Zeal Education Society's

# ZEAL POLYTECHNIC, PUNE.

NARHE | PUNE -41 | INDIA

## SECOND YEAR (SY)

## DIPLOMA IN ELECTRICAL ENGINEERING

**SCHEME: I** **SEMESTER: IV**

**NAME OF SUBJECT: ELECTRICAL POWER TRANSMISSION AND DISTRIBUTION**

**SUBJECT CODE: 22419**

**MSBTE QUESTION PAPERS & MODEL ANSWERS**

1. **MSBTE SUMMER-19 EXAMINATION**
2. **MSBTE WINTER-19 EXAMINATION**

# 22419

**21819**

**3 Hours / 70 Marks** Seat No. | | | | | | | | |

*Instructions* – (1) All Questions are *Compulsory.*

(2) Illustrate your answers with neat sketches wherever necessary.

(3) Figures to the right indicate full marks.

(4) Assume suitable data, if necessary.

(5) Use of Non-programmable Electronic Pocket Calculator is permissible.

(6) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

**Marks**

**1. Attempt any FIVE of the following:** **10**

a) List standard voltage level used in India.

b) Define: voltage regulation of transmission line.

c) State the disadvantages of skin effect.

d) State four HVDC transmission line route on India with their voltage level.

e) Define: primary and secondary distribution system

f) State the classification of distribution substation.

g) State any four properties of conductor material used for overhead conductor.

**Marks**

**2. Attempt any THREE of the following:** **12**

a) Explain any four advantages of high voltage power transmission.

b) Describe the proximity effect and state its two disadvantages.

c) Draw and explain Bi-polar HVDC transmission line.

d) State the different methods of improving string efficiency. Explain any one method in detail.

**3. Attempt any THREE of the following:** **12**

a) Draw the single line diagram of AC electric transmission and distribution system.

b) Explain the Ferrantio effect in detail.

c) Explain the grid system of distribution and state its advantages.

d) Draw and explain the construction of underground cables.

**4. Attempt any THREE of the following:** **12**

a) State the classification of transmission lines based on voltage level and length of lines.

b) Draw the circuit diagram and phasor diagram of nominal T method of medium transmission line.

c) State the limitations of EHVAC transmission line.

d) Draw the single line diagram (layout) of 33/11 kV substation.

e) Explain the shackle type insulator with neat sketch.

**Marks**

**5. Attempt any TWO of the following:** **12**

a) Discuss the effect of transmission line parameters on the performance of transmission line (any six points).

b) Explain the features of flexible AC transmission line (any four). State types of FACTS controller.

c) A single phase AC distributor AB 300 M long is fed from end A and is loaded as under.

(i) 100 A at 0.707 pf lagging 200 m from point A.

(ii) 200 A at 0.8 pf lagging 300 m from point A
The load resistance and reactance of the distributor is 0.2 Ω and 0.1 Ω per kilometer. Calculate total voltage drop in the distributor. The load power factors refer to the voltage at the far end.

**6. Attempt any TWO of the following:** **12**

a) A 3 phase line of 4 km length delivers 4000 kW at a p.f of 0.8 lagging to a load the resistance and reactance per km of each conductor are 0.2 Ω and 0.5 ohm respectively if the voltage at the supply end is maintained at 11 kV. Calculate the received end voltage and efficiency of line.

b) Each line of a 3 ph system is suspended by a string of 3 similar insulators. If the voltage across the line unit is 17.5 kV, calculate the line to neutral voltage. Assume that the shunt capacitance between each insulator and earth is $1/8^{th}$ of the capacitance of insulator itself. Also find the string efficiency.

c) Draw the symbols and state their function of components used in substation (any six).

**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 FIVE of the following** | **10 Marks** |
|---|---|---|
| **a)** | **List standard voltage level used in India.** | |
| Ans: | **Standard voltage level used in India:** | **(2 Marks)** |
| | ➢ **Generation Voltage :** 3.3KV, 6.6KV,11KV and 17.5 KV,21KV (Now a days generation voltage is in the range of 11KV- 33KV)<br>➢ **Primary Transmission voltage :-** 220 KV, 400KV, 765 KV (750 KV)<br>➢ **Secondary Transmission voltage :-** 220 KV, 132 KV, 110 KV, 66 KV<br>➢ **Primary Distribution voltage :-** 33 KV, 22KV, 11 KV and for long distance line it may be 66 KV<br>➢ **Secondary Distribution voltage: -** 3-phase, 400 Volt, for single phase 230 Volt.<br>**OR**<br>➢ Standard Transmission voltages in India are 765 KV (750KV), 400KV, 220KV, 132KV, 110KV, 66KV, 33KV, 22KV, 11KV. | |
| **b)** | **Define: voltage regulation of transmission line.** | |
| Ans: | **voltage regulation of transmission line:** | **( 2 Marks)** |
| | Voltage regulation is nothing but voltage drop in transmission line expressed in | |

% of receiving end voltage

$$\% \textbf{ Regulation} = \frac{Sending\ \ End\ \ Voltage - \text{Re}\, ceiving\ \ End\ \ Voltage}{\text{Re}\, ceiving\ \ End\ \ Voltage} \times 100$$

$$\%regulation = \frac{No\ load\ receiving\ end\ voltage\ -\ \ Full\ loa}{}$$

**c) State the disadvantages of skin effect.**

Ans: **Disadvantages of skin effect:- ( Any Two point expected: 1 Mark each, Total 2 Marks)**

1. Full cross section of conductor is not utilized, Therefore effective area of conductor reduces so its resistance increases $(Since\ R = \rho\frac{l}{A})$
2. Due to increase in resistance, copper losses increases (Since copper losses = $I^2R$ )
3. So transmission efficiency reduces.
4. Due to increase in resistance, Voltage drop increases (Since Voltage drop = $IR$ )
5. So voltage regulation becomes poor (increases)

**d) State four HVDC transmission line route on India with their voltage level.**

Ans: **HVDC transmission line route on India with their voltage level:**
**( Any Four point expected: 1/2 Mark each, Total 2 Marks)**

| S.N. | From | To |
|---|---|---|
| 1 | Rihand | Dadri |
| 2 | Talcher | Kolar |
| 3 | Chandrapur | Padghe |
| 4 | Bersoor (M.P.) | Lower Sileru |
| 5 | Connecting Northern region (Sasaram- Pusawali) | Eastern Region |

| | | | |
|---|---|---|---|
| | | 6 | Connecting Northern region (Vindhyachal) | Western Region |
| | | 7 | Connecting Southern region (Chandrapur) | Western Region |
| | | 8 | Connecting Southern region(Vizag- Gajuwaka) | Eastern Region |

**e) Define: primary and secondary distribution system**

Ans:

**i) Primary Distribution:** **( 1 Mark)**

It is a 3-phase, 3-wire transmission line connected in between receiving substation to Distribution substation. **OR** It is link between receiving substation & distribution transformer

**ii) Secondary Distribution:** **( 1 Mark)**

It is a 3-phase, 4-wire Distribution line in between Distribution substation to consumer line. **OR** It is link between distribution transformer substation & consumer.

**f) State the classification of distribution substation.**

Ans:

**The classification of distribution substation.**

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

1. Pole mounted distribution substation
2. Plinth mounted distribution substation
3. Compact/prefabricated distribution substation
4. Underground distribution substation
5. Indoor distribution substation
6. Outdoor distribution substation
7. Mobile distribution substation

| | |
|---|---|
| **g)** | **State any four properties of conductor material used for overhead conductor.** |
| Ans: | **Following are the properties of conductor material:-**<br>**( Any Four point expected: 1/2 Mark each, Total 2 Marks)**<br>1. **High conductivity :-** Material should have high conductivity<br>2. **High mechanical strength:-** Material should have sufficiently high mechanical strength<br>3. **Flexible :-** Material should be flexible<br>4. **Weight: -** Material should be light in weight to reduce transportation & handling cost.<br>5. **High resistance to corrosion:-** Material should have high resistance to corrosion<br>6. **Brittleness: -** Material should not be brittle.<br>7. **Temperature coefficient of resistance:-** Material should have low temperature coefficient of resistance.<br>8. **Availability & cost: -** Material should be easily available & less costly.<br>9. **Scrap Value: -** Material should have high scrap value. |
| **Q. 2** | **Attempt any THREE of the following** **12 Marks** |
| **a)** | **Explain any four advantages of high voltage power transmission.** |
| **Ans:** | We know that, $P = \sqrt{3}\ V_L I_L \cos\phi$<br>For,<br>• Same power to be transferred<br>• At same power factor<br>• At same transmission line distance<br>$I \alpha \frac{1}{V}$ from This Equation It is clear that due to High Transmission Voltage<br>Following are the advantages Hence EHVAC Transmission is adopted:<br>**Advantages:** **( Any Four point expected: 1 Mark each, Total 4 Marks)**<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. |

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. As transmission voltage increases power handling capacity of transmission line increases (as P $\alpha$ $V^2$)
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.

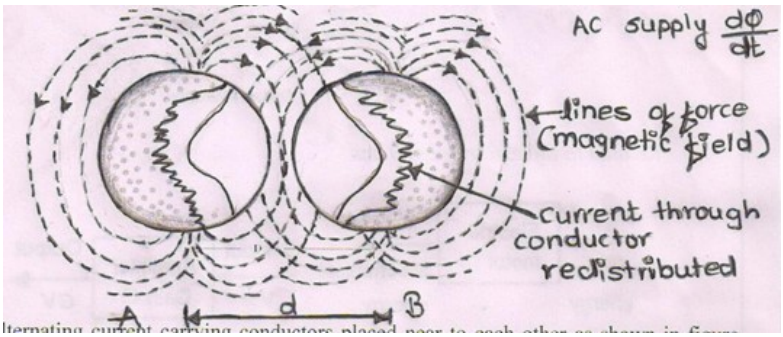
**Hence,** HVAC transmission line becomes necessary for bulk power to be transmitted over a long distance

**b) Describe the proximity effect and state its two disadvantages.**

**Ans:**

**Proximity effect:**

**( Figure: 1 Mark, Explanation: 2 Mark & disadvantages: 1 mark, Total 4 Marks)**




**Explanation:**

Let two alternating current carrying conductors placed near to each other as

shown in figure. Due to electro-magnetic action, flux produced by each conductor links with each other. Due to this super –impose of magnetic field on conductor causes current in each conductor is re-distributed. This is known as proximity effect.

**Disadvantages of proximity effect:- ( Any Two point expected)**

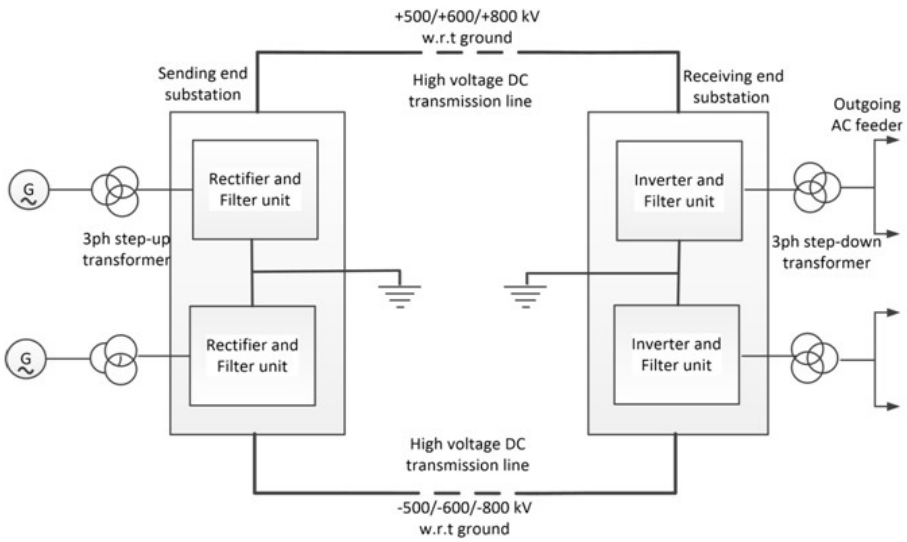
1. Current in each conductor is re-distributed
2. That is current is not uniformly distributed through cross section of conductor
3. Due to above two reasons Cross section of conductor is not fully utilized.
4. Therefore effective area of conductor reduces so its resistance increases

   $(Since\ R = \rho\frac{l}{A})$
5. Due to increase in resistance, copper losses increases (Since copper losses = $I^2R$ )
6. So transmission efficiency reduces.
7. Due to increase in resistance, Voltage drop increases (Since Voltage drop = $IR$ )
8. So voltage regulation becomes poor (increases)

**c) Draw and explain Bi-polar HVDC transmission line.**

Ans: **Bipolar HVDC transmission line (System):**

**( Figure : 2 Mark & Explanation: 2 Mark, Total 4 Marks)**




**or equivalent figure**

**Explanation:-**

- It has two conductors. One at positive potential & other at negative potential at same magnitude w.r.t. ground
- Both conductors operate at equal potential, so current at ground is zero.

**d) State the different methods of improving string efficiency. Explain any one method in detail.**

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 of 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 = $C_1/C$.

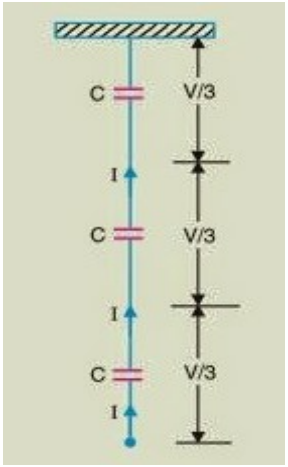
In order to reduce value shunt capacitance ($C_1$) distance of string of insulator from tower must be increased. i.e. by using longer cross arm. Due to this value of shunt capacitance ($C_1$) reduces.

