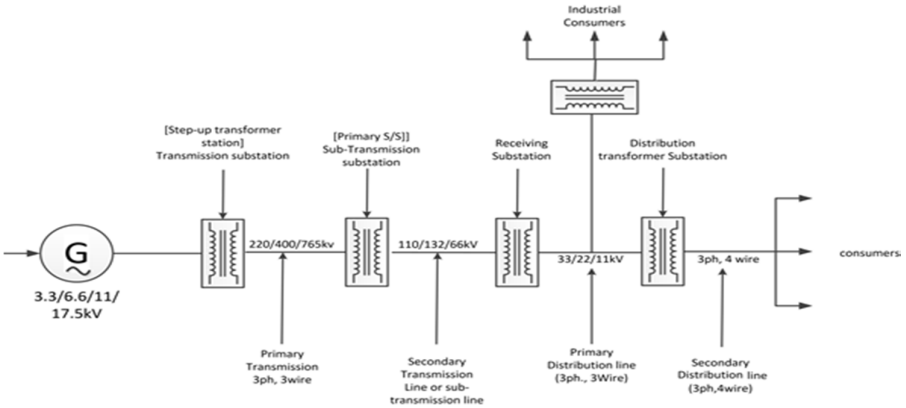
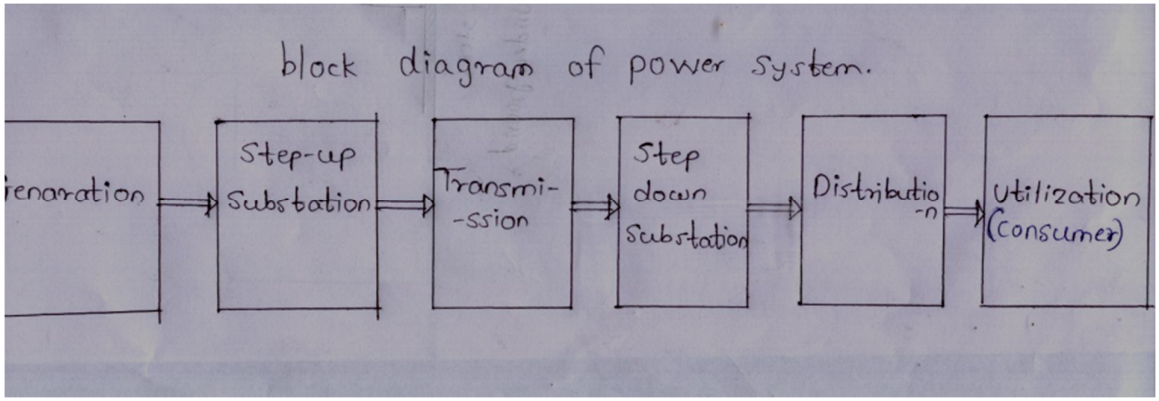
Important suggestions to examiners:

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.

Q.1	**Attempt any TEN of the following:**	20
i)	**State any two reasons for the necessity of transmission of electricity.**	
Ans:	**Because of following points there is necessity of transmission of power:-** **(Any Two Points are Expected : 1 Mark each Total 2 Marks)** 1. Load points are located away from generating station. 2. Electrical load on power system is not concentrated at one place but it is widely spread. 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) Due to above reasons transmission of electricity is necessary.	
b)	**Draw simple line diagram or block diagram of A.C. supply system.**	
Ans:	**Block diagram of A.C. supply system** **(Block Diagram: 2 Mark)** Layout of generating plant 	

OR



c) State any four properties of conductor material used for transmission line or cable.

Ans: **Following are requirements of conductor:-**

(Any Four Points are Expected : 1/2 Mark each Total 2 Marks)

1.High conductivity :-

Material should have high conductivity

2. **High mechanical strength:-**
   Material should have sufficiently high mechanical strength
3. **Flexibility:-**
   Material should be flexible
4. **Weight:-**
   Material should be light in weight.
5. **High resistance to corrosion:-**
   Material should have high resistance to corrosion
6. **Brittleness:-**
   Material should not be brittle.
7. **Availability & cost:-**
   Material should be easily available & less costly.
8. **Scrap Value:-**
   Material should have high scrap value.
9. **Temperature coefficient of resistance:-**
   Material should have low temperature coefficient of resistance.

d)	**State any four names of insulating materials used in manufacturing of cable.**
Ans:	**(Any Four Names are Expected : 1/2 Mark each Total 2 Marks)** **Followings are the names of insulating materials used in manufacturing of cable:-** 1. PVC (Polyvinyl Chloride) 2. Polyethene 3. XLPE (Cross- linked polyethylene) 4. VIR (Vulcanized Indian Rubber) 5. Gutta-Percha (It is similar to rubber) 6. Silicon Rubber 7. Silk and Cotton 8. Enamel insulation 9. Impregnated Paper 10. Varnished cambric (Empire tape)
e)	**Enlist various types of supports (poles) used for transmission and distribution.**
Ans:	**Following are the different types of supporting structure:** **(Any Two types are Expected : 1 Mark each Total 2 Marks)** 1) Wooden pole 2) Cement Pole/ RCC Pole (Re-in forced cement concrete) 3) Steel Pole: Following are the different types of steel pole: a) Tubular Steel Pole b) Stepped Tubular Pole c) Rail Pole/ RSJ Pole (Rolled steel Joist) / Girder steel pole d) Lattice Steel Pole e) Lattice Steel Towers (LST)
f)	**Define regulation of transmission line and write formula.**
Ans:	**(Definition 1 Mark & formula 1 Mark ,Total 2 Marks)** **Regulation:** Voltage regulation is nothing but voltage drop in transmission line expressed in % of receiving end voltage

