e.g./ using ACSR, bundled conductor<br>3. By using smooth body conductor and hardware. |
| **c)** | **Draw layout of Homopolar HVDC transmission line mention polarity of overhead conductor.** |
| Ans: | **layout of Homopolar HVDC transmission with polarity of overhead conductor:**<br>**( 4 Marks)**<br>  <br>**OR Equivalent Figure** |

| | |
|---|---|
| d) | **Write sequence of operation of isolator and circuit breaker while opening and closing.** |
| Ans: | **Sequence of operation of Isolator and C.B while opening & closing is as below:**<br><br>**While Opening:** **( 2 Marks)**<br><br>1. Open circuit breaker<br><br>2. Open Isolator<br><br>3. Close earthing switch<br><br>➢ **While Closing:** **( 2 Marks)**<br><br>1. Ensure circuit breaker is open<br><br>2. Open earthing switch<br><br>3. Close isolator<br><br>4. Close circuit breaker |
| e) | **State the function of equipment's used in sub-stations : (i) Earth Switch (ii) Relay (iii) Lighting Arrester (iv) Auxiliary transformer** |
| Ans: | **(i) Earth Switch** **( 1 Mark)**<br><br>It's function is to discharge the ground capacitance when line is open circuited for maintenance purpose by isolator.) Earthing switch is inter - locked with isolator from the safety point of view<br><br>**ii) Relay:** **( 1 Mark)**<br><br>It sense the faults & gives signal to trip circuit of C.B. to open. There are different types of relay e.g. Earth fault relay, Phase to Phase fault relay, Thermal relay etc.<br><br>**iii) Lightning Arrester: -** **( 1 Mark)**<br><br>It is provided for protection of substation, transformer against lightning stroke .It is connected in between line and ground at the starting point of substation. Under normal condition it acts as an insulator. |

**iv) Auxiliary Transformer : -** **( 1 Mark)**

Its function is to step down the input voltage (11 KV) to distribution voltage (3-ph, 4wire, 400V) to give supply to control room, area lighting, staff quarters etc,

**f) A single phase 11 kV short transmission line delivers 1000 kW power at 0.8 p.f. lagging total resistance and inductive resistance of the line are 5 ohm and 5.6 ohm. Determine: (i) Sending end voltage (ii) Percentage regulation of transmission line.**

**Ans:** $\therefore Cos\varphi_R = 0.8 \ \therefore \ \sin\varphi_R = 0.6$ Resistance 5.0 ohm Reactance 5.6 ohm

**Step 1: To calculate Sending end voltage:**

Power P = $VI\cos\phi$ .---------- **(1/2 Mark)**

$$I \equiv \frac{P}{V\cos\phi}, \quad I \equiv \frac{1000\times10^3}{11\times10^3\times0.8}$$

$I \equiv 113.6363 \ amp$.---------- **(1/2 Mark)**

**Step 2: To calculate Sending end voltage:**

**Vs** = $V_R + I(R_T\cos\phi_R - X_T\sin\phi_R)$ .---------- **(1 Mark)**

$= 11\times10^3 + 113.6363\,(5\times0.8 - 5.6\times0.6)$

**= 11000 +72.7272**

**=** 11072.7272 volt

Vs = 11.07272 KV .---------- **(1/2 Mark)**

**Step 4:To calculate voltage regulation:**

% Voltage Regulation = $\frac{V_S - V_R}{V_R}\times100$ .---------- **(1 Mark)**

$= \frac{11072.7272 - 11000}{11000}\times100$

**= 0.6611 %** ---------- **( 1/2 Mark)**

**Q.4** **Attempt any FOUR of the following :** **16 Marks**

**a)** **State two reasons the transposition of conductor. Draw figure of transposition of conductor.**

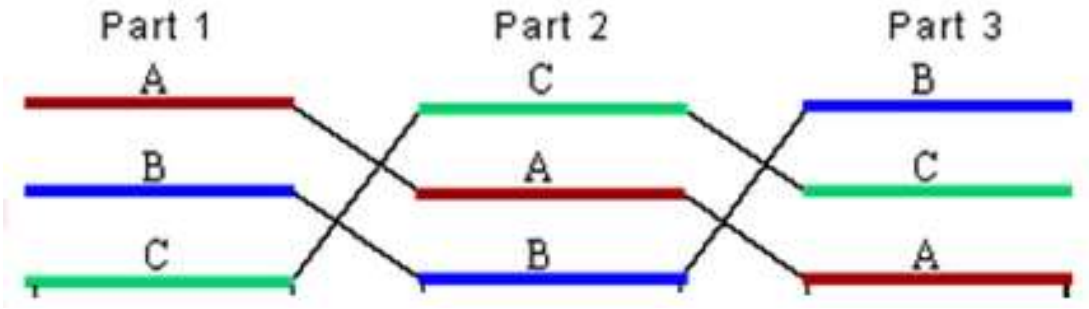
Ans:

**Following reasons the transposition of conductor:**

**( Any Two reasons Expected: 1 Mark each ,Total 2 Marks)**

1. Due transposition of conductor inductance of each line is same $L_A = L_B = L_C$, So drop due to inductive reactance in each line is same so voltage at receiving end between any two line become same.
2. So to obtain same voltage in any two line at receiving end ($V_{RY} = V_{YB} = V_{RB}$) transposition is necessary.
3. Radio interferences are less due to transposition.