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 :-**

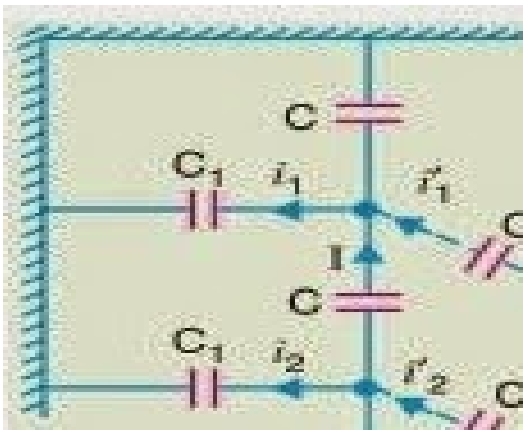
In this method, disc insulators of different dimensions are so selected that each disc has different capacitance. The assembly in the string of suspension insulator is made in such a way that the top unit insulator has fewer dimensions. (Less capacitance) ($C \alpha$ A) and dimensions of insulators progressively 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 increase 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**

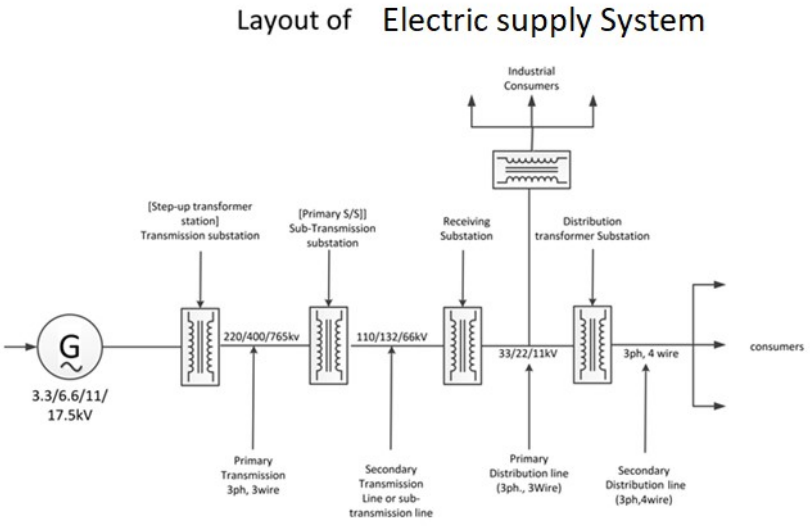
Guard ring is a metal ring electrically connected to conductor and surrounding the bottom insulator.

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

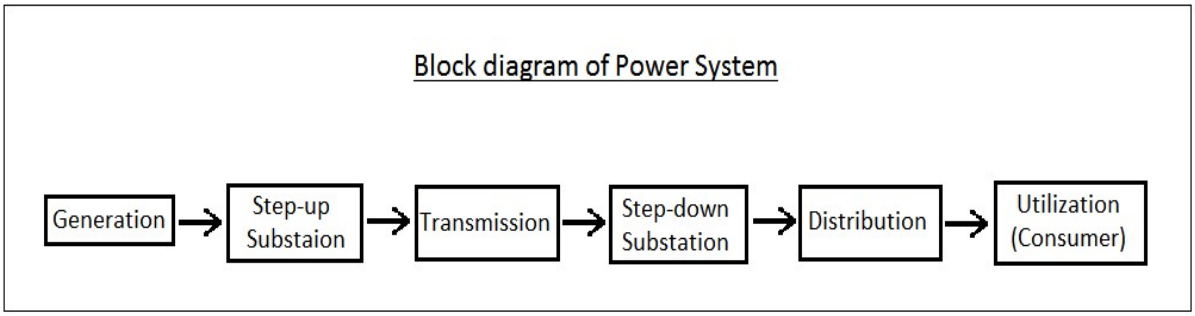
So, we will get uniform voltage distribution along the string of suspension insulator, In this way string efficiency increases.

| | | |
|---|---|---|
| **Q.3** | **Attempt any THREE of the following** | **12 Marks** |
| **a)** | **Draw the single line diagram of AC electric transmission and distribution system.** | |

Ans: **Single line diagram of AC electric transmission and distribution system : ( 4 Mark)**




**OR**

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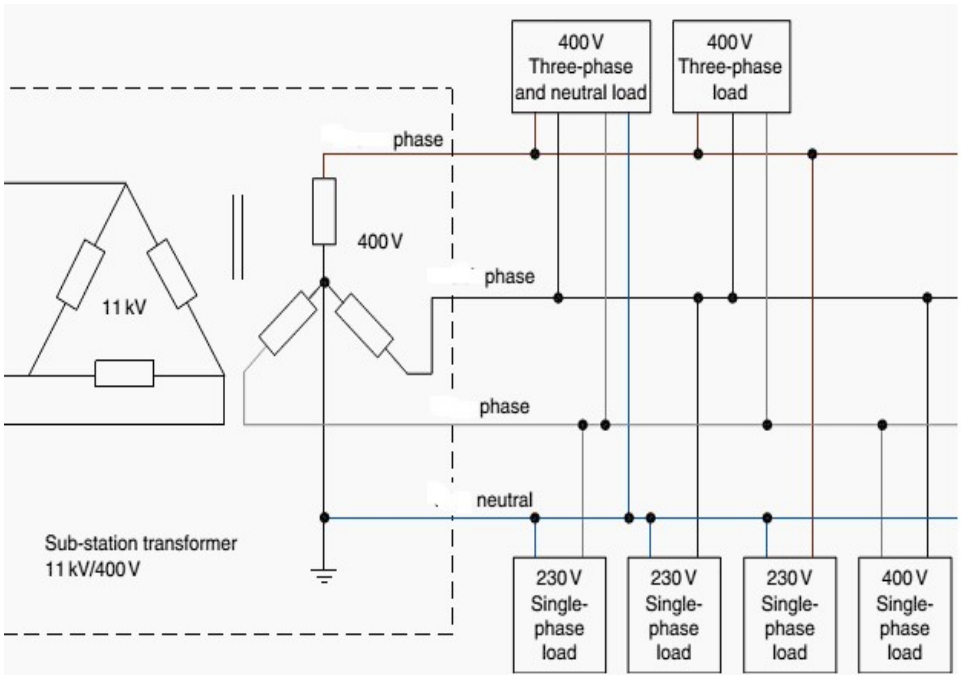



**b) Explain the Ferrantio effect in detail.**

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

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

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

**Ferranti effect :** **( 2 Marks)**

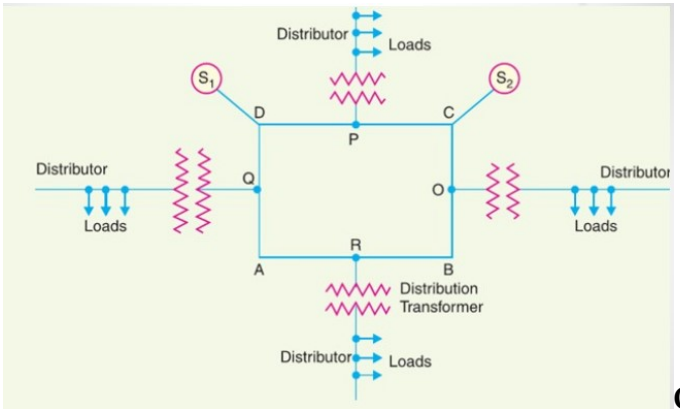
Under any one above condition, it is observe that receiving end voltage ($V_R$) is found to be greater than sending end voltage ($V_S$). This phenomenon is known as Ferranti effect.

**c) Explain the grid system of distribution and state its advantages.**

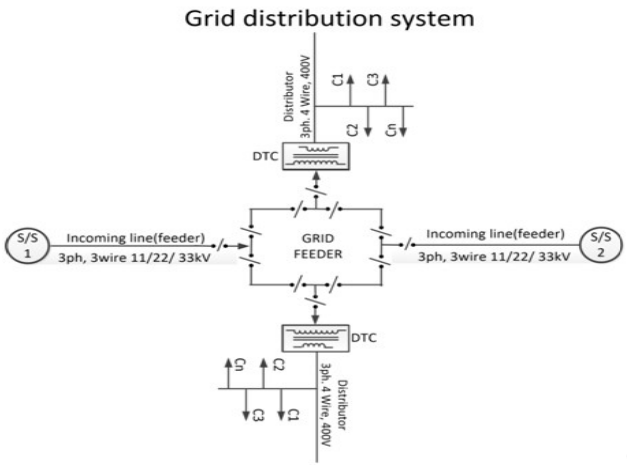
**Ans:** **Grid distribution system:-** **( 2 Marks)**

In this system, when the feeder or loop or ring is charged (energized) by two or more than two substations from two or more than two different generating stations then it is known as "Grid distribution system. In this system only one feeder is utilized at a time.

**Layout of Grid distribution scheme:** **( 1 Marks)**




**OR**




**or equivalent figure**

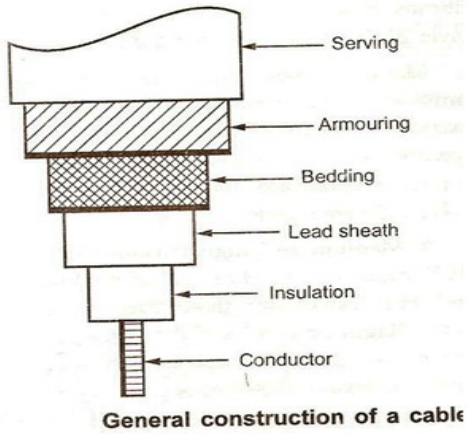
**Advantages of Grid distribution scheme:**

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

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.

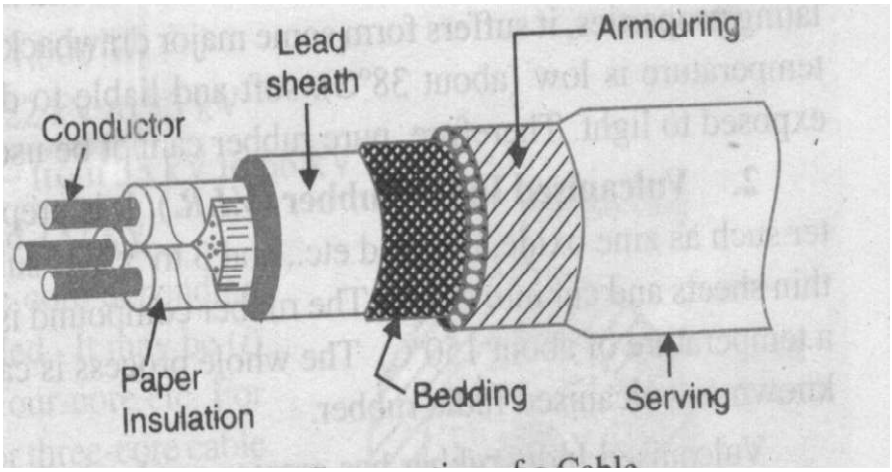
**d) Draw and explain the construction of underground cables.**

**Ans: Underground cables:** **( Diagram : 2 Mark & Explanation: 2 Mark, Total 4 Marks)**




General construction of a cable

**or equivalent figure OR**




**or equivalent figure**

**Explanation:-**

**i) Core or conductor:**

- It function is carry current.
- Cable may have single or more than single core conductor.
- Conductor are made up of copper or aluminium material
- Cross section of conductor is directly proportional to current. (Cross section of conductor depends upon current carrying capacity)
- Conductor used is -
  - Annealed
  - Tinned

**ii) Insulation:**

- Each core of conductor is provided with suitable thickness of insulation to avoid short circuit between two conductors.
- The thickness of insulation layer depends on **magnitude of voltage** for which it is designed.
- Commonly used materials for insulation are e.g.:-
  - PVC (Polyvinyl Chloride)
  - Polyethene
  - XLPE (Cross- linked polyethylene)

**iii) Lead (Metallic) Sheath:**

- It is provided over insulation.
- To provide the protection of core from entry of moisture, gases or other damaging liquids (acids & alkaline) in the soil & atmospheric.
- The metallic sheath is made up of lead or lead alloys recently aluminum is also being used as a metallic sheath.

**iv) Bedding:**

- Over the metallic sheath there is layer of bedding.
- The function of bedding is protecting the metallic sheath against corrosion &

from the mechanical injury due to armouring.