	% Regulation = $\frac{Sending\ End\ Voltage - Receiving\ End\ Voltage}{Receiving\ End\ Voltage} \times 100$ % Voltage Regulation = $\frac{V_S - V_R}{V_R} \times 100$ Where, V_R = receiving end voltage V_S = Sending end voltage
g)	**Write classification of transmission line according to distance.**
Ans:	**(Total 2 Marks)** **Classification of transmission line according to distance:-** 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 **100KV.**
h)	**State assumption made while calculating performance of transmission line in `T" network.**
Ans:	**Assumptions:** **(1 Mark each assumption , Total 2 Marks)** ➢ It is assume that line capacitance is connected at center of transmission line. ➢ It is assume that half of the resistance & reactance per phase are divided in either side of capacitance.
i)	**State any two applications of HVDC transmission system.**
Ans:	**(Any Two Applications are Expected : 1 Mark each, Total 2 Marks)** **Applications of HVDC transmission system:-** 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
j)	**State why three-phase four wire supply system is preferred for secondary distribution system.**
Ans:	Reason: **(Total 2 Marks)** 3-Ph Four-Wire System (R-Y-B-N) and Voltage level 3-Ph 400 Volt, are required to Three phase consumers & for single phase (Between phase & neutral) supply voltage is 230 volt, are required to single phase consumers. Hence three-phase four wire supply system is preferred for secondary distribution system**.**

k)	**State main components of distribution system.**
Ans:	**(Any four components are Expected : 1/2 Mark each Total 2 Marks)** **Following are the different components of distribution system:-** 1. Feeder (Primary distribution) 2. Distribution Transformer (DTC) 3. Distributor (Secondary distribution System) 4. Service mains
l)	**State types of line insulators used in Transmission and distribution.**
Ans:	**(Any four types are Expected : 1/2 Mark each Total 2 Marks)** **Types of line insulators used in Transmission and distribution: -** i) Pin type insulator ii) Suspension or Disc type insulator. iii) Strain type insulator. iv) Shackle type insulator. v) Stay or Guy or Egg type insulator. vi) Post insulator: These are used for supporting bus bars & switchgear
Q.2	**Attempt any FOUR of the following : 16 Marks**
a)	**State any four factors that are considered while designing a distributor.**
Ans:	**(Any four factors are Expected : 1 Mark each, Total 4 Marks)** **Factors to be considered while designing a distributor:-** 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.
b)	**State long form of `ACSR' conductors. State its three advantages.**
Ans:	**long form ACSR conductor**:- **(1 Mark)** Aluminum conductor steel reinforced. **Advantages of ACSR Conductors:** **(Any Three Advantages Expected: 1 Mark each)** 1. Due to steel re-enforcement, mechanical strength of conductor increases 2. As the mechanical strength is more ACSR conductors produces small Sag. 3. It takes advantages of Skin effect. So skin effect is minimized. 4. Corona Loss reduces. 5. It is 50% stronger & 20% Lighter than copper. 6. It is cheaper than copper.
c)	**State any four desirable properties of cable.**
Ans:	**(Any four properties are Expected : 1 Mark each, Total 4 Marks)** **Following are the main requirement & properties of cables:** 1. 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 should be used to become conductor soft.

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

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

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

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

7. The material used for cable should have long life.

d) Compare RCC pole and steel tubular pole based on (i) cost (ii) life (iii) tensile strength (iv) application.

Ans: **(1 Mark each point, Total 4 Marks)**

Sr.No	Parameters	Cement pole	Steel pole
1	**Cost**	Less than steel pole	High
2	**Life**	Long	Longest
3	**Tensile strength**	High	Highest mechanical strength.
4	**Application**	For transmission (up to 11 KV) & distribution purpose i.e. LT line. Used in rural areas.	**Steel Tubular Pole & RSJ Pole**: are used for transmission and distribution, maximum up to 33 KV generally used in urban areas. **Steel Tubular Pole:** Are specially used for street lighting. **Lattice Steel pole**: are used for distribution purpose in ruler area and maximum11KV transmissions. **Steel Tower**: are used high voltage transmission lines above 66 KV.

e) State any four reasons of failure of line insulators.

Ans: **(Any four reasons are Expected : 1 Mark each ,Total 4 Marks)**

The Reasons for the Failure of Insulators: -

1. Manufacturing Defect:-

Insulator may fail due to manufacturing defect. So, it must be tested before use.

2. Uneven Expansion and Contraction:-

Insulator is manufactured by using combination of material. For.eg: porcelain, glass,

cements and also attachment steel is used.

Co-efficient of expansion and contraction of each material is different. So, there is possibility of cracking of insulator, so it may fail.

3. Mechanical Stress:-

Due to mechanical stress of wind insulator may fail.

4. Porous:-

Porcelain is porous material. So, if insulator is not glazed properly then direct dust will accumulate on insulator and It will absorb moisture from air, so reduces resistance of insulation.

Hence leakage current increase which increases temperature of insulator. It may cause failure of insulator.

5. Flashover due to lightning stroke:-

If lightning stroke directly attacks on insulator than there is flash over and causes failure of insulator**.**

6. Flash over due to large birds or similar objects:-

Large birds or similar objects causes short circuit resulting in flash over and causes of failure insulator.

7. Flash over caused due to dust deposition:-

Transmission line running over/near dusty area for e.g. coal mine, large stone crusher, cement factory etc.

Dust will deposit on insulator which reduces clearance between two conductors. So, there is possibility of flash over and causes failure of insulator.

8. Wrong Selection:-

If 11 KV insulators are used for 22 KV, then it causes failure of insulator.

9. Rough Handing:-

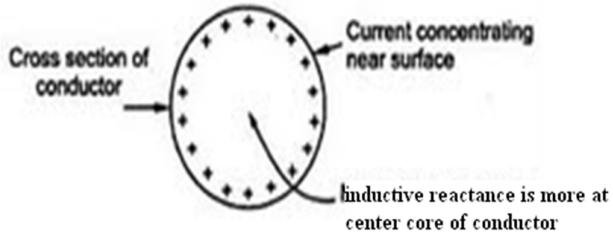
Due to rough handling of insulator during transportation, construction of line work etc causes failure of insulator.