**Figure of transposition of conductor:** **( 2 Marks)**




**OR Equivalent Figure**

**b)** **Compare indoor and outdoor sub-station on given points : (i) Capital cost (ii) Time required for completion (iii) Availability of natural light (iv) Space required**

Ans:

**( Each point : 1 Mark, Total 4 Marks)**

| Sr. No. | Points | Indoor substation | Outdoor substation |
|---|---|---|---|
| i) | **Capital cost** | High, as construction work cost is more. | Less, as construction work cost is less. |
| ii) | **Time required for completion** | More, as construction work is more. | Less, as construction work is less. |
| iii) | **Availability of natural light** | Natural light is not available even in day time, so there is need of illumination even during a day time. This | Natural light is available in day time, so there is no need of illumination during |

| | | | |
|---|---|---|---|
| | | increases energy consumption charges due to indoor installation | day time. So it saves electrical energy & its cost |
| **iv)** | **Space Require** | Less | More |

**c)** **Compare pin type and suspension insulators on given points: (i) Position of insulator on cross arm. (ii) Position of conductor on insulator. (iii) Reaction on cross arm. (iv) Possibility of flash over due to large birds (v) Maintenance/Replacement cost (vi) Maximum voltage level (vii) Effect on height of supporting structure. (viii) Life**

Ans: **( Each point expected: 1/2 each : Total 4 Marks)**

| S.No | Points | Pin Type insulator | Suspension or Disc Type insulator |
|---|---|---|---|
| i | **Position of insulator on cross arm** | It is fixed on top of cross arm by using galvanized steel pin. So it is called as pin type insulator. | These insulators are hanging below the cross arm hence its name is suspension type insulator. |
| ii | **Position of conductor on insulator** | On the top of the insulator | Conductor is clamped at the bottom of the insulator in a string |
| iii | **Reaction on cross arm** | More | Less |
| iv | **Possibility of flash over due to large birds** | Due to large birds, flash over is possible because distance between two insulators is less than suspension insulator | As insulators are suspended & distance between two conductors is more than pin type insulator so there is no possibility of flash over due to large birds or similar object. |

| | | | | |
|---|---|---|---|---|
| | v | **Maintenance / replacement cost** | If pin type insulator of existing line break down (failure) by any reason. Then it should be replaced by new one | If any insulator in the string of suspension insulator break down/fails then only that insulator/disc in the string require to be replace by new one instead of replacement of whole string unit. |
| | vi | **Maximum voltage level** | 33 KV maximum. | 66/110/132/220/400/765 KV & even for more voltages. or above 33Kv |
| | vii | **Effect on height of supporting structure** | Conductor is fixed on the top of insulator so to maintain minimum ground clearance height of pole required as compared to suspension type insulator is less | As insulators are suspended below the cross arm & conductor is clamped below the insulator so to maintain minimum ground clearance height of pole increase. |
| | viii | **Life** | Less | More |

**d) Which are the factors to be considered while designing feeders ?**

Ans: **Following factors are to be considered while designing the Feeder:**

**( Any Four Factors expected: 1 each point : Total : 4 Marks)**

**1) Current carrying capacity of conductor:-**

Conductor should have high current carrying capacity. While voltage drop consideration is relatively not so important

It is because voltage drop in feeder can be adjusted with the help of tapings of distribution transformer manually or by using AVR (Automatic Voltage Regulator)

| | |
|---|---|
| | **2) Need:**<br>Depending upon application design of distribution system should be selected i.e. whether continuity of supply is important or not so important<br>Example: 1) Use Radial distribution system in rural area<br>2) Use Ring main distribution system in urban area<br>3) Use Grid distribution system where continuity of supply is important. e.g. Supply to - electric traction, TV broadcasting centre, AIR, telephone exchange, major hospitals, important government buildings and major industries<br>**3) Availability of power:** It should be available whenever needed<br>**4) Maintenance:** It should be low, easy, less costly & less time consuming.<br>**5)** Power Factor of load should be consider while designing |
| **e)** | **State the four methods of laying of cable. State precautions while laying of underground cable in the situation :**<br>**(i) Minimum clearance between cable and water pipe line when running in parallel.**<br>**(ii) Minimum clearance between cable and water pipe line when running in parallel.**<br>**(iii) If cable is laid through pipe what should be diameter of pipe.**<br>**(iv) When more than one cable is to be laid in the same trench, what should be minimum spacing between two cables ?** |
| **Ans:** | **(1 Mark to each point, Total 4 Marks)**<br>**(i)** Minimum clearance between cable and water pipe line when running in parallel:-<br>➢ **0.5 mtr.**<br>**(ii)** Minimum clearance between cable and water pipe line when running in parallel:-<br>➢ **0.5 mtr.**<br>**(iii)** If cable is laid through pipe what should be diameter of pipe**:-**<br>➢ **Diameter of pipe is 2 to 3 cm, greater than cable diameter**<br>**(iv)** When more than one cable is to be laid in the same trench, what should be minimum spacing between two cables :-<br>➢ **Then minimum 30 cm spacing is provided between 2 cables** |