- It is made from fibrous material such as jute, hessian tape

**v) Armouring:**

- This layer is over a bedding only for underground cable and not for over head cable
- Its function is to protect the cable from mechanical injury.
- It covers the bedding, which consists of 1 or 2 layers of galvanized steel wire or steel tapes

**vi) Serving:**

- This layer is last layer which comes over armouring.
- Its function is to protect armouring against rusting and it also helps for easy handling of cables.
- It is similar to bedding & consists of fiborous material such as jute.

| Q.4 | **Attempt any THREE of the following** | **12 Marks** |
|---|---|---|
| **a)** | **State the classification of transmission lines based on voltage level and length of lines.** | |

Ans:

**A) According to Voltage level:** **( 2 Marks)**

a) High voltage Transmission Line (HV) up to 33 KV

b) Extra High Voltage Transmission Line (EHV) above 33 KV up to 400 KV

c) Ultra High voltage Transmission Line (UHV) above 400 KV

**B) According to Length of Transmission line:** **( 2 Marks)**

a) Short Distance Transmission Line - (up to 50 KM)

b) Medium Distance Transmission Line - (up to 50 to 150 KM)

c) Long Distance Transmission Line - (above 150 KM)

**OR**

1) **Short Transmission Line: -** The length of Short transmission Line is up to **50KM** and its line voltage is less than **20 KV**

2) **Medium Transmission Line: -** The length of Medium transmission Line is up to

**50KM- 150KM** and its line voltage is between **20KV to** 100 **KV**

3) **Long Transmission Line: -** The length of Long transmission Line is above **150KM** and its line voltage is above **100K**

**OR**

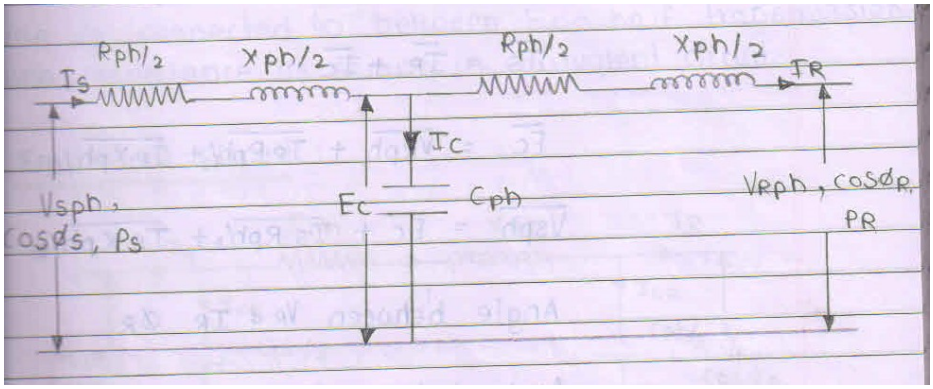
1) **Short Transmission Line: -** The length of Short transmission Line is up to **80KM** and its line voltage **is less than 20 KV**

2) **Medium Transmission Line: -** The length of Medium transmission Line is up to **80KM- 200KM** and its line voltage is between **20KV to 100 KV**

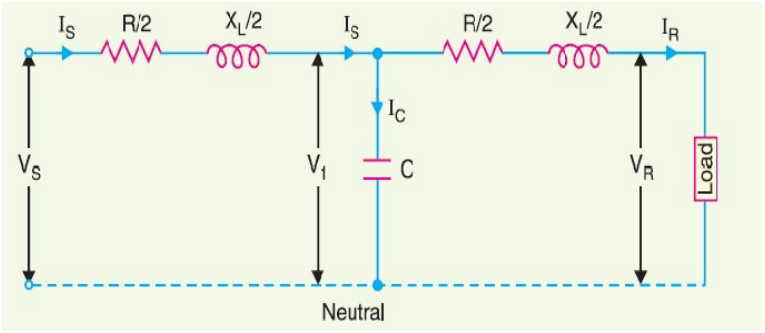
3) **Long Transmission Line: -** The length of Long transmission Line is above **200KM** and its line voltage is above **100KV**

**b)** **Draw the circuit diagram and phasor diagram of nominal T method of medium transmission line.**

Ans: **Circuit Diagram:-** **( Diagram: 2 Mark & Vector diagram: 2 Mark: Total 4 Marks)**

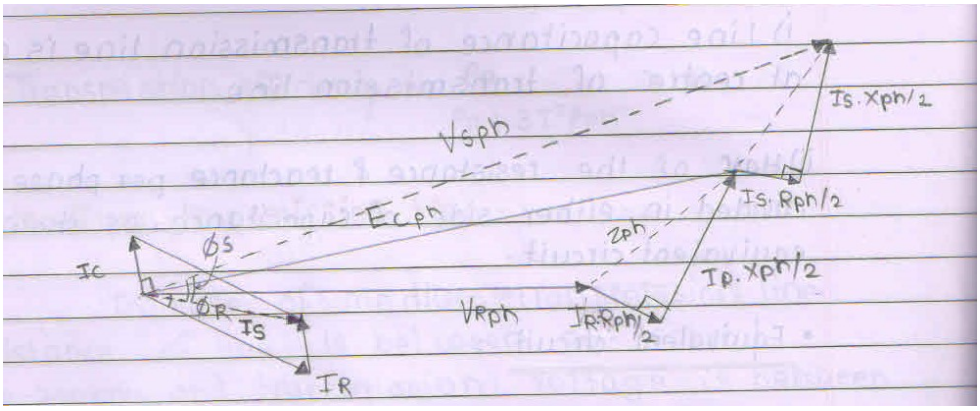



**OR**



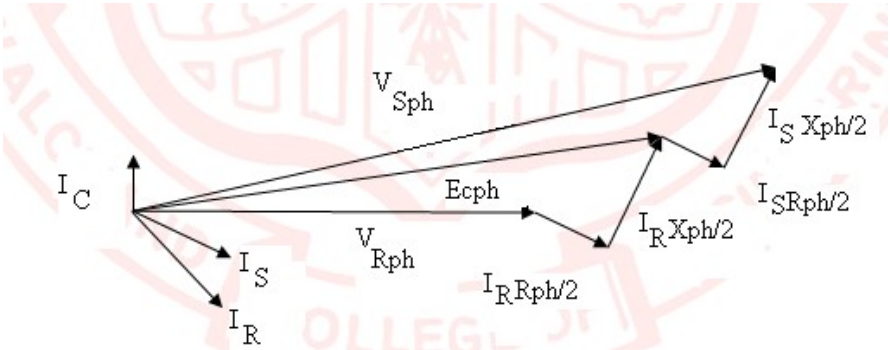

**or equivalent figure**

**Vector Diagram:-**




**or equivalent figure**

**OR**

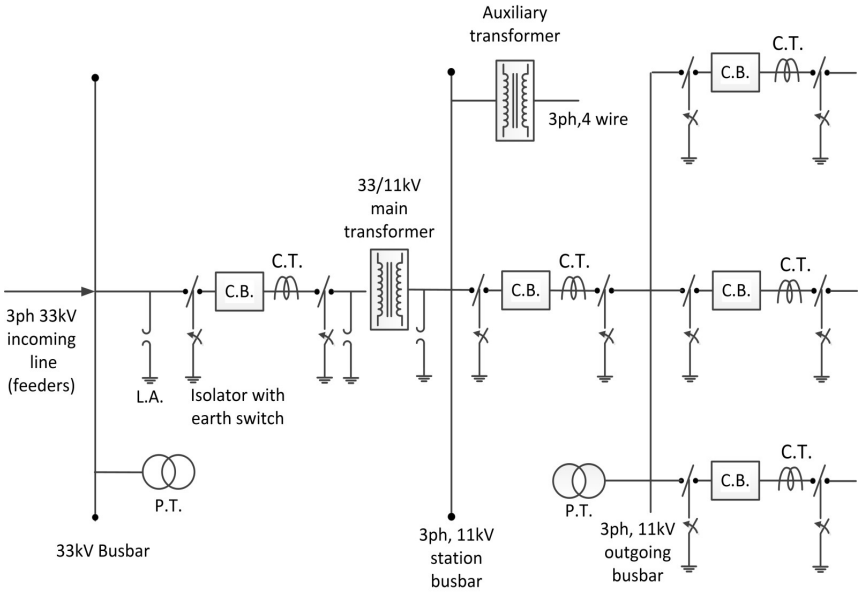



**c) State the limitations of EHVAC transmission line.**

Ans: **Following are the Limitations of EHVAC Transmission:**

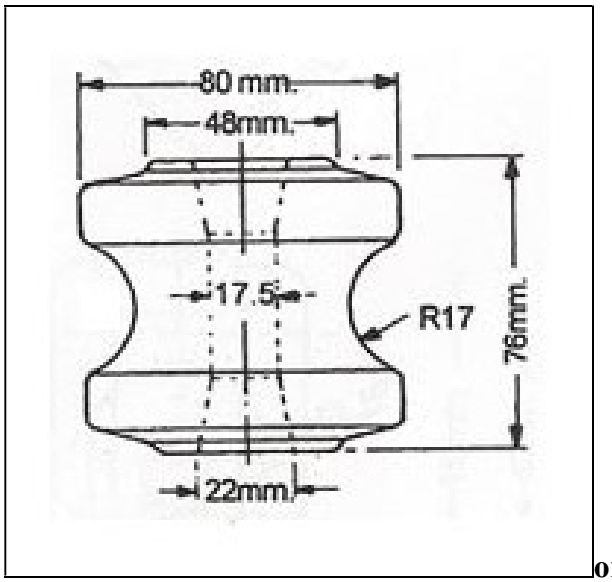
**( Any four point expected: 1 each point, Total 4 Marks)**

1. Insulation cost increases as voltage increases
2. Skin effect is more
3. Proximity effect is more.
4. Corona loss increases.
5. Radio interference increases
6. String efficiency is less than100%
7. Ground return not possible.
8. Voltage control is not easily possible.
9. Power flow cannot be easily controlled.
10. Short circuit current level is more

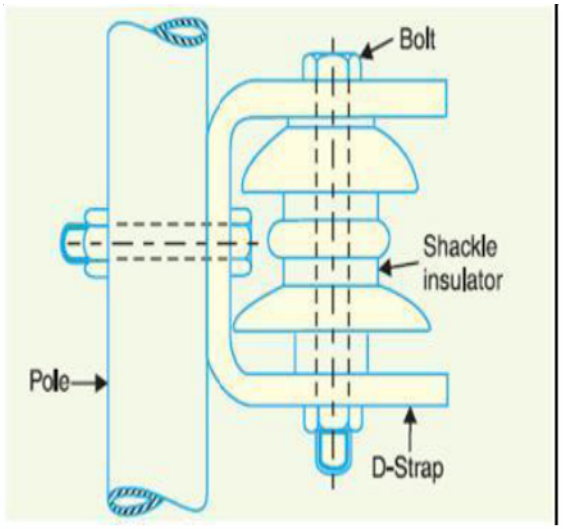
| | |
|---|---|
| | 11. In case of EHVAC, Intermediate substation is required at every 250 km to improve the performance of transmission line<br>12. If power is to be transmitted of EHVAC through underground cable then there is limitation on the length of cable due to charging current. e.g. for 400 KV line limitation on length of cable is 25 Km<br>13. Asynchronous tie not possible.<br>14. Stability of EHVAC is very low because of presence of inductance.<br>15. Transient performance is poor.<br>16. There is limitation on power transfer due to presence of inductance of transmission line & power angle.<br>17. To improve the performance of transmission line additional equipments such as series & shunt reactor & capacitor are required which increases cost of substation.<br>18. EHVAC is economical only for bulk amount of power is to be transmitted over long distance. |
| **d)** | **Draw the single line diagram (layout) of 33/11 kV substation.** |
| Ans: | **single line diagram (layout) of 33/11 kV substation :** **( 4 Marks)**<br>Layout of 33kV Substation<br>  <br><br>**OR Equivalent** |

| e) | Explain the shackle type insulator with neat sketch. |
|---|---|
| Ans: | **Shackle type insulator with neat sketch:** |

**( Figure : 2 Mark, Explanation: 2 Marks, Total : 4 Marks)**




**or**




**Explanation:**

- These insulators are clamped to the cross arms by one metal '**U**' clamp with the help of bolts, nuts & washers.
- Function of Shackle insulator is to reduce excessive tension on line. Also on supporting structure (pole).

**Applications:**

1) Shackle insulators are used in following circumstances when line is subjected excessive tension. E.g. shackle insulators are used below 11 KV line & above 11 KV line strain insulators are used

2) Shackle insulators are also used when line is going straight but in case of vertical conductor configuration only

| Q.5 | Attempt any TWO of the following 12 Marks |
|---|---|
| a) | **Discuss the effect of transmission line parameters on the performance of transmission line (any six points).** |
| Ans: | **Following are the effect on performance of transmission line:**<br>**( Any Six point expected: 1 Marks each, Total 6 Marks)**<br>1. Due to resistance (R), voltage drop in transmission line produces<br>2. Due to resistance (R), copper losses in transmission line produces.<br>3. Due to inductance (L) voltage drop in transmission line produces.<br>4. Capacitor (C) draws charging current through transmission line. This charging current produces additional copper losses & voltage drop in transmission line.<br>5. Due to above reasons, transmission line efficiency gets affected<br>6. voltage regulation of transmission line gets affected<br>7. Also power factor of transmission line gets affected |
| b) | **Explain the features of flexible AC transmission line (any four). State types of FACTS controller.** |
| Ans: | **Features of flexible AC transmission line:- ( Any Four features expected: 1 Mark each, l 4 Mark & Types: 2 Mark, Total 6 Marks)**<br>1. FACTS increase the reliability of AC grids.<br>2. It controls the voltage under various load condition<br>3. It balance reactive power (both lagging and leading reactive power)<br>4. It improves power quality<br>5. It increases transmission efficiency<br>6. It also help to solve technical problems in the interconnected power system.<br>7. They reduce power delivery costs.<br>8. There is fast voltage regulation. |

9. Increased power transfer over long AC lines.
10. Better utilization of the network,
11. Increased availability and reliability
12. As well as improved network stability are achieved along with higher supply quality.

**OR**

- In conventional AC transmission system the ability to transfer AC power is limited due to various reasons.
- So the actual amount of power transferred to the load (active power) is always less than apparent power.
- For ideal transmission, the active power should be equal to apparent power.
- The main purpose of facts to obtain active power nearly equal to apparent power by supplying lagging reactive power or leading reactive power as per requirements.
- For this, FACTS uses static power electronics devices for series & shunt compensation automatically as per requirements.