10. Ageing Effect:-

Due to continuous use of insulator for a long period, its dielectric strength reduces. So, it may fail insulator.

f) State what is skin effect ? How it can be reduce ?

Ans: **Skin effect:-** ---------- **(2 Marks)**



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 center core is known as skin effect. **OR**

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

How it can be reduce:- ---------- **(2 Marks)**

Skin effect can be reduced by:

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.

Q.3 Attempt any Four of the following : 16 Marks

a) Compare on any four points primary and secondary distribution system.

Ans: **(Any four points are Expected : 1Mark each ,Total 4 Marks)**

Sr.No.	Primary distribution system	Secondary distribution system.
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	Voltage is 11KV/22KV/33KV	Voltage is for 3-ph consumer- 400V

	depending upon load	and 1-Ph consumer- 230V
5	These are high capacity conductors.	These are low capacity conductors
6	It is also called as a Feeder	It is also called as a Distributor.
7	While designing primary distribution system its current carrying capacity is important.	While designing secondary distribution system its voltage drop calculation is important.
8	Primary distribution system is not tapped along its length	Secondary distribution systems are tapped throughout its length.
9	Its loading point is at substation only	Its loading point is throughout its length.

b) A three phase transmission line system is suspended by a string of three discs. The lowest insulator voltage is 13 kV and across the next is 11 kV. Find out line voltage and string efficiency.

Ans:

$\therefore V_2 = V_1 \ (1+m)$ ----(1/2 Mark)

$\therefore 11 = V_1 \ (1+m) - equation - I$

$\therefore \therefore V_1 = \frac{11}{1+m}$

$V_3 = V_1 \ (1+3m+m^2) - equation - II$ --- (1/2 Mark)

$13 = V_1 \ (1+3m+m^2) - equation - II$

Substitute value of V_1 in equation number 2

$$13 = \left(\frac{11}{1+m}\right)(1+3m+m^2)$$

$$13 = \frac{11+33m+11m^2}{1+m}$$

$$13(1+m) = 11+33m+11m^2$$

$$13+13m = 11+33m+11m^2$$

$$11m^2+33m-13m+11-13 = 0$$

$$11m^2+20m-2 = 0$$

Comparing above equation with

$am^2 + bm + c = 0$

a= 11, b=20 and c = -2

Using quadratic equation formula,

$$m = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

$$m = \frac{-20 \pm \sqrt{20^2 - 4(11)(-2)}}{2(11)}$$

By solving above quadratic equation, we get

m = 0.095 or m=-1.91

Therefore m = 0.095 ---------- **(1/2 Mark)**

$$\therefore V_1 = \frac{11}{(1+m)}$$

V_1= 10.04 KV ----------**(1/2 Mark)**

Voltage across string = $V_1 + V_2 + V_3$

= 34.04 KV ----------**(1/2 Mark)**

$\therefore$ **Line voltage** = $\sqrt{3} \times 34.04$

= 58.95 KV ---------- **(1/2 Mark)**

String % $\eta = \frac{votage\ \ across\ \ whole\ \ string\ \ (Vph = V_L/\sqrt{3}\ )}{n \times voltage\ \ across\ \ disc\ \ nearer\ \ to\ \ conductor} \times 100$ ------**(1/2 Mark)**

$= \frac{34.04}{3 \times 13}$

= **87.205%** ----------**(1/2 Mark)**

c) **Define string efficiency. What does it indicates? What will be the value of string efficiency of HVDC transmission line?**

Ans:

Define string efficiency:- ---------- **(2 Marks)**

String Efficiency:-

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

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

OR

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

Where, n = Number of Disc insulators, Vn = Voltage across disc nearer to conductor

What does it indicates:- ---------- **(1 Marks)**

i) Uniformity of potential distribution along a string of suspension insulator.

ii) Greater string efficiency means more uniform voltage distribution along a string of suspension insulator.

iii) 100 % string efficiency means voltage across each disc of a suspension insulator is equal.

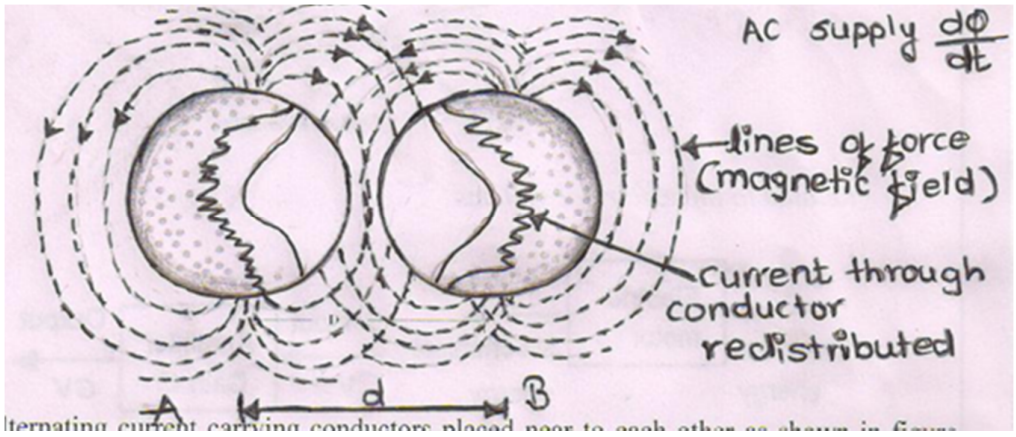
Value of string efficiency of HVDC transmission line:- ---------- **(1 Marks)**

String efficiency is 100 % in case of DC transmission line because in case of DC frequency is zero, so capacitance is ineffective.

d) State what is proximity effect ? How it can be reduce ?

Ans:

Proximity effect :- ---------- **(2 Marks)**



ternating current carrying conductors placed near to each other as shown in figure

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.