| | |
|---|---|
| f) | **Give the classification of cables. (i) According with voltage levels. (ii) According to numbers of core.** |
| Ans: | **. Classification of cables with their voltage levels: (Any Four types from following are expected) (2 Marks)**<br><br>1. Low voltage (tension) cable/LT cable: for operating voltage 1.1 KV.<br><br>2. High voltage (tension) cable/HT cable: for operating voltage 11 KV.<br><br>3. Super tension cable/ST cable: for operating voltage 22 KV to 33 KV.<br><br>4. Extra-Super tension cable: for operating voltage 33 KV to 66 KV.<br><br>5. Extra-high tension cable (EHT): for operating voltage up to 132 KV<br><br>6. Extra-super voltage power cables**:** for operating voltage beyond 132 KV<br><br>**2. Classification of cables According to numbers of cores: (Any Four types from following are expected) (2 Marks)**<br><br>1. Single Core cable<br><br>2. Two core cable<br><br>3. Three core cable.<br><br>4. Three & half core cable.<br><br>5. Four core cable<br><br>6. Six core cable<br><br>7. Multi core cable |

| Q.5 | Attempt any FOUR of the following : 16 Marks |
|---|---|
| a) | State any eight requirements or properties of the line supports used in transmission and distribution. |
| Ans: | Following are requirements or properties of the line supports used in transmission and distribution. ( Each point 1/2 Mark, Total 4 Marks) |

1. **High mechanical strength:-**
   It should have high mechanical strength to withstand against -
   - Wind pressure
   - Load of fabrication
   - Weight of Insulator
   - Weight of conductor etc.
2. **Light in weight:-**
   It should be light in weight to reduce-
   - Transportation cost
   - Handling, loading, unloading cost and
   - Erection cost.
3. **Effect of atmospheric conditions:** It should be withstand even at bad atmospheric condition.
4. **High resistance to corrosion:** It should have high resistance to corrosion to avoid rusting.
5. **Initial & Maintenance cost:** It should be less.
6. **Easy access:** It should be easily accessible for wireman for line work and maintenance work. or They must be easily accessible for point and erection of line conductors
7. **Life:** It should have longer life.
8. **Appearance:** It should have good appearance or They must be of pleasing shape

**b) A overhead there phase transmission line delivers 5000 kW at 22 kV at 0.8 lagging p.f. The resistance and reactance per phase is 4 ohm and 6 ohm respectively. Determine (i) Sending end voltage (ii) Percentage regulation of Transmission line**

Ans:

**Given Data:-**

$P_R$ =5000KW $V_R$ = 22KV P.F. = 0.8 lag $R_{ph}$ = 4 ohm $X_{ph}$ = 6 ohm

**Step 1: To calculate current:**

Power P = $\sqrt{3}\, V_L\, I_L \cos\phi \quad for\ 3-ph$ ---------- **(1/2 Mark)**

$$I \equiv \frac{P}{\sqrt{3}\ V_{LR} \times \cos\phi}, \qquad I \equiv \frac{5000}{\sqrt{3} \times 22 \times 0.8}$$

$$I \equiv 164.01996\, amp$$ ------ **(1/2 Mark)**

**Step 2: To calculate value of sin :**

$$\therefore Cos\phi_R = 0.8; \quad \sin\phi_R = 0.6$$

$$V_{Rph} \equiv \frac{V_{RL}}{\sqrt{3}}$$

$$V_{Rph} \equiv \frac{22}{\sqrt{3}}$$

$$V_{Rph} \equiv 12.7017\ KV \ or\ V_{Rph} = 12.7017 \times 10^3\ V$$ --------- **(1/2 Mark)**