**Types of FACTS controller:-**

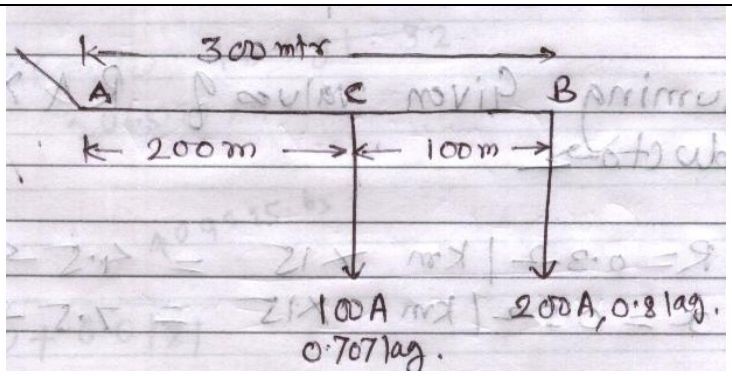
**Examples of FACTS for series compensation :- ( Any one types expected)**

1. Thyristor-controlled series reactor (TCSR)
2. Thyristor-controlled series capacitor (TCSC)

**Examples of FACTS for shunt compensation:- ( Any one types expected)**

1. Static synchronous compensator (STATCOM)
2. Static VAR compensator (SVC)

| | |
|---|---|
| c) | **A single phase AC distributor AB 300 M long is fed from end A and is loaded as under. (i) 100 A at 0.707 pf lagging 200 m from point A. (ii) 200 A at 0.8 pf lagging 300 m from point A, The load resistance and reactance of the distributor is 0.2 ohm and 0.1 ohm per kilometer. Calculate total voltage drop in the distributor. The load power factors refer to the voltage at the far end.** |
| Ans: | **Given data:** |




$R_T = 0.2$ ohm/km $X_T = 0.1$ ohm/km $\therefore Z_T = (0.2 + j0.1)\Omega / km$

**Step :1 : Section Impedance:-**

$$Z_{AC} = \frac{200}{1000}(0.2 + j0.1)$$

$$Z_{AC} = 0.04 + j0.02$$

$$Z_{AC} = 0.0447 \angle 26.57^0 \ ohm$$ ---------- **(1/2Marks)**

$$Z_{CB} = \frac{100}{1000}(0.2 + j0.1)$$

$$Z_{CB} = 0.02 + j0.01$$

$$Z_{CB} = 0.022 \angle 26.57^0 \ ohm$$ ---------- **(1/2Marks)**

**Step :2: Calculate Section Current:**

**Given, $I_B$ = 200A, 0.8 lag**

$$200 \angle -36.87^0$$

$$160 - j120 \ Amp$$ ---------- **(1/2Marks)**

**Given, $I_C$ = 100A, 0.707 lag**

$$100 \angle -45^0$$

$$70.71 - j70.71 \ Amp$$ ---------- **(1/2Marks)**

**Section Current:** $I_{CB} = I_B$

**Section Current:** $I_{AC} = I_C + I_B$

$= (70.71\text{-}j70.71) + (160\text{-}j120)$

$= 230.71\text{-}j190.71$

$I_{AC} = 299.3282 \angle -39.5778 \ Amp$ ---------- **(1/2Marks)**

**Step :3: Calculate Voltage drop in section AC:-**

$$V_{AC} = I_{AC} \times Z_{AC}$$ ---------- **(1/2Marks)**

$$= (299.3282 \angle -39.5778)\ (0.0447 \angle 26.57)$$

$$= 13.37997054 \angle -13.0078\ V$$

$$= 13.0366 - j\ 3.01161\ V$$ ---------- **( 1/2 Mark)**

**Calculate Voltage drop in section BC:-**

**= $I_{CB}$ X $Z_{CB}$**---------- **(1/2Marks)**

$$= (200 \angle -36.87)\ (0.02236 \angle 26.565)$$

$$= 4.48 \angle -10.3 \quad Volts$$

$$V_{BC} = 4.407 - j\ 0.80 \quad Volts$$---------- **(1/2Marks)**

**Step 4: Calculate total voltage drop in distributor $V_{AB}$ :-**

**Voltage drop in section BC + Voltage drop in section AC**

$$= (4.407 - j\ 0.80) + (13.0366 - j\ 3.01161)$$

$$= 17.9936 - j\ 3.8116\ Volt$$---------- **( 1 Mark)**

$$V_{AB} = 17.8552 \angle -12.359\ Volt$$

**Step 5: Calculate Load power factor :-**

$$= Cos\ (12.3259)$$

$$= 09769\ lagging$$ ---------- **(1/2Marks)**

| Q.6 | **Attempt any TWO of the following** | **12 Marks** |
|---|---|---|
| **a)** | **A 3 phase line of 4 km length delivers 4000 kW at a p.f of 0.8 lagging to a load the resistance and reactance per km of each conductor are 0.2 ohm and 0.5 ohm respectively if the voltage at the supply end is maintained at 11 kV. Calculate the received end voltage and efficiency of line.** | |

Ans: $P_R$ = 4000KW= 4000 x $10^3$ W, $V_R$ = 11KV= 11 x$10^{3V}$ , P.F. = 0.8 lag, R Per conductor =0.2 ohm, X Per conductor = 0.5 ohm

$V_{Rph}$ = $V_{RPh} \equiv \frac{11 \times 10^3}{\sqrt{3}}$ $V_{R_{Ph}} \equiv 6.3508 \times 10^3 V$

**To Calculate Total /loop values of R & X**

Total resistance $R_T$ = 4 R= 0.2× 4= 0.8 ohm

Total Reactance $X_T$ = 4 X =0.5×4= 2 ohm **Step 1: To calculate current:**

Power P = $VI\cos\phi$

$$I \equiv \frac{P}{\sqrt{3}\, V_L \cos\phi}, \quad I \equiv \frac{4000\times10^3}{\sqrt{3}\times11\times10^3\times0.8}$$

$$I \equiv 262.4319\, amp$$ ---------- **( 1 Mark)**

**Step 2: To calculate Total Line Losses:**

$$\text{Total Line Losses} = 3\, I^2\, R_{Ph}$$

$$= 3\,(262.4319)^2 \times 0.8$$

$$= 16289.2051 \text{ Watt}$$ ---------- **( 1 Mark)**

**Step 3: To calculate Total Transmission efficiency:**

$$\%\,\eta_T = \frac{P_R}{P_R + I^2 R_{Lossses}} \times 100$$ ---------- **( 1/2 Mark)**

$$\%\,\eta_T = \frac{4000\times10^3}{4000\times10^3 + 165289.2051} \times 100$$

$$\%\,\eta_T = 69.0317\%$$ ---------- **( 1 Mark)**

**Step 6:To calculate % regulation:**

$$\%\text{ Voltage Regulation} = \frac{I\,(R_{ph}\, Cos\phi R \pm X_{Ph}\, Sin\phi_R}{V_R} \times 100$$ ---------- **( 1/2 Mark)**

$$= \frac{262.4319\,(0.8\times0.8 + 2\times0.6)}{6.3508\times10^3} \times 100$$

$$= 7.6034\ \%$$ ---------- **(1 Mark)**

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

$$\mathbf{V_{Sph}} = V_R + I\left(R_{RPh}\cos\phi_R + X_{Ph}\sin\phi_R\right)$$ ---------- **( 1/2 Mark)**

$$= 6.3508\times10^3 + 262.74\,(0.8\times0.8 + 2\times0.6)$$

$$= 6.3508\times10^3 + 483.4416$$

$$V_{SPh} = 6833.6747 \text{ volt}$$

$$V_{SL} = 6833.6747 \times \sqrt{3}$$

$$V_{SL} = 11836.2718 \text{ volt}$$ ---------- **( 1/2 Mark)**

**b) Each line of a 3 ph system is suspended by a string of 3 similar insulators. If the voltage across the line unit is 17.5 kV, calculate the line to neutral voltage. Assume that the shunt capacitance between each insulator and earth is 1/8th of the capacitance of insulator itself Also find the string efficiency.**

Ans:

**$V_L$ = 17.5 KV**

**i) Ratio of capacitance 'm' :-**

$$m = \frac{1}{8} = 0.125$$

**k = m = 0.125** ---------- **( 1 Mark)**

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

$$V_3 = V_1 (1 + 3 \times 0.125 + (0.125)^2)$$

$$17.5 = 1.3906 \; V_1$$

$$V_1 = \frac{17.5}{1.390625}$$

$V_1$ = 12.58426966 KV

---------- **( 1 Mark)**

**ii)** $V_2 = V1 (1 + m)$

$$V_2 = V_1 (1 + 0.125)$$

$V_2$ = 12.58426966 x 1.125

$V_2$ = 14.15730337

---------- **( 1 Mark)**

**iii) Voltage across string = Vph** = $V_1 + V_2 + V_3$

= 12.58426966 +14.15730337 +17.5

$V_{Ph}$= 44.24157336 KV

---------- **( 1 Mark)**

**vi) String efficiency :-**

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

$$\text{String } \eta\% \equiv \frac{10.1036}{3 \times 17.5} \times 100$$

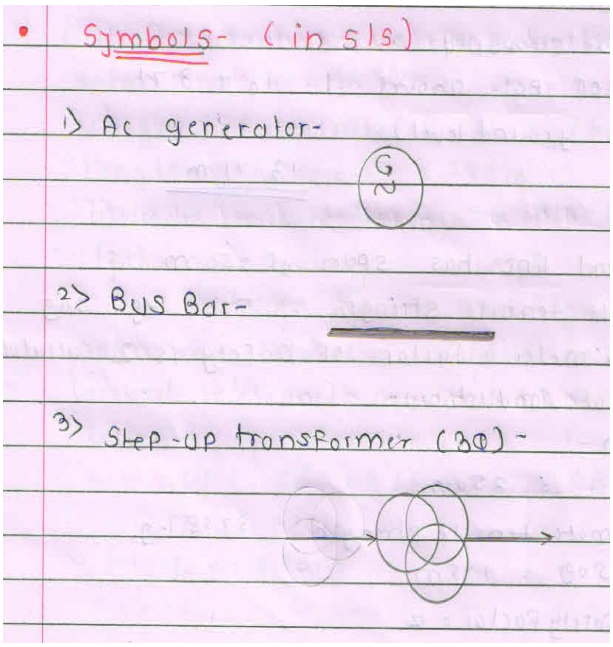
$$\text{String } \eta\% \equiv 84.2696\ \%$$

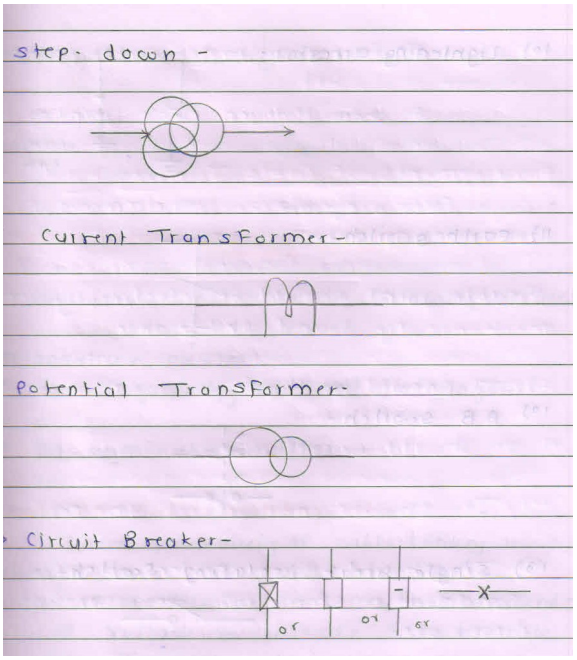
---------- **( 1 Mark)**

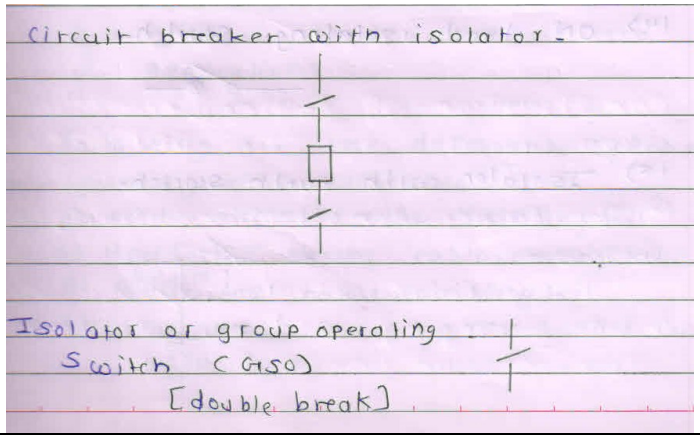
**c) Draw the symbols and state their function of components used in substation (any six).**

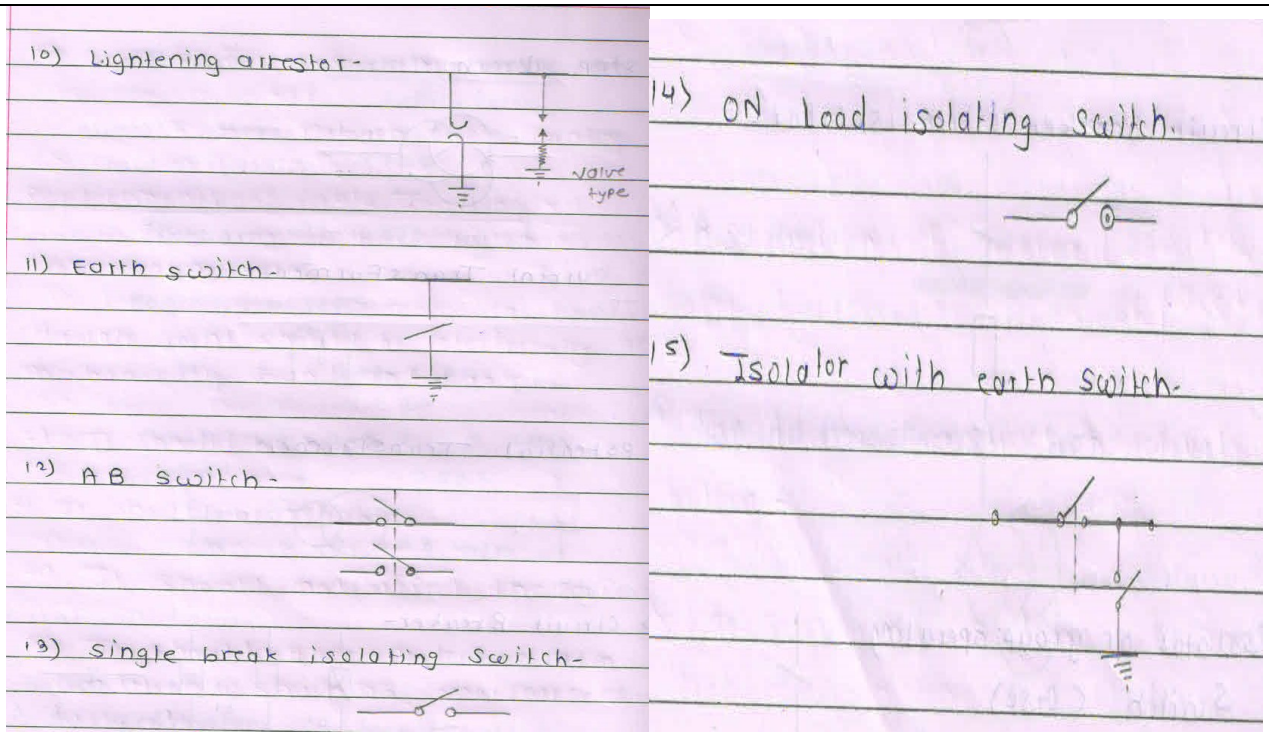
Ans: **Symbols in Sub- Station:**

**( Any six symbol from following are equivalent : 1/2 Mark & their function 1/2 Mark expected: 1 Mark each, Total 6 Mark)**