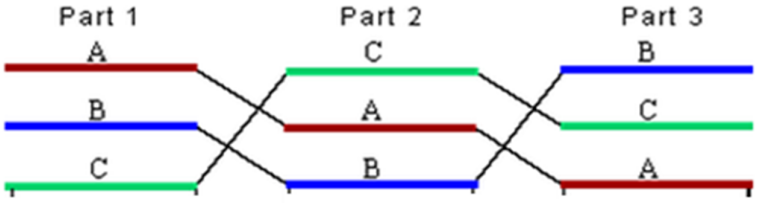
Proximity effect can be reduced:- ---------- (2 Marks)

- By increasing the distance between two conductors i.e. by using longer cross arm
- By using overhead transmission system instead of underground.
- Effects are negligible for small size, small current carrying conductor
- Use DC transmission system instead of AC transmission system to avoid proximity effect, Since frequency of DC supply is Zero (No rate of change of flux linkages)

e) Draw figure of transposition of conductor. Why it is necessary ?

Ans: **(Figure of transposition 2 Marks and Necessity of transposition 2 Marks, Total 4 Marks)**

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

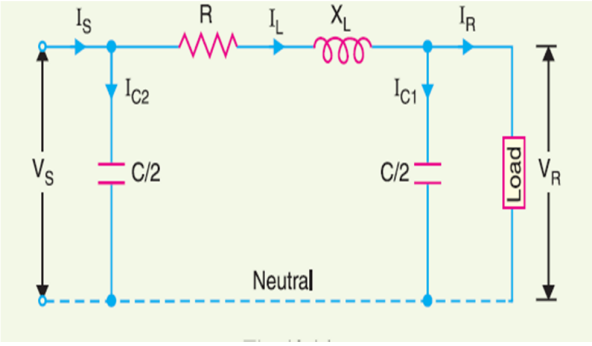


Necessary for the transposition of conductor: (Any Two points expected) **(2 Mark)**

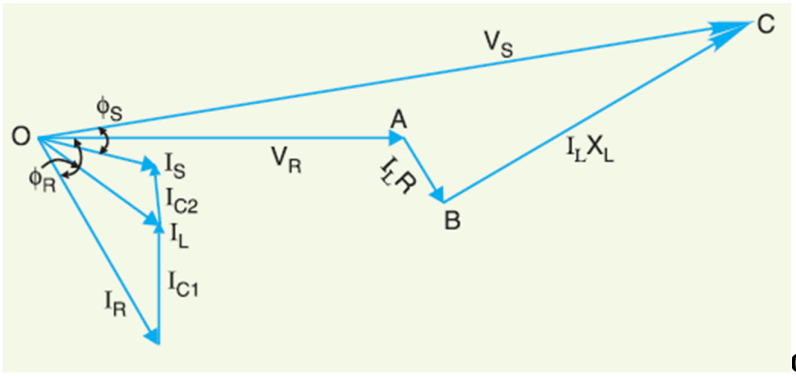
1. Due transposition of conductor inductance of each line is same $L_A = L_B = L_C$, So drop due to inductive reactance in each line is same so voltage at receiving end between any two line become same.
2. So to obtain same voltage in any two line at receiving end ($V_{RY} = V_{YB} = V_{RB}$) transposition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

f) Draw equivalent circuit of medium transmission line of nominal 'n' network. Draw vector diagram.

Ans: **Circuit Diagram Nominal π (pi) Network: -** ----------**(2 Marks)**



Vector diagram of π network for: ---------- **(2 Marks)**



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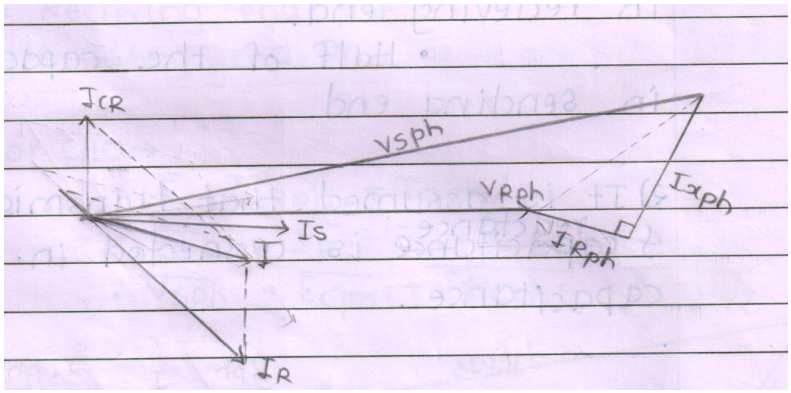
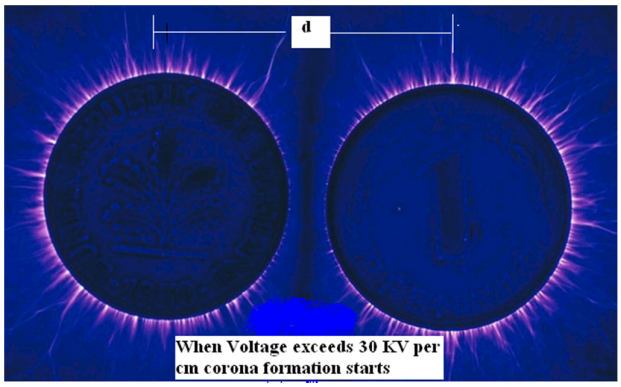


Q.4	**Attempt any FOUR of the following :** **16 Marks**
a)	**State what is corona? State its two disadvantages.**

Ans: **Corona:-** ----------**(2 Marks)**



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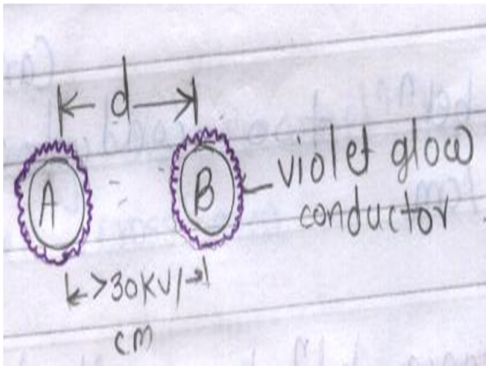


When AC Voltage given across two conductors separated by distance ‘d’ as shown figure is increased greater than breakdown voltage of air i.e. 30KV/cm, then air around the conductor gets ionized and ionized air is conducting under this condition corona will takes place (form) .