**Step 3: To calculate Sending end voltage:**

Sending end phase voltage **( $V_{Sph}$) =**

**=** $V_{Rph}$ +I ($R_{Ph}$ Cos $\emptyset_R$ + $X_{Ph}$ Sin $\emptyset_R$) ------- **(1/2 Mark)**

$=12.7017 \times 10^3 + 164.01996\ (4 \times 0.8 + 6 \times 0.6)$

$= 13817.03573V$

**=13.81703 KV** ----------**(1/2 Mark)**

Sending End Line Voltage = $\therefore V_{SL} = \sqrt{3} \times V_{sph}$

$$V_{SL} = \sqrt{3} \times 13.81703$$

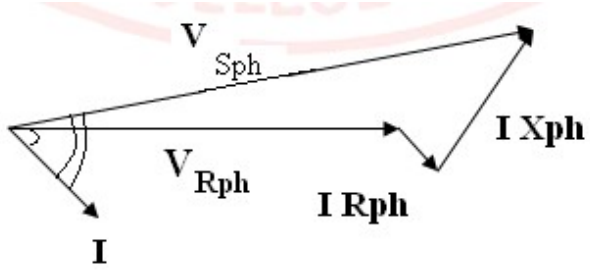
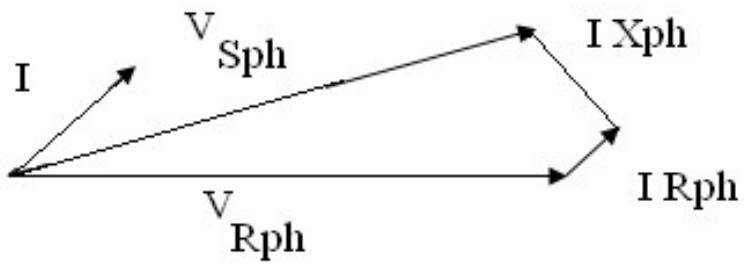
**= 23.9317** KV ---------- **(1/2 Mark)**

**Step 4:To calculate voltage regulation:**

% Voltage Regulation $= \frac{V_{S\,Ph} - V_{R\,Ph}}{V_{R\,Ph}} \times 100$ - ---------- **(1/2 Mark)**

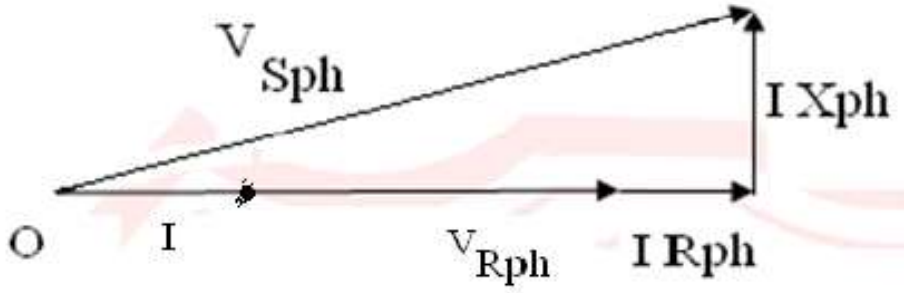
$$= \frac{13.81703 - 12.7017}{12.7017} \times 100$$

**= 8.7809 %** ---------- **( 1/2 Mark)**

| | |
|---|---|
| c) | **While calculating performance of medium transmission line, what assumptions are made in case of (i) Nominal 'T' Method (ii) Nominal 'TT' Method.** |
| Ans: | **(i) Assumptions are made in case of Nominal 'T' Method:** **( 2 Marks)**<br>**a.** It is assume that line capacitance is connected at center of transmission line.<br>**b.** It is assume that half of the resistance & reactance per phase are divided in either side of capacitance.<br>**(ii) Assumptions are made in case of Nominal ' TT ' Method:** **( 2 Marks)**<br>a. It is assumed that capacitance of transmission line is divided into half of the line capacitance is connected at receiving end & half of capacitance is connected at sending end.<br>b. It is assumed that transmission line resistance & reactance per phase is connected in between two half transmission line capacitance |
| d) | **State the effect of lag, lead and unity power factor on regulation of transmission line.** |
| Ans: | **(Vector diagram 3 Mark, Each effect on regulation 1 Mark , Total 4 Marks)**<br>**i) Vector Diagram for Lagging Power Factor:-**<br>  <br><br>**or equivalent figure**<br>**EFFECT :-** At Lagging PF Receiving voltage is less than Sending end hence regulation is positive<br>ii) **Vector Diagram for Leading Power Factor:-**<br>  <br><br>**or equivalent figure** |

**EFFECT: - At** Leading PF Receiving voltage is more than Sending end hence regulation is negative.

**iii) Vector Diagram for Unity Power Factor: ()**




**or equivalent figure**

**EFFECT :-** At UPF receiving voltage is less than Sending end hence regulation is positive

**e) State the effect of inductance and capacitance on performance of transmission line.**

**Ans:** **(Effect of inductance 2 Marks and capacitance 2 Marks , Total 4 Marks)**

**Following are the effect on performance of transmission line:**

1. Due to inductance (L) voltage drop in transmission line produces.
2. Capacitor (C) draws charging current through transmission line. This charging current produces additional copper losses & voltage drop in transmission line.