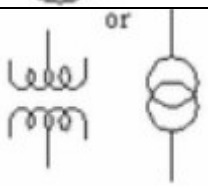
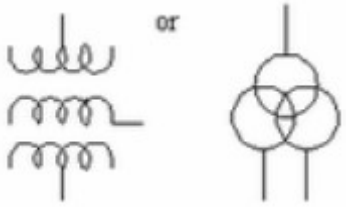
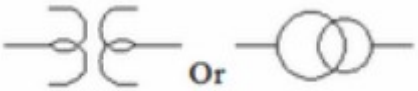
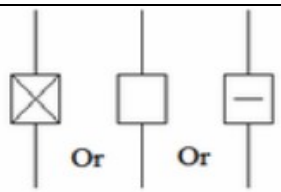
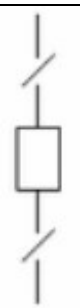


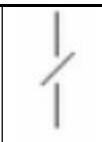
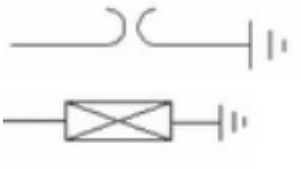
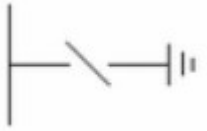
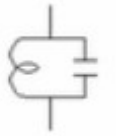
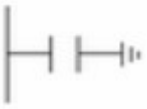
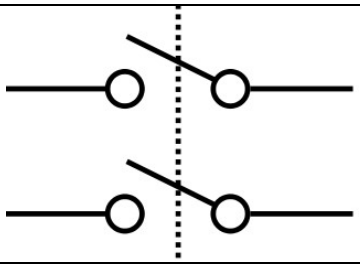






**OR**

| Electrical Equipment | Symbols | Electrical Equipment | Symbols |
|---|---|---|---|
| A C Generator |  | Bus Bar |  |
| Power Transformer- Two winding |  | Three Winding Transformer |  |
| Current Transformer (CT) |  | Voltage Transformer or Potential transformer (PT) |  |
| Circuit Breaker |  | Circuit Breaker with isolator |  |

| | | | |
|---|---|---|---|
| **Isolator or Group Operating Switch (GOS)** |  | **Lightening Arrestor (L.A)** |  **OR** |
| **Earth Switch (ES)** |  | **Wave or Line trap** |  |
| **Coupling Capacitor (CC)** |  | **A B Switch** |  |

**List of the equipment's, circuit elements in substation & their function:**

**1) Bus bar: -**

Bus bar is common conductor to which incoming & outgoing lines are connected

**2) Power Transformer (Main transformer) :-**

Its function is to step down the incoming voltage (e.g.33 KV) to outgoing voltage (22/11KV) without change in frequency. Its rating is in MVA.

It is installed on strong concrete foundation (plinth). It is oil cooled also air blast cooling system is provided.

**3) Auxiliary Transformer (Station transformer): -**

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,

**4) Lightning Arrester:** -

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.

**5) Earth switch: -**

Its function is to discharge the ground capacitance when line is open circuited for maintenance purpose by isolator.

**6) Isolator (No load Switch): -**

Its function is to connect or disconnect the circuit only when there is no load.

**7) Circuit Breaker: -** It is protective device. It open or break the circuit whenever there is fault & protect the equipment. It can be operated manually or remote control whenever required.

**8) Relay:**

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.

**9) Instrumental Transformer (CT & PT)**:-

C.T & P.T are used for measurement of electrical quantities (Current, voltage, power & energy) also C.T. is used for protection purpose as a part of tripping circuit of C.B.

**10) Horn Gap Fuse: -**

It is provided to primary side of transformer for protection against over current.( Its frame shape is like a Horn gap due to which arc /spark will extinguish quickly) If C.B. is installed on primary side of transformer than Horn gap fuse is not provided.

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

# 22419

**11920**

**3 Hours / 70 Marks** Seat No. | | | | | | | | |

*Instructions* – (1) All Questions are *Compulsory.*

(2) Illustrate your answers with neat sketches wherever necessary.

(3) Figures to the right indicate full marks.

(4) Assume suitable data, if necessary.

(5) Attempt answers in sequential order, preferably.

(6) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

**Marks**

**1. Attempt any FIVE of the following:** **10**

a) State the meaning of Single line diagram

b) State the classification of transmission lines depending on length of transmission lines.

c) State the type of distribution substation.

d) List different transmission line components used for power transmission. (any four)

e) State features of wireless power transmission.

f) State line parameters of transmission line.

g) Define voltage regulation and Transmission Efficiency.

**Marks**

**2. Attempt any THREE of the following:** **12**

a) Differentiate between overhead transmission and underground transmission.

b) Draw the layout of Homopolar transmission line.

c) State the advantages of use of high voltage in transmission of Electric power.

d) Draw the layout of power system indicating Generation, Transmission and distribution parts.

**3. Attempt any THREE of the following:** **12**

a) Draw the diagram representing transposition of conductor and state its importance.

b) State the standard voltage in India for Generation, transmission distribution system.

c) List the factors to be considered while designing feeders and distribution with their functions in brief.

d) State advantages and disadvantages of radial distributor system.

**4. Attempt any THREE of the following:** **12**

a) List classification of distributor system with their advantages each. (any two)

b) A 3-$\phi$ overhead line supported by 6 disc insulators, the potential across the unit is 11 KV. Assuming shunt capacitance between each Insulator and each metal link is of 1/5th of capacitance of insulator. Calculate :

(i) line voltage

(ii) string efficiency.

c) State the meaning of skin effect and how can it be minimised.

d) Draw the diagram of pin type and suspension type insulators.

e) State the effects of low power factor on efficiency and voltage regulation of short transmission lines.

f) State the condition for selecting site for distribution substation.

**Marks**

**5. Attempt any TWO of the following:** **12**

a) Derive equation for string efficiency with 3 - disc insulators of suspension type.

b) Define Corona, List its causes and state how can it be avoided. (two each)

c) State the meaning of ferranti effect and proximity effect.

**6. Attempt any TWO of the following:** **12**

a) Compare nominal - I and nominal - II method of transmission line (Any six points)

b) State the meaning of FACTS and explain in brief d-types facts controller.

c) (i) List the properties of line insulators in brief.

(ii) List the methods of Line Support Erection and explain in brief any one.

**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 FIVE of the following** | **10 Marks** |
|---|---|---|
| **a)** | **State the meaning of Single line diagram** | |
| Ans: | **Meaning of Single line diagram: (Or equivalent)** **(2 Marks)**<br><br>The single line diagram of a power system is the network which shows the main connections and arrangement of the system components along with their data (such as output rating, voltage, resistance and reactance, etc.).<br><br>**OR**<br><br>In power engineering, a one-line diagram or single-line diagram (SLD) is a simplified notation for representing a three-phase power system. Electrical elements such as circuit breakers, transformers, capacitors, bus bars, and conductors are shown by standardized schematic symbols. | |
| **b)** | **State the classification of transmission lines depending on length of transmission lines.** | |
| Ans: | **According to Length of Transmission line:** **( 2 Marks)**<br><br>a) Short Distance Transmission Line - (up to 50 KM)<br><br>b) Medium Distance Transmission Line - (up to 50 to 150 KM)<br><br>c) Long Distance Transmission Line - (above 150 KM) | |

**OR**

1) **Short Transmission Line: -** The length of Short transmission Line is up to **50KM** and its line voltage is less than **20 KV**

2) **Medium Transmission Line: -** The length of Medium transmission Line is up to **50KM- 150KM** and its line voltage is between **20KV to** 100 **KV**

3) **Long Transmission Line: -** The length of Long transmission Line is above **150KM** and its line voltage is above **100K**

**OR**

1) **Short Transmission Line: -** The length of Short transmission Line is up to **80KM** and its line voltage **is less than 20 KV**

2) **Medium Transmission Line: -** The length of Medium transmission Line is up to **80KM- 200KM** and its line voltage is between **20KV to 100 KV**

3) **Long Transmission Line: -** The length of Long transmission Line is above **200KM** and its line voltage is above **100KV**

**c) State the type of distribution substation.**

Ans: **The classification of distribution substation.**

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

1. Pole mounted distribution substation
2. Plinth mounted distribution substation
3. Compact/prefabricated distribution substation
4. Underground distribution substation
5. Indoor distribution substation
6. Outdoor distribution substation
7. Mobile distribution substation

| | |
|---|---|
| **d)** | **List different transmission line components used for power transmission. (any four)** |
| Ans: | **Following are the Transmission line components used for power transmission line:-**<br>**( Any Four components are expected: 1/2 Mark each, Total 2 Marks)**<br>1. Supporting structure (pole)<br>2. Line insulator<br>3. Overhead conductor<br>4. 'V' Cross arm<br>5. Top pin support<br>6. Two Pin Cross arm<br>7. Four pin cross arm<br>8. Stay set (Stay wire of 7/8 or 7/10 SWG)<br>9. Lighting arrestors<br>10. Guarding wires<br>11. Continuous earth wire<br>12. Cables<br>13. Fuses and Isolating switches<br>14. Different types of fabrication Clamp (A-type, B-Type)<br>15. Bird guards<br>16. Vibration damper<br>17. Jumpers |
| **e)** | **State features of wireless power transmission.** |
| Ans: | **Features of wireless power transmission:**<br>**( Any four point expected: 1/2 Mark each, Total 2 Marks)**<br>1. Energy delivered anywhere in the world<br>2. Zero fuel cost |

3. Less losses
4. Less use of copper wires
5. More efficiency
6. Minimum long-range environmental impact

OR

**Features of wireless power transmission:**

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

1. An electrical distribution system, based on this method would eliminate the need for an inefficient, costly, and capital intensive grid of cables, towers, and substations.
2. It will rid the landscape of wires, cables, and transmitting towers.
3. The electrical energy can be economically transmitted without wires to any terrestrial distance, so there will be no transmission and distribution loss.
4. More efficient energy distribution systems and sources are needed by both developed and under developed nations.
5. To transmit wireless power to any distance without limit. It makes no difference what the distance is.
6. The power failure due to short circuit and fault on cables would never exist in the transmission.
7. Power theft would be not possible at all.

| | |
|---|---|
| **f)** | **State line parameters of transmission line.** |
| Ans: | **Following are the of Line parameters of transmission line:** **( 2 Marks)** |

1. Resistance
2. Inductance
3. Capacitance

**g) Define voltage regulation and Transmission Efficiency.**

Ans:

**Define voltage regulation of transmission line:** **( 1 Marks)**

Voltage regulation is nothing but voltage drop in transmission line expressed in % of receiving end voltage

$$\% \textbf{ Regulation} = \frac{Sending\ \ End\ \ Voltage - \text{Re}ceiving\ \ End\ \ Voltage}{\text{Re}ceiving\ \ End\ \ Voltage} \times 100$$

$$\%regulation = \frac{No\ load\ receiving\ end\ voltage\ -\ \ Full\ load\ receiving\ end\ voltage}{Full\ load\ receiving\ end\ voltage} 100\%$$

**Define Transmission efficiency:-** **( 1 Marks)**

$$Transmission\ \ Efficency\ \ = \frac{Output\ \ power\ \ \ at\ receiving\ \ \ end}{Input\ \ power\ \ \ at\ sending\ \ \ end} \times 100$$

$$\eta_{\ T}\ \% = \frac{Output\ (P_R)\ (Load\ (power)\ at\ reciving\ \ end)}{Output\ (P_R) + Total\ \ losses} \times 100$$

**Where, $P_R$ is o/p power at receiving end**

**OR**

**% Efficiency =**

$$\frac{P_R}{P_R + I^2 R_T} \times 100 \quad ------\text{for} - 1 - \text{Phase} \qquad \text{Where, } R_T \text{ is total resistance}$$

**OR**

**% Efficiency =**

$$\frac{P_R}{P_R + 3\, I^2 R_{ph}} \times 100 \quad ------\text{for} - 3 - \text{Phase} \qquad \text{Where, R is resistance of per phase}$$