During corona following observations are noted:

- Luminous violet glow (typically a purple glow) occurs around the conductor.
- Hissing or cracking sound will produce.
- Ozone gas will produce.

This phenomenon is known as "corona" effect.

Disadvantages of corona:- ---------- **(1 Mark each disadvantage, Total 2 Marks)**

1. There is power loss due to corona which reduces transmission efficiency.
2. Ozone gas produced, due to chemical action there is possibility of corrosion (rusting) of hardware & conductor.
3. Harmonics are produced which will cause radio interference due to corona.
4. There is electromagnetic & electrostatic interference due to corona.

b) State any four possible conditions when Ferranti effect will occur.

Ans: **(1 Mark each condition, Total 4 Marks)**

Possible conditions when Ferranti effect will occur:-

Suppose transmission line is subjected to following Conditions:

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.

Under any one of the above mention conditions, 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**.**

c) An overhead three phase transmission line delivers 5 MW at 22 kV at 0.8 lagging power factor. The resistance and reactance of each conductor is 4 Ohm and 6 Ohm respectively. Determine sending end voltage and percentage regulation.

Ans:

Given Data:-

P_R =5 MW= 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)**

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

$$I \equiv 164.01996 amp$$ ---------- **(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}) =**

$= V_{Rph} + I (R_{Ph} \text{ Cos } Ø_R + X_{Ph} \text{ Sin } Ø_R)$ ---------- **(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 = $\therefore V_{SL} = \sqrt{3} \times V_{sph}$

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

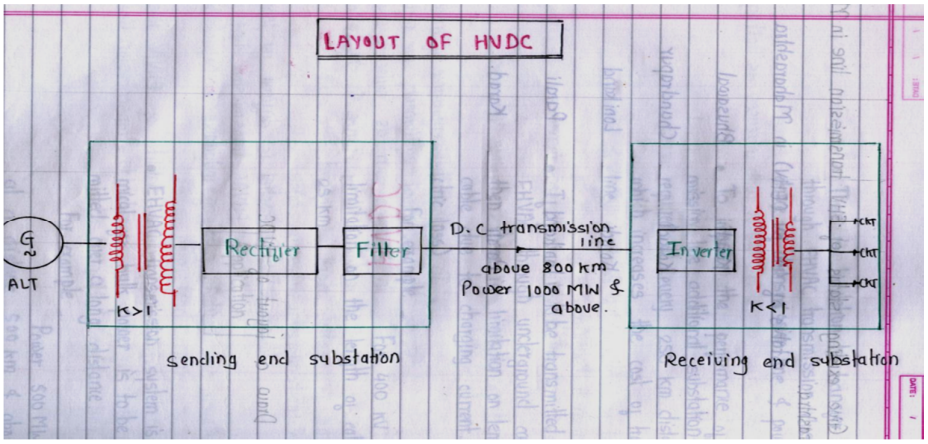
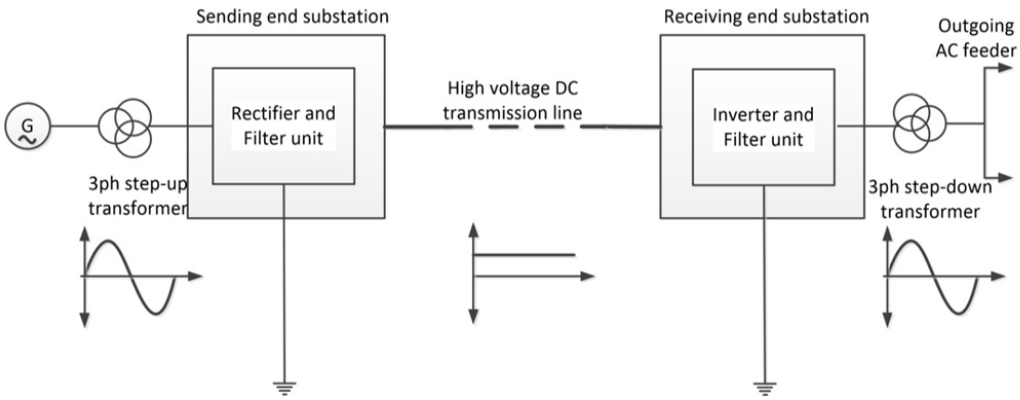
= 23.9317 KV ---------- **(1/2 Mark)**

Step 4:To calculate voltage regulation:

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

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

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

d)	**State effect' of low power factor on efficiency and regulation of transmission line.**
Ans:	**Effect of poor power factor on efficiency:-** ----------(2 Marks) ➢ When power factor of load reduces current drawn by transmission line increases so copper losses in transmission line increases, hence transmission efficiency reduces. **Effect of poor power factor on voltage Regulation:-** ----------(2 Marks) ➢ When power factor of load reduces current through transmission line increases, so voltage drop in transmission line increases so regulation increases. (Become Poor)
e)	**Draw basic block diagram for HVDC transmission line starting from generating station- and end at receiving station.**
Ans:	**block diagram for HVDC transmission line:** ---------- (4 Marks)  **OR** Basic Layout of DC transmission 

f)	**State four advantages and four limitations of EHVAC transmission line.**
Ans:	**Following are the advantages**:-

(Four advantages are expected 1/2 Mark each advantage, Total 2 Marks)

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** α **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** α **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 α 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

Following are the Limitations of EHVAC Transmission:

(Four limitations are expected 1/2 Mark each limitation , Total 2 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
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
13. Asynchronous tie not possible.
14. Stability of EHVAC is very low because of presence of inductance.
15. Transient performance is poor.
16. There is limitation on power transfer due to presence of inductance of transmission line & power angle.
17. To improve the performance of transmission line additional equipments such as series & shunt reactor & capacitor are required which increases cost of substation.