**Effect of inductance and capacitance on performance of transmission line:-**

Due to above reasons, transmission line efficiency, voltage regulation & also power factor of transmission line gets affected.

**f) A single phase 11 kV line with a length of 20 km is to transmit 750 kVA load. The total inductive reactance of line is 0.5 ohm per km and total resistance is 0.2 ohm per km. Calculate the sending end voltage and efficiency of the line at 0.8 pl. lagging.**

Ans: $P_R$ = 750KVA, $V_R$ = 11KV, P.F. = 0.8 lag, R Per conductor =0.2 ohm/km,

X Per conductor = 0.5 ohm /km

**Step 1: To calculate Power :**

Power in KW ( $P_R$) = KVA × P.F.

$= 750 \times 0.8$

$= 600$ kW ---------- **( 1/2 Marks)**

**Step 2: To calculate value of sin :**

$\therefore Cos\phi_R = 0.8 \ \therefore \ \sin\phi_R = 0.6$

**Step 3: To calculate Current :**

Power P = $VI\cos\phi$

$$I \equiv \frac{P}{V\cos\phi}, \quad I \equiv \frac{600}{11\times 0.8}$$

$I \equiv 68.1818\, amp$ ---------- **( 1/2 Marks)**

$R_T$= 0.2 ohm/km x 20 = 4 ohm

---------- **(1/2 Marks)**

$X_T$=0.5 ohm/km 20 =10 ohm

**Step 4: To calculate Sending end voltage:**

$$\mathbf{Vs} = V_R + I(R_T\cos\phi_R + X_T\sin\phi_R)$$

$$= 11\times 10^3 + 68.1818(4\times 0.8 + 10\times 0.6)$$

$$= 11627.2725 \text{ volt}$$

Vs = 11.6272 KV ---------- **( 1 Marks)**

**Step 5 : To calculate Total Line Losses:**

Total Line Losses = $I^2 R_T$

$= (68.1818)^2 \times 4$

= 18595.0314 Watt

= 18.5950 KW ---------- ( 1/2 Marks)

**Step 6: To calculate Total Transmission efficiency:**

$$\%\,\eta_T = \frac{P_R}{P_R + I^2 R_T} \times 100$$

$$\%\,\eta_T = \frac{600 \times 10^3}{600 \times 10^3 + 18595.0314} \times 100$$

$$\%\,\eta_T = 96.9939\,\% \text{ ---------- ( 1 Marks)}$$

| | |
|---|---|
| **Q.6** | **Attempt any FOUR of the following : 16 Marks** |
| **a)** | **Define EHV line. State its necessity any four points.** |

Ans: **(Define 2 Mark, necessity any four points 1/2 Mark each, Total 4 Marks)**

**Define EHV line :-** **(2 Marks)**

**EHV line means transmission voltage** between 400 KV To 765 kV.is known as EHV line

We know that, $P = \sqrt{3}\ V_L I_L \cos\phi$

For,

- Same power to be transferred
- At same power factor
- At same transmission line distance

$I \alpha \frac{1}{V}$ from This Equation It is clear that due to High Transmission Voltage

**Necessity Of EHV transmission line:- (Any four points are expected) (2 Marks)**

**EHV** AC transmission line becomes necessary for bulk power to be transmitted over a long distance because of following advantages:-

1. As Transmission voltage increases, current decreases. **( as** $I \alpha \frac{1}{V}$ )
2. As current decreases, cross section of conductor decreases. **[as c/s of conductor** $\alpha$

**I]**

3. As cross section of conductor decreases, its weight decreases.
4. As weight of the conductor decreases, design of tower becomes lighter in weight.
5. As current decreases, cross section of bus bar and size of switch gear contact etc. reduces.
6. Due to above advantages, Transmission cost per KM decreases
7. As transmission voltage increases. A current decreases, so copper losses in transmission line reduces.**(as** $Cu.losses \ \alpha \ I^2$ **)**
8. As copper losses reduces, transmission efficiency increases **[as Tr.** $\eta_T \alpha \frac{1}{Cu.loss}$ **]**
9. As current reduces, voltage drop in transmission line reduces. **[as Voltage drop** $\alpha$ **I** $\alpha \frac{1}{V}$ **]**
10. As voltage drop in transmission reduces, voltage regulation becomes better (improved).
11. As efficiency and regulation of transmission line gets improved, so performance of transmission line increases
12. 12. As transmission voltage increases power handling capacity of transmission line increases (as P $\alpha$ V²)
13. Due to high voltage transmission line, successful interconnection of transmission line is possible than low voltage.
14. Generating Stations are generally located away from load centre.