**OR**

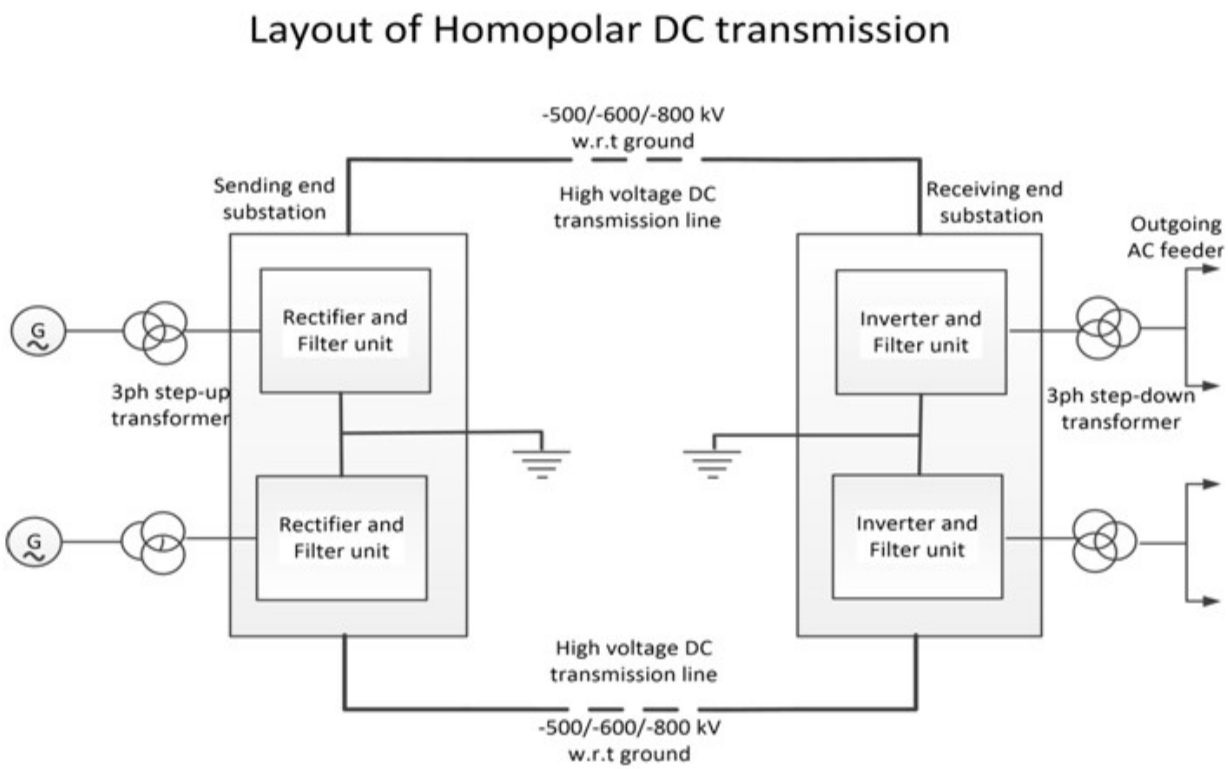
$$\textbf{\% Efficiency} = \frac{output\ \ power}{output\ \ power + total\ \ copper\ \ losses} \times 100$$

**Q. 2** **Attempt any THREE of the following** **12 Marks**

**a)** **Differentiate between overhead transmission and underground transmission.**

**Ans:** **(Any Four points expected: 1 Mark each, Total 4 Marks)**

| S.No | Points | Overhead line | Underground cable |
|---|---|---|---|
| 1 | Capital cost | Less | More |
| 2 | Erecting cost | Less | More |
| 3 | Time require for completion of work | Less | More |
| 4 | Flexibility | More flexibility | No flexibility |
| 5 | Future expansion in voltage level | System voltage can be increased easily | System voltage cannot be increased |
| 6 | Overload capacity | More | Less |
| 7 | Fault finding | Easy | Difficult |
| 8 | Charging Current | Less | More |
| 9 | Chances of fault | More | Less |
| 10 | Chances of accident | More | No chances of accident |
| 11 | Safety | Less | More |
| 12 | Radio interference | Produces radio interferences | Not produces radio interferences |
| 13 | Short cute route | Difficult | Possible |
| 14 | Theft Of energy | More possibility | Less possibility |
| 15 | Voltage drop | More | Less |
| 16 | Power factor | Less | More |
| 17 | Reliability | Less | More |
| 18 | Life | Less | More |
| 19 | Space consumed | Space consumed | No space consumed |
| 20 | Appearance | Not good | Very good |

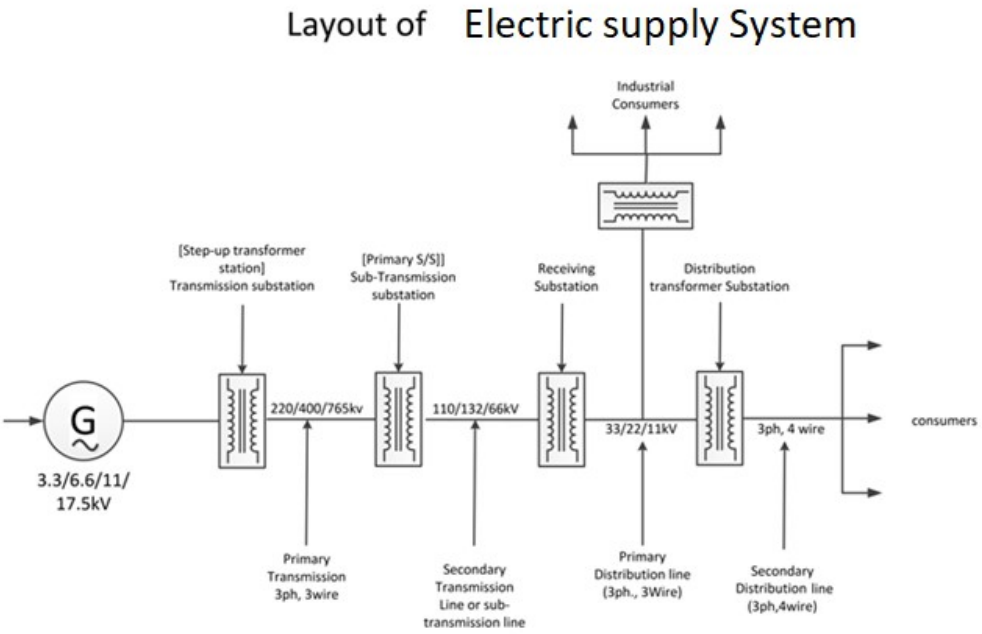
| | |
|---|---|
| **b)** | **Draw the layout of Homo polar transmission line.** |
| **Ans:** | **layout of Homo polar HVDC transmission with polarity of overhead conductor:** **( 4 Marks)**   **OR Equivalent Figure** |
| **c)** | **State the advantages of use of high voltage in transmission of Electric power.** |
| Ans: | **Advantages:** **( Any Four points expected: 1 Mark each, Total 4 Marks)**<br>1. As Transmission voltage increases, current decreases.<br>2. As current decreases, cross section of conductor decreases.<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.<br>8. As copper losses reduces, transmission efficiency increases<br>9. As current reduces, voltage drop in transmission line reduces.<br>10. As voltage drop in transmission reduces, voltage regulation becomes better |

(improved).

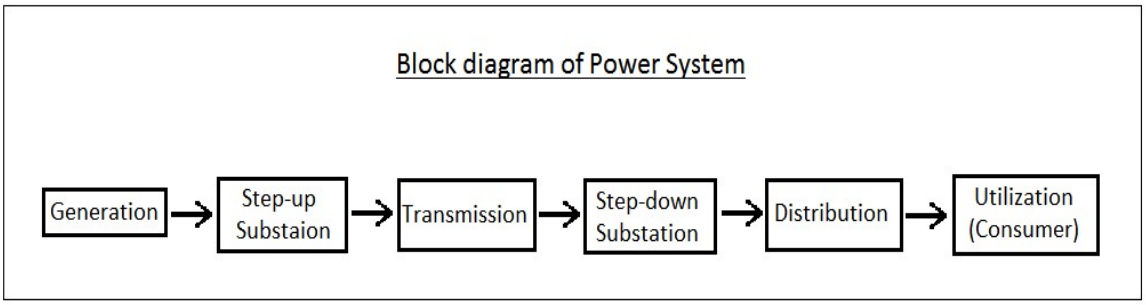
11. As efficiency and regulation of transmission line gets improved, so performance of transmission line increases
12. As transmission voltage increases power handling capacity of transmission line increases
13. Due to high voltage transmission line, successful interconnection of transmission line is possible than low voltage.

**d) Draw the layout of power system indicating Generation, Transmission and distribution parts.**

Ans: **Single line diagram of AC electric transmission and distribution system : ( 4 Mark)**




**OR**



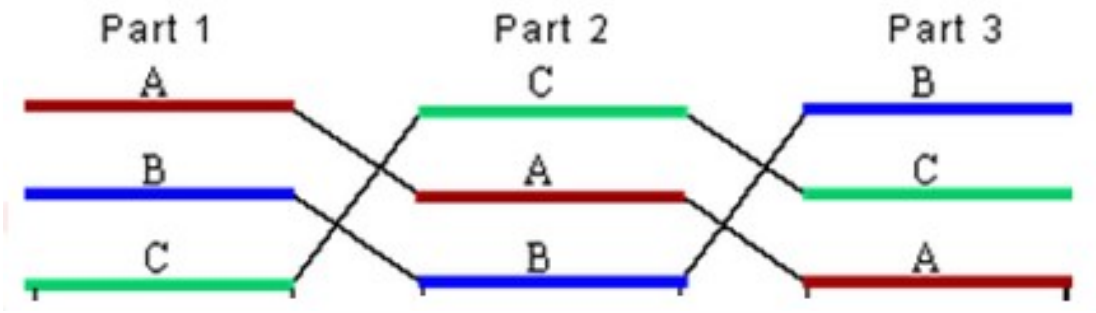

**OR**

**or equivalent figure**

| Q.3 | Attempt any THREE of the following | 12 Marks |
|---|---|---|
| a) | Draw the diagram representing transposition of conductor and state its importance. | |

Ans: **(Figure : 2 Mark Importance of Transposition: 2 Mark , Total 4 Marks)**

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




**OR Equivalent Figure**

Transposition of conductor means exchanging the position of 3 phases (R-Y-B) at regular interval.

Each phase occupies 3 different positions consequently on line support (Tower) as shown in fig.

**OR**

Transposition of line conductors means changing the positions of 3 phases on the line supports twice over the total length of the line

**The Importance of transposition of conductors: ( 2 Marks)**

Due to transposition of conductor voltage at receiving end between any two phases are same

i.e. $V_{ry} = V_{yb} = V_{rb}$

| b) | State the standard voltage in India for Generation, transmission distribution system. |
|---|---|

Ans: **Standard voltage in India for Generation, transmission distribution system: (4 Marks)**

**1. Generation Voltage :**

3.3KV, 6.6KV,11KV and 17.5 KV

**2. Transmission voltage :- (Any four voltage magnitude are expected)**

400KV, 765 KV (750 KV) , 220 KV, 132 KV, 110 KV, 33 KV, 22KV, 11 KV for long distance line it may be 66 KV

**OR**

| | |
|---|---|
| | ➢ **Primary Transmission voltage :-**<br>▪ 220 KV, 400KV, 765 KV (750 KV)<br>➢ **Secondary Transmission:**<br>▪ 220 KV, 132 KV, 110 KV<br>➢ **Primary Distribution:**<br>33 KV, 22KV, 11 KV for long distance line it may be 66 KV<br>3. **Distribution voltage :-**<br>**OR Secondary Distribution:**<br>for 3-phase, 400/440 Volt, for single phase 230 Volt |
| c) | **List the factors to be considered while designing feeders and distribution with their functions in brief.** |
| Ans: | **( Factor of Feeder: 2 Marks & Distribution : 2 Marks, Total 2 Marks)**<br>**Following factors are to be considered while designing the Feeder.**<br>**( Any Two factors are expected: 1 Mark each)**<br>**1) Current carrying capacity of conductor:-**<br>Conductor should have high current carrying capacity. While voltage drop consideration is relatively not so important<br>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)<br>**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. |

**5)** Power Factor of load should be consider while designing

**Following factors are to be considered while designing a distributor:- ( Any Two factors are expected: 1 Mark each)**

1. While designing the distributor voltage drop calculation is important.
2. Voltage drop in distribution system should be maintained within permissible limit (± 6%).
3. Layout should be simple in design.
4. It should have less initial cost
5. Make the distribution system with minimum distribution losses.
6. From safety point of view distribution system should maintain proper clearances.
7. Select the cross section of conductor from the result of load densities present & future.
8. While selecting cross section of conductor P.F. of the load should be consider.
9. Power should be available to consumers whenever needed.
10. A steady, non-fluctuating, quality supply (Pure sine wave) should be available to consumers.
11. Distribution system should not be over loaded.
12. Distribution system lay out should not affect the appearance of locality.
13. Before installation of distribution system proposed widening of the road in the near future are to be kept in mind
14. Fault on nearest distribution system should not affect stability of existing distribution system.

| | |
|---|---|
| d) | **State advantages and disadvantages of radial distributor system.** |
| Ans: | **( Advantages : 2 Marks & disadvantages: 2 Marks, Total : 4 Marks)**<br>**Advantages of radial distributor system: ( Any Two point expected)**<br>1. Design of layout is simple.<br>2. Capital cost & Erecting cost is less as there is only one feeder.<br>3. Time required for completion of work is less.<br>**Disadvantages of radial distributor system: ( Any Two point expected)**<br>1. No reliability to maintain supply to consumers when there is fault on feeder.<br>2. No reliability to maintain supply to consumers when there is maintenance on feeder.<br>3. Voltage fluctuations are more. |
| **Q.4** | **Attempt any THREE of the following 12 Marks** |
| **a)** | **List classification of distributor system with their advantages each. (any two)** |
| Ans: | **( 4 Marks)**<br>**According to scheme of connection there are three types of distribution systems: -**<br>1.Radial (Tree) distribution system<br>2.Ring mains (Loop) distribution system<br>3. Grid (interconnected) distribution system<br>**1. Advantages of Radial (Tree) connection scheme:- ( 1 Marks)**<br>1. Design of layout is simple.<br>2. Capital cost & Erecting cost is less as there is only one feeder.<br>3. Time required for completion of work is less.<br>**2. Advantages of Ring Main System of distribution: ( 1 Marks)**<br>1. Supply to distribution transformer center is given through two different Feeders<br>2. Reliability to maintain supply is more even when there is a fault on any one feeder.<br>3. Reliability to maintain supply is more even when there was maintenance on any one feeder. |

**3. Advantages of Grid or interconnected system of distribution:-** **( 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.