Q.5 **Attempt any FOUR of the following : 16 Marks**

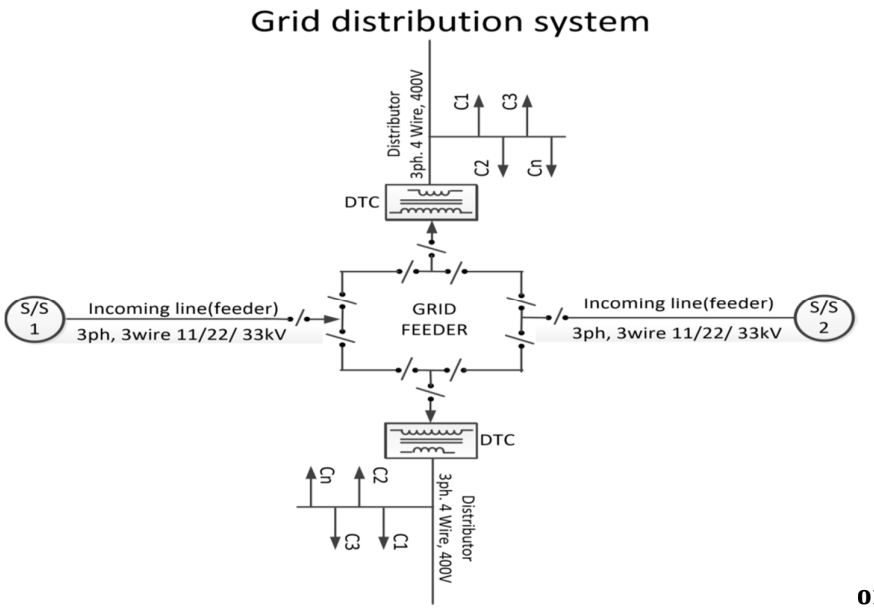
a) State generalized constants A, B,C and D of formula for nominal 'T' network.

Ans: Values of ABCD constants T-equivalent circuits of are as bellows: **(1 Mark each formula, Total 4 Mark)**

$$\therefore A = D = 1 + \frac{YZ}{2}$$

$$\therefore B = Z \left[1 + \frac{YZ}{4} \right] \text{ ohm}$$

$$\therefore C = Y \quad \text{mho}$$

b)	**Draw line diagram of "grid system". State its two advantages.**
Ans:	**(Layout 2 Marks, Advantages 2 Marks)**  **or equivalent figure** **Advantages:** **(Any Two points 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/ generating station 3. It has highest reliability to maintain supply even when there was maintenance on any one feeder/ generating station.
c)	**State why radial distribution system is used for short distance only.**
Ans:	**(4 Marks)** **Because of following disadvantages radial distribution system is not used for long distance:** 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. 3) If the system is used for long distance then it takes more time for fault finding & repairing Hence radial distribution system is not used for long distance even its initial cost is low

d) State any four requirements of an ideal distribution system.

Ans:

(Any Four requirements are expected: 1 Mark each, Total 4 Marks)

Ideal distribution system should possess following properties or requirements

1. Layout should be simple in design.
2. It should have less initial cost
3. Make the distribution system with minimum distribution losses.
4. Voltage drop in distribution system should be less and within permissible limit (± 6%).
5. From safety point of view distribution system should maintain proper clearances.
6. Select the rating of distribution transformer & cross section of conductor from the result of load densities present & future.
7. Power should be available to consumers whenever needed.
8. A steady, non-fluctuating, quality supply (Pure sine wave) should be available to consumers.
9. Distribution system should not be over loaded.
10. Distribution system should have high reliability to maintain supply.
11. Distribution system lay out should not affect the appearance of locality.
12. Before installation of distribution system proposed widening of the road in the near future are to be kept in mind
13. It should have low, easy, less costly & less time consuming maintenance.
14. Fault on nearest distribution system should not affect stability of existing distribution system.
15. Time required for completion of work should be less.

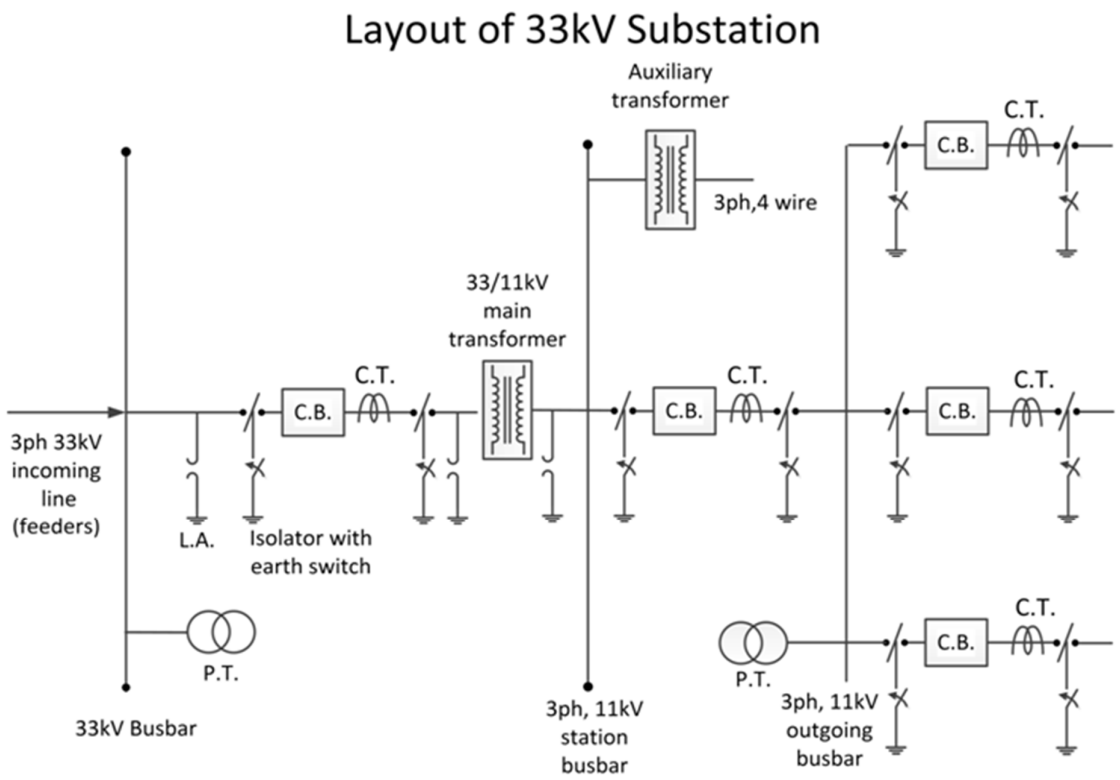
e) Compare Indoor and outdoor substation any four points.