**b) Write limitation and application of High Voltage DC (HVDC).**

Ans: **Limitation and application of High Voltage DC (HVDC):**

**( Any Four Limitation Expected: 1/2 each Point : Total 2 Marks)**

**Limitation:-**

1) It is difficult to step up and step down DC voltage like AC voltage.

2) Special cooling arrangements are necessary for converter, so it increases cost of substation.
3) Cost of DC substation is more than AC substation, due to additional equipment required like rectifier, inverter etc.
4) Maintenance cost of DC substation is more due to additional equipment.
5) Space required for DC substation is more due to additional equipment
6) Losses in DC substation are more due to additional equipment.
7) Over load capacity Converter is very less.
8) Reliable DC circuit breakers are not available like AC circuit breakers.
9) Cost of DC circuit breaker is more than AC circuit breaker.
10) Converters consumes reactive power
11) Generation of harmonics.
12) If ground is used as the return path, then it leads
    - Corrosion of underground metallic structure of buildings, pipes, etc. due to chemical action.
    - Causes disturbance in underground communication cable.
13) HVDC is not economical for short distance transmission because termination cost equipment is more.

**Application of High Voltage DC (HVDC):**

**( Any Four Application Expected: 1/2 each Point : Total 2 Marks)**

1) HVDC is economical to transmit bulk amount of power 1000 MW & above. Over a long distance 800 Km & above
2) Interconnection of two transmission lines having different frequencies is

possible through HVDC link.

3) HVDC is preferred for underground cable when power transmission through underground cable is greater than 40-50 KM than only HVDC uniquely suited.
4) HVDC is preferred for underground cable transmission as incoming line in megacities. ./ City centre in- feed.
5) HVDC is preferred for underground cable transmission for crossing long lake, ocean etc.
6) HVDC is preferred for underground cable transmission where atmospheric conditions are too bad for overhead transmission line, e.g. High wind pressure, rainfall, icefall etc.
7) HVDC is preferred for underground cable for long distance underwater power links.
8) HVDC is preferred for underground cable for powering island from onshore.
9) HVDC is preferred for underground cable for taking power from offshore wind farm.
10) HVDC is preferred for underground cable for powering oil and gas offshore floating platform.
11) Integration of generation( conventional/non-conventional)
12) Increasing existing grid utilization.
13) Interconnection of different grids or networks

**c) Give comparison between Feeder and Distribution.**

Ans: **( Any Four points are Expected: 1 each Point : Total 4 Marks)**

| Sr.No | Feeder | Distributor |
|---|---|---|
| 1 | It is link between receiving substation & distribution transformer | It is link between distribution transformer substation & consumer |

| | | |
|---|---|---|
| 2 | It is also called as a High Tension Line | It is also called as a low Tension Line |
| 3 | It is a 3-Ph, 3 wire system.(R-Y-B) | It is a 3-Ph, 4 wires system. (R-Y-B-N) |
| 4 | Feeder voltage is 11KV/22KV/33KV depending upon load | Distributor voltage is for 3-ph consumer- 400V and 1-Ph consumer-230V |
| 5 | Feeder is high capacity conductors. | Distributors are low capacity conductors |
| 6 | Feeder forms the primary distribution system | Distributors forms secondary distributor system. |
| 7 | While designing feeder its current carrying capacity is important | While designing distributor its voltage drop calculation is important. |
| 8 | Feeder is not tapped along its length | Distributors are tapped throughout its length. |
| 9 | Its loading point is at substation only | Distributors loading point is throughout its length. |

**d) What are different types of distribution scheme.**

Ans: **According to scheme of connection: -** **( 4 Marks)**

a) Radial (Tree) distribution system

b) Ring mains (Loop) distribution system

c) Grid (interconnected) distribution system

**OR**

**Types of distribution scheme:** **( 4 Marks)**

**1) According to nature of Current**

**a) DC Distribution System:**

i) Two wire DC distribution System ii) Three wires DC distribution System.

**b) AC Distribution System:**

i) Primary distribution system. ii) Secondary distribution system:

**2) According to Method of construction: -**

a) Overhead distribution system

b) Underground distribution system

**3) According to scheme of connection: -**

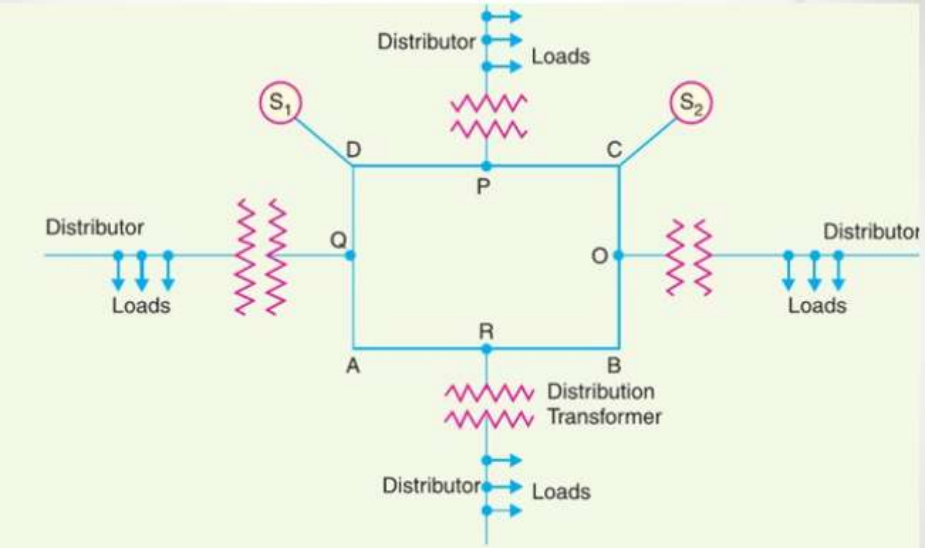
a) Radial (Tree) distribution system

b) Ring mains (Loop) distribution system

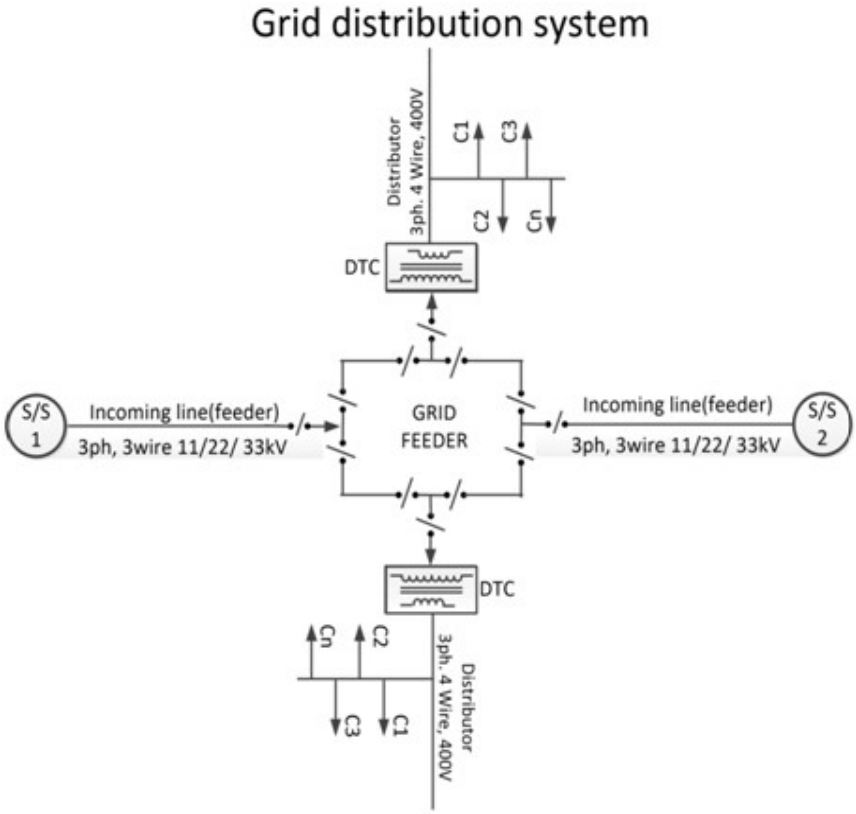
c) Grid (interconnected) distribution system

**e) Draw layout of Grid distribution scheme and write two advantages.**

Ans: **Layout of Grid distribution scheme:** **( 2 Marks)**




OR



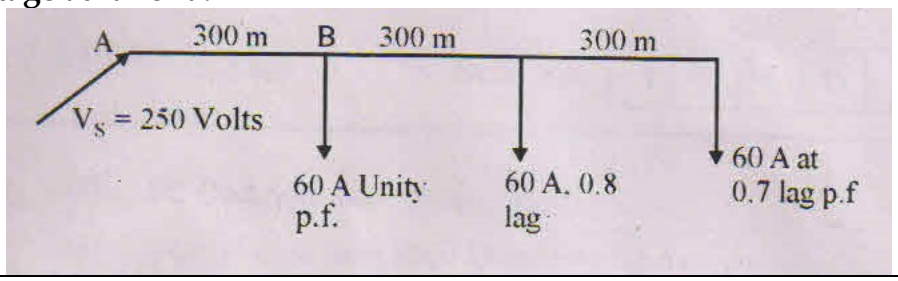

**OR Equivalent Figure**

**Advantages of Grid distribution scheme:**

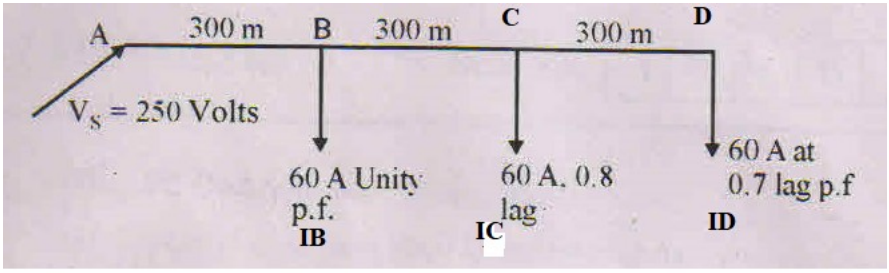
**( Any Two point expected: 1 Mark each : Total 2 Marks)**