**b) A 3-ph overhead line supported by 6 disc insulators, the potential across the unit is 11 KV. Assuming shunt capacitance between each Insulator and each metal link is of 1/5th of capacitance of insulator. Calculate: (i) line voltage (ii) string efficiency.**

Ans: **$V_6$ = 11 KV**

**i) Ratio of capacitance 'm' :-**

$$m = \frac{1}{5} = 0.2$$

**k = m = 0.2** ---------- **( 1/2 Mark)**

**ii)** $V_6 = V_1 (1 + 15m + 35m^2 + 28m^3 + 9m^4 + m^5)$

$$V_6 = V_1 (1 + 15 \times 0.2 + 35 \times (0.2)^2 + 28 \times (0.2)^3 + 9(0.2)^4 + (0.2)^5)$$

$$11 = 5.638 \; V_1$$

$$V_1 = \frac{11}{5.638}$$

$V_1 = 1.951$ KV

---------- **( 1/2 Mark)**

**iii)** $V_5 = V_1 (1 + 10m + 15m^2 + 7m^3 + 9m^4 + m^5)$

$$V_6 = 1.951 (1 + 10 \times 0.2 + 15 \times (0.2)^2 + 7 \times (0.2)^3 + (0.2)^4)$$

$$V_5 = 1.951 \; (3.365)$$

$V_5 = 7.135$ KV

---------- **( 1/2 Mark)**

**iv)** $V_4 = V_1 (1 + 6m + 5m^2 + m^3)$

$V_4 = 1.951\ (1 + 6 \times 0.2 + 5 \times (0.2)^2 + (0.2)^3)$

$V_4 = 1.951\ \ (2.408)$

$V_4 = 4.69$ KV

---------- ( 1/2 Mark)

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

$V_3 = V_1\ (1 + 3 \times 0.2 + (0.2)^2)$

$= 1.951\ (1.64)$

$V_3 = 3.2$ KV

---------- ( 1/2 Mark)

**vi)** $V_2 = V1\ (1 + m)$

$V_2 = 1.951\ (1 + 0.2)$

$V_2 = 1.951$ x 1.2

$V_2 = 2.3412$

**vii) Voltage across string = Vph** $= V_1 + V_2 + V_3 + V_4 + V_5 + V_6$

$= 1.95 + 2.3412 + 3.2 + 4.69 + 7.13 + 11$

$V_{Ph} = 30.3112$ KV

---------- ( 1/2 Mark)

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

$V_L = \sqrt{3} \times 30.3112$

**$V_L$ = 52.50 KV** ---------- (1/2 Mark)

**ix) String efficiency :-**

**String %** $\eta = \dfrac{votage\,across\,whole\,string\,(Vph = V_L/\sqrt{3}\,)}{n \times voltage\,across\,disc\,nearer\,to\,conductor} \times 100$

$$\text{String } \eta\% \equiv \frac{Vph}{n \times V_n} \times 100$$

$$\text{String } \eta\% \equiv \frac{30.3112}{6 \times 11} \times 100$$

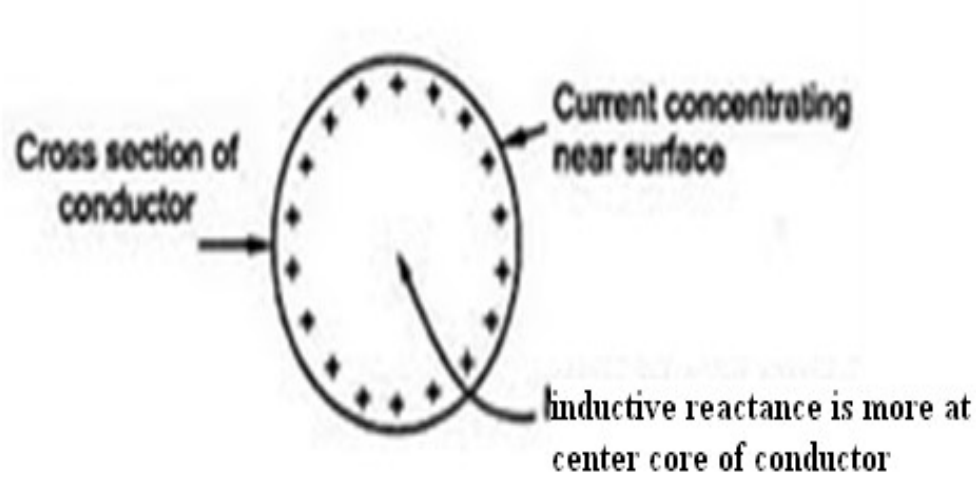
$$\text{String } \eta\% \equiv 45.926\ \%$$

---------- **( 1/2 Mark)**

**c) State the meaning of skin effect and how can it be minimised.**

Ans: **( Meaning : 2 Marks and effect minimized : 2 Marks, Total 4 Marks)**

**Meaning of skin effect**




**OR equivalent figure**

When alternating current flows through conductor it has tendency to flow away from center of conductor.

i.e. maximum current density is near skin of conductor and goes on reducing towards centre core is known as skin effect.( Since the inductive reactance ($X_L$) at the centre of the conductor is more than surface of conductor)

**OR**

The tendency of alternating current to concentrate near the surface of a conductor is known as skin effect.

**Skin effect can be minimized by: (Any two points are expected)**

1. Use stranded conductors instead of solid conductors.
2. Use hollow conductors instead of solid conductor.
3. Use ACSR /AAAC conductors for transmission purpose
4. Use D.C. supply whenever possible as Skin effect is absent (Since frequency 0) instead of A.C. supply.

**d) Draw the diagram of pin type and suspension type insulators.**

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

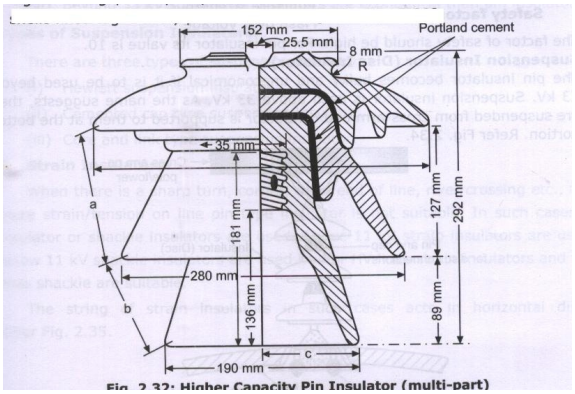
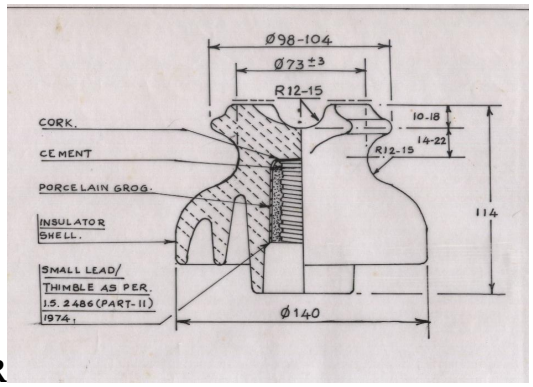


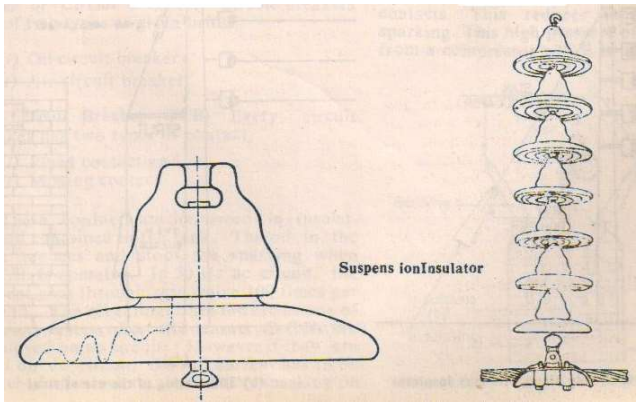

Fig. 2.32: Higher Capacity Pin Insulator (multi-part)

**OR**




**OR Equivalent Figure**

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




**OR Equivalent Figure**

**e) State the effects of low power factor on efficiency and voltage regulation of short transmission lines.**

Ans:

| | |
|---|---|
| | **i) Effect of Low power factor on efficiency:-** **( 2 Marks)**<br>When power factor of load reduces current drawn by transmission line increases so copper losses in transmission line increases, hence transmission efficiency reduces.<br>**ii) Effect of Low power factor on voltage Regulation:-** **( 2 Marks)**<br>When power factor of load reduces current through transmission line increases, so voltage drop in transmission line increases so regulation increases. (Become Poor) |
| f) | **State the condition for selecting site for distribution substation.** |
| Ans: | **Following condition should be considered while selecting site for distribution sub-station:-**<br>**1. Near load center :** **( Any four points expected: 1 Mark each, Total 4 Marks)**<br>Sub-station should be located near load center to reduce cost of Transmission and distribution lines and to reduce losses in it.<br>**2. Easy access for transmission Line :**<br>There should be easy access for incoming and outgoing line.<br>**3. Easy access towards sub-station :-**<br>There should be easy access towards sub-station for transportation of equipments and manpower etc.<br>**4. Space(Land ) available :**<br>The land proposed for a substation should be normally level and open from all sides & sufficient land should be available for installation of sub-station and future expansion.<br>**5. Atmospheric conditions :**<br>Atmospheric condition in the area of sub-station should be clean and dry also There should be less atmospheric pollution.<br>**6. Cost of land :**<br>Cost of land should be less to reduce capital cost of sub-station.<br>**7. Municipal restriction :**<br>Where municipal restriction will not take any objection for required type building of |

sub-station.

**8. Staff amenities :**

The site should be such that essential amenities must be available to staff like residential quarters, drinking water, school, hospital, public transportation, communication.

**9. Bearing capacity of land (Hard land ):**

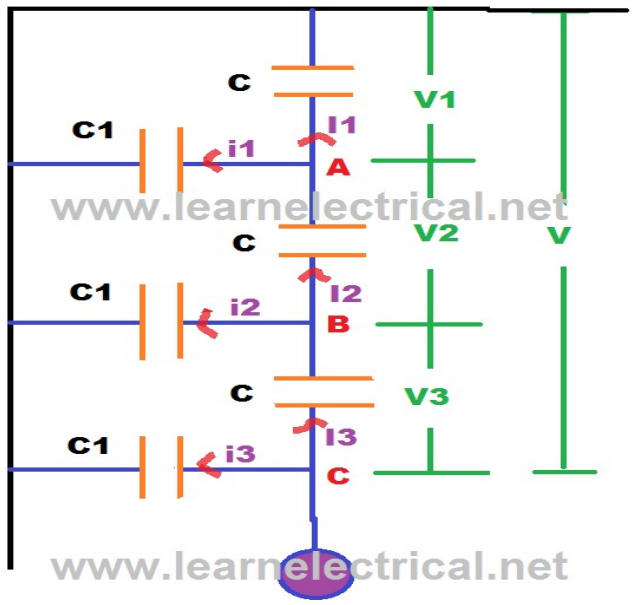
To reduce construction cost of building and for better foundation of equipment's land should have high bearing capacity.

**10. Area free from earthquake :**

To avoid damage to sub-station area should be free earth quake.

| | | |
|---|---|---|
| Q.5 | **Attempt any TWO of the following** | **12 Marks** |
| a) | **Derive equation for string efficiency with 3 - disc insulators of suspension type.** | |

**Ans: Derive equation of String of three Disc insulators of suspension type:- ( 6 Marks)**




**Mathematical expression for String Efficiency**

**Mathematical proof:**

**Where,**

**$C_1$ = Shunt capacitance C = Self capacitance**

$$m = K = \frac{C_1}{C} \qquad C_1 = mc$$

**Step- I: Applying KCL to node 'A'**

$$I_2 = I_1 + i_1$$

$$V_2\,\omega C = V_1\,\omega C + V_1\,\omega C_1 \qquad But, C_1 = mc$$

$$V_2\,\omega C = V_1\,\omega C + V_1\,\omega mc$$

$$\therefore\ V_2 = V_1 + V_1\,m$$

$$\therefore\ V_2 = V_1\ (1+m) \text{ ----------equation-I}$$

**Step- II: Applying KCL to node 'B'**

$$I_3 = I_2 + i_2$$

$$V_3\,\omega C = V_2\,\omega C + (V_1 + V_2)\,\omega C_1 \qquad But, C_1 = mc \ \ \&\ V_2 = (m+1)\,V_1\omega$$

$$V_3\,\omega C = V_1\ (1+m)\,\omega C + V_1\,\omega mc + V_1\,(1+m)\,\omega C$$

$$V_3 = V_1\ (1+m) + V_1\,m + V_1\,(1+m)\,m$$

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

$$V_3 = V_1\ (1+3m+m^2) \text{ ---------- equation - II}$$

$$V = V_1 + V_2 + V_3$$

**String Efficiency:-**

Unequal potential distribution along a string of suspension insulator is usually expressed in terms of string efficiency.

$$\textbf{String \%}\ \eta = \frac{votage\,across\,whole\,string\,(Vph = V_L/\sqrt{3}\,)}{n \times voltage\,across\,disc\,nearer\ to\ conductor} \times 100$$

| | |
|---|---|
| | **OR**<br><br>**String** $\eta\% = \frac{Vph}{n \times V_n} \times 100$<br><br>Where, n = Number of Disc insulators, Vn = Voltage across disc nearer to conductor\ |
| **b)** | **Define Corona, List its causes and state how it can be avoided. (two each)** |
| Ans: | **(Definition: 2 Marks, Causes: 2 Marks and corona avoided: 2 Mark, Total 6 Marks)**<br><br>**Define Corona:** **( 2 Marks)**<br><br>When AC Voltage given across two conductors separated by distance 'd' as shown figure is increased greater than breakdown voltage of air i.e. 30KV/cm, then air around the conductor gets ionized and ionized air is conducting under this condition corona will takes place (form) .<br><br>During corona following observations are noted:<br>➢ Luminous violet glow (typically a purple glow) occurs around the conductor.<br>➢ Hissing or cracking sound will produce.<br>➢ Ozone gas will produce. (smell the presence of ozone that was produced by the corona)<br><br>This phenomenon is known as "corona" effect.<br><br>**The following causes:- (Any Two points are expected)** **( 2 Marks)**<br><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. |

**3. Size of conductor:**

If size (Cross section) of conductor is more, than magnitude of voltage required to occur the corona increases.