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

Sr. No.	Points	Indoor substation	outdoor substation
1	**Capital cost**	High, as construction work cost is more.	Less, as construction work cost is less.
2	**Time required for completion**	More, as construction work is more.	Less, as construction work is less.
3	**Distance between two equipment**	Less, this will increase possibility of fault & safety reduces.	More, this will reduce possibility of fault & safety increases

	4	**Access for incoming & outgoing line**	Difficult access for incoming & outgoing lines because of indoor installation.	Easy access for incoming & outgoing lines because of outdoor installation.
	5	**Cooling arrangement**	Natural cooling is not available so artificial cooling arrangement is required This increases energy consumption charges due to indoor installation.	Natural cooling is available due to outdoor installation. This reduces energy consumption charges due to outdoor installation.
	6	**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 increases energy consumption charges due to indoor installation	Natural light is available in day time, so there is no need of illumination during day time. So it saves electrical energy & its cost
	7	**Detection of fault**	Difficult, as all equipments are not easily viewed.	Easy, as all equipments are easily viewed.
	8	**Replacement of equipment**	Difficult, due to indoor installation.	Easy, due to outdoor installation.
	9	**Future expansion**	Expansion of substation is not easily possible whenever needed because of construction work. Also it require more time & cost.	Expansion of substation is easily possible whenever needed & can be completed in less time & cost.
	10	**In case of accident**	In case of accident there is more risk & damage to other equipments than outdoor substation.	In case of accident there is less risk & damage to other equipments than indoor substation.
	11	**Space Require**	Less	More
	12	**Effect of Atmospheric condition**	Switching operation is not difficult in rainy season & it is more safe due to indoor installation	Switching operation is difficult in rainy season & it is less safe
	13	**Chances of leakage current**	Less due to indoor installation	More due to outdoor installation
	14	**Maintenance cost**	Less due to indoor installation	More due to outdoor installation.
	15.	**Applications**	In places where heavy rainfall, snow fall occurs or there is humidity in atmosphere also where availability of space is less then under such situations sub stations are installed indoor.	Where atmospheric conditions are clean and dry also where space available is more then subs stations are installed outdoor.

f)	**Draw layout of 33/11 kV sub-station.**
Ans:	**Layout of 33/11 kV sub-station and label:** **(4 Marks)**



or equivalent figure

Q.6	**Attempt any FOUR of the following :** **16 Marks**
a)	**A single phase 11 kV short transmission line delivers 1000 kW power at 0.8 p.f lagging total resistance and inductive reactance of the line are 5 Ohm and 5.6 Ohm. Determine sending end voltage and regulation.**
Ans:	$\therefore Cos\varphi_R = 0.8 \ \therefore \ \sin\varphi_R = 0.6$ Resistance 0.5 ohm Reactance 5.6 ohm **Step 1: To calculate Sending end voltage:** Power P = $VI\cos\phi$.---------- **(1/2 Mark)** $I \equiv \frac{P}{V\cos\phi}$, $I \equiv \frac{1000\times10^3}{11\times10^3\times0.8}$ $I \equiv 113.6363 \ amp$.---------- **(1/2 Mark)**

Step 2: To calculate Sending end voltage:

$$\mathbf{Vs} = V_R + I(R_T \cos\phi_R - X_T \sin\phi_R) \text{ .---------- (1 Mark)}$$

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

$$= \mathbf{11000 + 836.3631}$$

$$= 11836.3631 \text{ volt}$$

$$\text{Vs} = 11.836 \text{ KV .---------- (1/2 Mark)}$$

Step 4:To calculate voltage regulation:

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

$$= \frac{11836.3631 - 11000}{11000}\times100$$

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

$$= \mathbf{7.6033\ \%}$$

b) Write sequence of operation of isolator, earthing switch and circuit breaker while opening and closing.

Ans: **Sequence of operation of Isolator, C.B. and Earthing switch while opening & closing is as below:**

- **While Opening:** ----------(2 Marks)
  1. Open circuit breaker
  2. Open Isolator
  3. Close earthing switch
- **While Closing:** ----------(2 Marks)
  1. Open earthing switch
  2. Close isolator
  3. Close circuit breaker

c)	**State the factors to be considered while selecting site for sub-station.**
Ans:	**Following factors should be considered while deciding location of site for sub-station:-** **(Any Four factors are expected: 1 Mark each, Total 4 Marks)**

Near load center :

Sub-station should be located near load center to reduce cost of Transmission and distribution lines and to reduce losses in it**.**

1. **Easy access for transmission Line :**

   There should be easy access for incoming and outgoing line.