1. Supply to distribution transformer center is given through two different generating stations or major generating stations
2. It has highest reliability to maintain supply even when there is a fault on any one feeder
3. It has highest reliability to maintain supply even when there was maintenance on any one feeder.

**f)** **A single phase AC distributor of 900 m length has total impedance of (0.03 + j 0.05) ohm and is fed from one end at 250 V. If it is 'loaded as in figure No. 1, calculate the voltage drop and voltage at far end.**




Ans:




$Z_T = Total\ \ impedance\ = 0.03 + j\ 0.05 ohm \quad given$

**Step-I:**

$I_B = 60 A, at\ Unity\ p.f.\ (L) = 60\angle 0^0\ A$

$I_B = 60 + j\ 0\ A$ ----------**(1/2 Marks)**

$I_C = 60 A, at\ \ p.f.\ = 0.8\ lag$

$I_C = 60\angle -36.86$

$I_C = 48.00 - j\ 36\ A$

$I_D = 60, at\ \ p.f.\ = 0.7\ lag$

$I_D = 60\angle -45.5729\ A$

$I_D = 42 - j\ 42.8485\ A$

$I_{AB} = I_B + I_C + I_D \qquad I_{AB} = (60 + j0) + (48.00 - j36) + (42 - j\ 42.8485)$

$I_{AB} = 150 - j\ 78.8485$

$I_{AB} = 169.4612\angle -27.7289\ \ A$ ----------**(1/2 Marks)**

$I_{BC} = I_B + I_C \qquad I_{BC} = (48.00 - j\ 36) + (42 - j\ 42.8485)$

$I_{BC} = 90 - j\ 78.8485$

$I_{BC} = 119.6540 \angle -41.2214 \ \ A$

$I_{CD} = I_D$

$I_{CD} = 42 - j\ 42.8485\ A$

**Step-II:**

$Z_T = Total \ \ impedance \ = 0.03 + j\ 0.05 ohm$

$Z_T = 0.05831 \angle 59.0362\,\Omega$

$Z_{AB} = Z_{BC} = Z_{CD}$

$Z_{AB} = Z_{BC} = Z_{CD} = \left[\frac{300}{900}(0.0583 \angle 59.0362)\right]$

$= \left[\frac{1}{3}(0.0583 \angle 59.0362)\right]$

$Z_{AB} = Z_{BC} = Z_{CD} = 0.0194 \angle 59.0362\,\Omega$ ----------**(1/2 Marks)**

**Voltage drop in section AB:-**

$= I_{AB} \times Z_{AB}$

$= (169.4612 \angle -27.7289) \times (0.0194 \angle 59.0362)$

$= 3.2875 \angle 31.3073 \quad Volts$

$V_{AB} = 2.8088 + j\ 1.7083 \quad Volts$ ----------**(1/2 Marks)**

**Voltage drop in section BC:-**

$= I_{BC} \times Z_{BC}$

$= (119.6540 \angle -41.2214) \times (0.0194 \angle 59.0362)$

$= 2.3213 \angle 17.8148^0 \quad Volts$

$V_{BC} = 2.2099 + j\ 0.7102 \quad Volts$ ---------- **(1/2 Marks)**

**Voltage drop in section CD:-**

$= I_{CD} \times Z_{CD}$

$= (60 \angle -45.5729^0) \times (0.0194 \angle 59.0362^0)$

$= 1.164 \angle 13.4633^0$ *Volts*

$V_{CD} = 1.1320 + j\,0.2710$ *Volts* ---------- **(1/2 Marks)**

**Total Voltage drop from A to D:-**

$= V_{AB} + V_{BC} + V_C$

$= (2.8088 + j1.7083) + (2.2099 + j\,0.7102) + (1.1320 + j\,0.2710)$

$= 6.1507 + j\,2.6895$ *Volts*

$= 6.7130 \angle 23.6182^0$ *Volts* ---------- **(1/2 Marks)**

**Voltage at far end:-** *Sending end volatge – Total volatge drop from A to D*

$= (250 + j\,0) - (6.1507 + j\,2.6895)$

$= 243.8493 - j\,2.6895$ *Volts*

$= 243.8493 \angle -0.6319^0$ *Volts* ---------- **(1/2 Marks)**

----------**END**----------