**4. Condition of conductor & Hardware:**

Rough and irregular surface of conductor and hardware will give more corona than solid, smooth body conductor & hardware.

**5. Atmospheric Condition:**

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)

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)

**Corona effect can be avoided for following way: (Any Two points are expected) ( 2 Marks)**

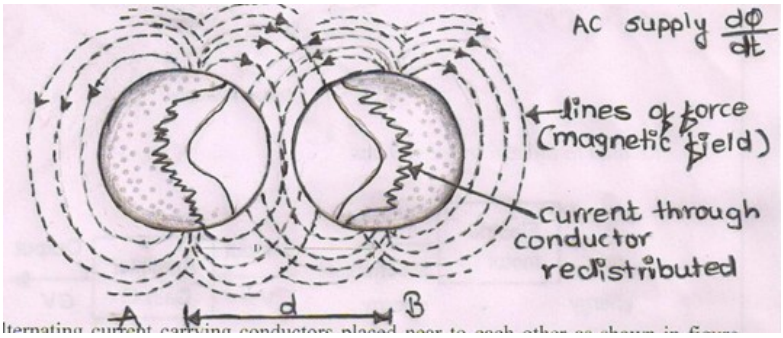
1. By increasing distance between two conductor i.e. by using longer cross arm.
2. By using larger size(diameter) of conductor e.g./ using ACSR, bundled conductor
3. By using smooth body conductor and hardware.

**c) State the meaning of ferranti effect and proximity effect.**

Ans: **i) Ferranti effect :** **( 3 Marks)**

When long distance transmission is lightly loaded or there is no load condition than it is observe that receiving end voltage ($V_R$) is found to be greater than sending end voltage ($V_S$). This phenomenon is known as Ferranti effect.

**ii) Proximity effect:** **( 3 Marks)**




**Explanation:**

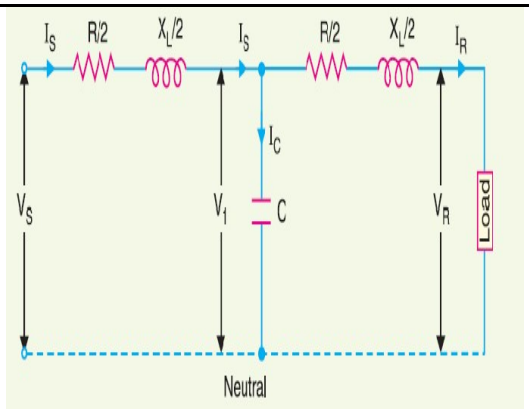
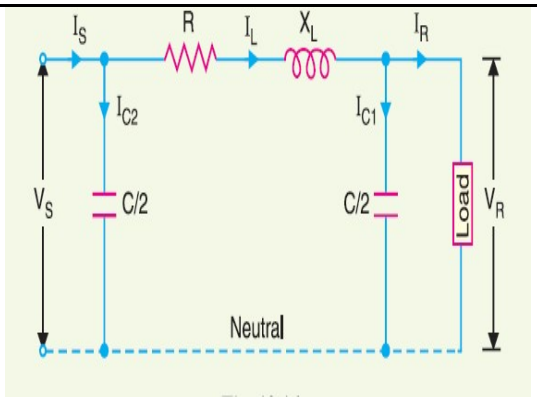
Let two alternating current carrying conductors placed near to each other as shown in figure. Due to electro-magnetic action, flux produced by each conductor links with each other. Due to this super –impose of magnetic field on conductor causes current in each conductor is re-distributed. This is known as proximity effect.

**Q.6** **Attempt any TWO of the following** **12 Marks**

**a)** **Compare nominal - T and nominal - II method of transmission line (Any six points)**

Ans: **(Total: 6 Marks)**

| S.No. | Nominal T Method | Nominal $\pi$ Method |
|---|---|---|
| 1 | It is assume that line capacitance is connected at centre of transmission line | 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. |
| 2 | It is assume that half of the resistance & reactance per phase are divided in either side of capacitance. | It is assumed that transmission line resistance & reactance per phase is connected in between two half transmission line capacitance |
| 3 | Shape of equivalent circuit is like letter 'T' hence its name is nominal 'T' method | Shape of equivalent circuit is like letter '$\pi$' hence its name is nominal '$\pi$' method |

| | | | |
|---|---|---|---|
| | 4 |  |  |
| | 5 | Values of ABCD constants T-equivalent circuits of are as bellows:<br>$\therefore A = D = 1 + \frac{YZ}{2}$<br>$\therefore B = Z \left[ 1 + \frac{YZ}{4} \right]$ ohm<br>$\therefore C = Y$ mho | Values of ABCD constants $\pi$ equivalent circuits of are as bellows:<br>$\therefore A = D = 1 + \frac{YZ}{2}$<br>$\therefore B = Z$ ohm<br>$\therefore C = Y \left[ 1 + \frac{YZ}{4} \right]$ mho |

**b) State the meaning of FACTS and explain in brief d-types facts controller.**

Ans: **Flexible AC Transmission System (FACTS):-** **( 3 Marks)**

A flexible alternating current transmission system (FACTS) is defined as it is a system composed of static equipment used for the AC transmission of electrical energy. It is meant to enhance controllability and increase power transfer capability of the network. It is generally a power electronics-based system.

**OR**

A Flexible AC transmission System refers to the system consisting of power electronic devices along with power system devices to enhance the controllability and stability of the transmission system and increase the power transfer capabilities.

**D-types facts controller:** **( 3 Marks)**

- **Series Controllers:** Series Controllers consists of capacitors or reactors which introduce voltage in series with the line. They are basically variable impedance devices. Their major task is to reduce the inductivity of the transmission line. They supply or consume

variable reactive power. Examples of series controllers are SSSC, TCSC, TSSC etc.

- **Shunt Controllers:** Shunt controllers consist of variable impedance devices like capacitors or reactors which introduce current in series with the line. Their major task is to reduce the capacitivity of the transmission line. The injected current is in phase with the line voltage. Examples of shunt controllers are STATCOM, TSR, TSC, SVC.
- **Shunt-Series Controllers:** These controllers introduce current in series using the series controllers and voltage in shunt using the shunt controllers. Example is UPFC.
- **Series-Series Controllers**: These controllers consist of a combination of series controllers with each controller providing series compensation and also the transfer real power along the line. Example is IPFC.

**OR**

**1. Shunt compensation**

In shunt compensation, power system is connected in shunt (parallel) with the FACTS. It works as a controllable current source. Shunt compensation is of two types:

**2. Shunt capacitive compensation**

This method is used to improve the power factor. Whenever an inductive load is connected to the transmission line, power factor lags because of lagging load current. To compensate, a shunt capacitor is connected which draws current leading the source voltage. The net result is improvement in power factor.

**3. Shunt inductive compensation**

This method is used either when charging the transmission line, or, when there is very low load at the receiving end. Due to very low, or no load – very low current flows through the transmission line. Shunt capacitance in the transmission line causes voltage amplification (Ferranti effect). The receiving end voltage may become double the sending end voltage (generally in case of very long transmission lines). To compensate, shunt inductors are connected across the transmission line. The power transfer capability is thereby increased depending upon the power equation

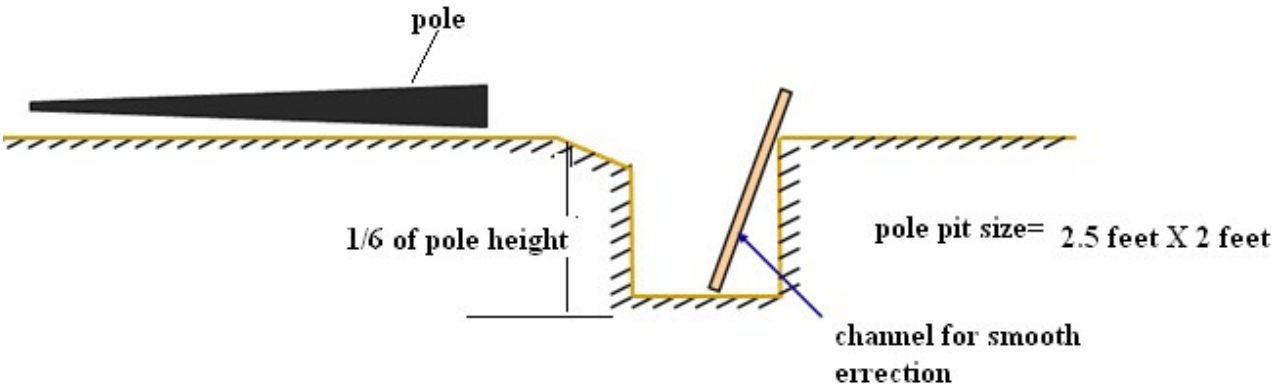
**4. Series compensation**

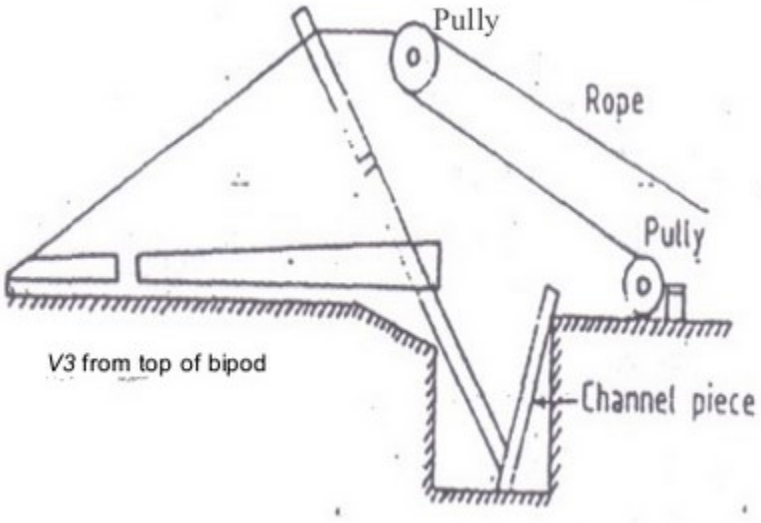
FACTS for series compensation modify line impedance: X is decreased so as to increase the transmittable active power. However, more reactive power must be provided.

| | |
|---|---|
| c) | **(i) List the properties of line insulators in brief.**<br>**(ii) List the methods of Line Support Erection and explain in brief any one.** |
| Ans: | **Following are the properties of line insulators: (Any three properties are expected)**<br>**( 3 Marks)**<br><br>**A) Electrical Properties of insulating material:-**<br>1. It should have high resistance.<br>2. It should have high breakdown voltage.<br>3. It should have high dielectric strength.<br>4. It should have low dielectric loss.<br>5. It should have low dielectric constant.<br>**B) Mechanical Properties of insulating material:-**<br>1) It should have high mechanical strength.<br>2) It should be tough and flexible.<br>3) It should be light in weight.<br>4) It should not be porous otherwise it increases moisture holding capacity which reduces insulating property.<br>**C) Chemical Properties of insulating material:-**<br>1. It should not be hygroscopic (which absorbs moisture).<br>2. It should have high resistance to acid & alkaline (Chemicals).<br>3. It should have high resistance to oil.<br>**D) Thermal Properties of insulating material:-**<br>1. It should have high thermal conductivity.<br>2. It should be non -inflammable.<br>3. It should withstand at high temperature.<br>4. It should have thermal Stability.<br>5. Co-efficient of thermal expansion should be low.<br>**E) General Properties of insulating material:-**<br>1. It should have longer life.<br>2. It should have low cost |

**ii) Following are the methods of Line Support Erection** : **( 3 Marks)**

**Figure**:




s

**Following are steps require for Erection of pole :-**

**Step 1**:

Preparation before Erection- Depends on type of pole e.g.

- **Wooden Pole :**
  - Top & bottom portion of pole is covered by aluminum cap and underground portion (1/6) of pole height is painted to increase life & remaining portion is well polished

with the help of varnish.

- **Cement Pole** :
  - 1/6 portion of pole height is No preparation is required like wooden pole and steel pole
- **Steel Pole :**
  - 1/6 portion of pole height of steel pole which goes under ground is painted with bituminous paint to protect pole from rusting. Also base plate of mild steel is welded at bottom for better foundation.
- **Steel towers:**
  - Are erected on site by constructing strong foundation (cement concrete foundation)

**Step 2**:

Prepare a pit on given marking.

**Step 3:**

Size of pit should be 2.5 feet X 2 feet and depth of pit 1/6 of the pole height.

**Step 4:**

Rest the pole on channel for smooth and gradual Erection.

**Step 5:**

Erect a pole in a prepared pit using accessories (such as rope, pole, tripod etc.) and sufficient man power. Now a days machineries are used for Erection of pole.

**Step 6:**

After Erection of pole, check the alignment before concreting.

**Step 7:**

Now pour the concreting of ratio 1:4:8 in pole pit.

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