2. **Easy access towards sub-station :-**

   There should be easy access towards sub-station for transportation of equipments and manpower etc.

3. **Space(Land) available :**

   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.

4. **Atmospheric conditions :**

   Atmospheric condition in the area of sub-station should be clean and dry also There should be less atmospheric pollution.

5. **Cost of land :**

   Cost of land should be less to reduce capital cost of sub-station.

6. **Municipal restriction :**

   Where municipal restriction will not take any objection for required type building of sub-station.

7. **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.

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

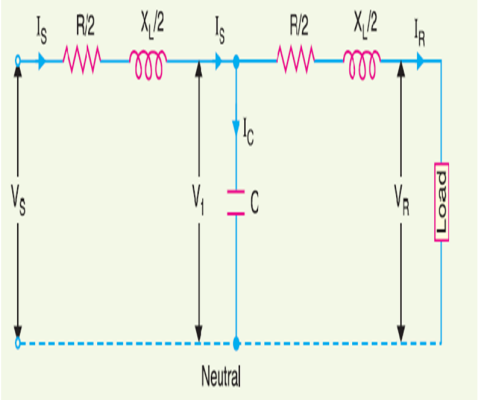
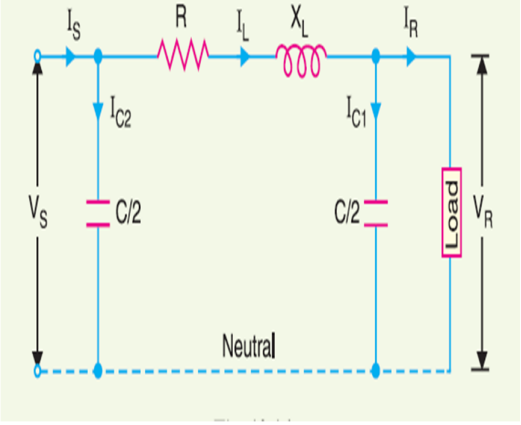
   To reduce construction cost of building and for better foundation of equipments land should have high bearing capacity**.**

9. **Area free from earthquake :**

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

d) Compare on any four points nominal 'T' and nominal 'π' network of medium transmission line.

Ans: **(Any Four Point Expected : 1 Mark each)**

Sr.No	Nominal T Method	Nominal π 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 'π' hence its name is nominal 'π' method
4		
5	Values of ABCD constants T-equivalent circuits of are as bellows: $\therefore A = D = 1 + \frac{YZ}{2}$ $\therefore B = Z \left[1 + \frac{YZ}{4} \right]$ ohm $\therefore C = Y$ mho	Values of ABCD constants π equivalent circuits of are as bellows: $\therefore A = D = 1 + \frac{YZ}{2}$ $\therefore B = Z$ ohm $\therefore C = Y \left[1 + \frac{YZ}{4} \right]$ mho

e)	**Name four important protective devices used in sub-station and mention their function.**
Ans:	**(Any Four protective devices are expected: 1 Mark each, Total 4 Marks)**

1) 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.

2) Earth switch: -

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

3) Isolator (No load Switch): -

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

4**) 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.

5) 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.

6) 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.

7) Horn Gap Fuse: -

It is provided to primary side of transformer for protection against over current.If C.B. is installed on primary side of transformer than Horn gap fuse is not provided.

f) Compare pin type and suspension type insulator on any four points.

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

S.No	Points	Pin Type insulator	Suspension or Disc Type insulator
1	**Shape**	It is vertical in Shape	It has Disc / Round in Shape
2	**Size**	Its size depends on voltage level. As voltage level increases size increases.	Its size is fixed and is design for 11 Kv.
3	**Construction**	It is so designed that even if top surface of insulator is wet, lower portion remains dry due to rain shades. Surface of insulator is well finished (glazed) to reduce moisture holding capacity.	It is so designed that even if top surface of insulator is wet, lower portion remains dry due to rain shades. Surface of insulator is well finished (glazed) to reduce moisture holding capacity.
4	**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.
5	**Position of conductor on insulator**	On the top of the insulator	Conductor is clamped at the bottom of the insulator in a string
6	**Protection against lighting stroke**	As conductor is fixed on top of insulator there is no protection to the conductor against lighting stroke.	As conductor is below the suspension insulator the conductor is protected against lighting stroke.
7	**Possibility of flash over**	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.
8	**Flexibility/Wind Pressure**	As it is permanently fixed on the cross arm so it is not flexible So effect of wind pressure is more.	It is provides flexibility as string of insulator is free to swing & take position where mechanical stresses are less. So effect of wind pressure is less

	9	**Reaction on cross arm**	More	Less
	10	**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.
	11	**Improvement of voltage level in existing line**	Old pin type insulator (e.g. suppose11 KV) should be replaced by new pin type insulator (of 22 KV)	If operating voltage of existing line has to be increased than we can add required number of disc insulators in existing string instead of replacing whole unit hence it is economical
	12	**Design/Limitation**	Pin type insulator are designed & manufactured up to 33 KV	Can be used For Any Higher Voltages by adding number of disc in a string of suspension insulator
	13	**Life**	Less	More
	14	**Effect on height of pole**	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.
	15	**Weight**	Weight of 11 KV pin type insulator is less than weight of 11 KV suspension type insulator	Weight of single suspension type insulator is more as compared to 11 KV pin type insulator.
	16	**Types**	1. Single shed Pin insulator: 2. Double shed pin insulator: 3. Triple shed pin insulator:	1) Hewlett or interlinking type 2) Cemented Cap type 3) Core & link type

	17	**Application**	Used for voltage level up to 33 KV maximum. & When Line is running straight. but in case of horizontal conductor configuration only	Here one disc is designed for 11 KV so by connecting number of discs in a string of suspension insulators it can be used for 66/110/ 132 /220/ 400/765 KV & even for more voltages. or above 33Kv & When Line is running straight	

----------END----------