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 Marks**
i)	**State necessity of transmission of electricity. (any two points)**
Ans:	**Because of following points there is necessity of transmission of power:** **(Any Two point expected : 1 Mark each)** a) Electrical load on power system is not concentrated at one place but it is widely spread. b) Load points are located away from generating station. c) Due to limitation of site selection criteria of major generating Station (HPP, TPP & NPP) are located far away from load centers and hence the electricity need to transmit from generating stations to the point of actual utilization of it (consumers) for this purpose transmission electricity is necessary.
b)	**State any four transmission line components.**
Ans:	**Following are the some components of transmission Line:-** **(Any Four are expected : 1/2 Mark each)** 1. Supporting structure (pole) 2. Line insulator 3. Overhead conductor 4. 'V' Cross arm 5. Top pin support

	6. Two Pin Cross arm 7. Four pin cross arm 8. Stay set (Stay wire of 7/8 or 7/10 SWG) 9. Lighting arrestors 10. Guarding wires 11. Continuous earth wire 12. Cables 13. Fuses and Isolating switches 14. Different types of Clamp (A-type, B-Type) 15. Bird guards 16. Vibration damper 17. Jumpers
c)	**Define stranded conductor. State its two advantages.**
Ans:	**Meaning of stranded conductor :** **(1 Mark)** Stranded conductor is made of several thin wires called as strand brought together to become single conductor. ➢ **Advantages of Stranded Conductors:-** **(Any Two expected : 1/2 Mark each)** 1. Conductor becomes flexible. 2. Its weight reduces. 3. Easy for handling. 4. Easy to store & transport. 5. Skin effect reduces.
d)	**Classify cables according to voltage level.**
Ans:	**Classification of cables with their voltage levels:** **(AnyFour Classification of cable with voltage level are expected: 1/2 Mark each)** 1. **Low voltage (tension) cable/LT cable:** for operating voltage 1.1 KV. 2. **High voltage (tension) cable/HT cable:** for operating voltage 11 KV. 3. **Super tension cable/ST cable**: for operating voltage 22 KV to 33 KV. 4. **Extra-Super tension cable:** for operating voltage 33 KV to 66 KV. 5. **Extra-high tension cable (EHT):** for operating voltage up to 132 KV 6. **Extra-super voltage power cables:** for operating voltage beyond 132 KV

e) Define : (i) VCV (ii) DCV referred to corona.

Ans:

(i) Visual Critical voltage (VCV): **(1 Mark)**

It is the minimum phase to neutral voltage at which corona just becomes visible. i.e. voltage glow occurs around the conductor.

(ii) Disruptive Critical voltage (DCV): **(1 Mark)**

It is the minimum phase to neutral voltage at which procedure of formation of corona just starts.

f) Classify transmission lines as per voltage levels.

Ans:

Classify transmission lines as per voltage levels: **(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

g) State two transmission routes of HVDC transmission line in Maharashtra.

Ans:

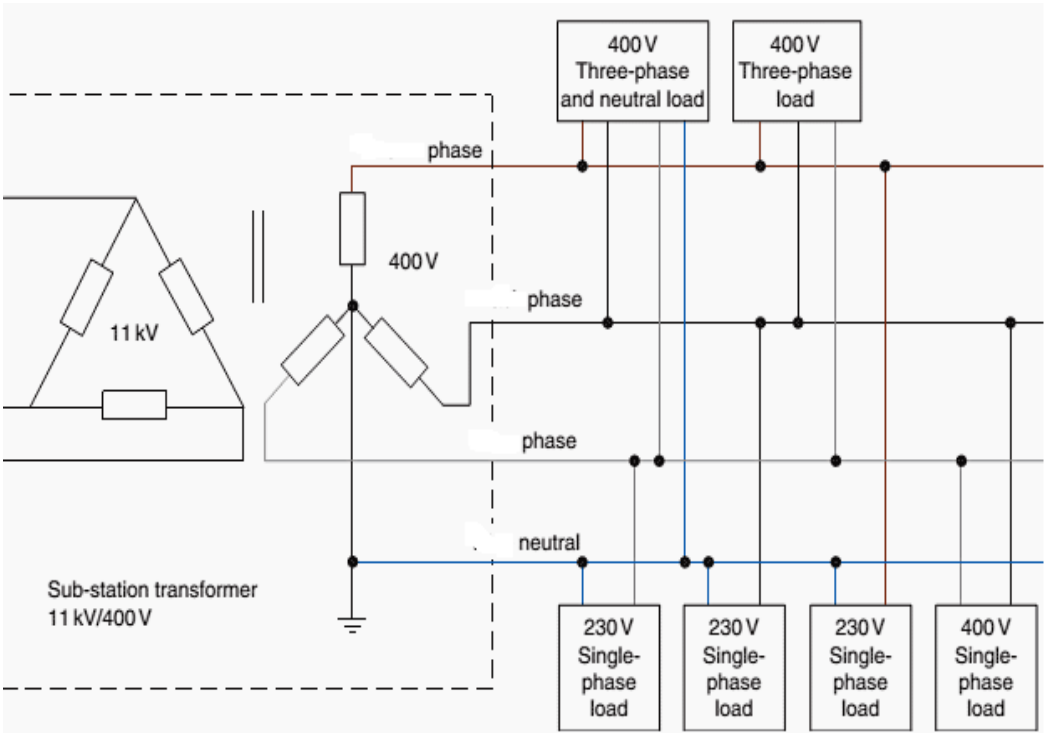
(Any Two Routes are expected : 1 Mark each)

S.N.	From	To	Distance	Power	Voltage
1	Rihand (U.P) (from 1990)	Dadri	814 Km	15000 MW	±500 KV (bipolar)
2	Talcher- is the biggest HVDC transmission passes through Orissa (A.P) Tamilnadu & Karnataka	Kolar	1376 Km.	2000 MW	±500 KV (bipolar)
3	Chandrapur- Padghe (Maharashtra) in Western Region	Padghe (Maharashtra)	752 Km	1500 MW	±500 KV (bipolar)
4	Bersoor (M.P.)	Lower Sileru (Arunachal Pradesh)	Mono Polar	100MW	100KV
5	Connecting Northern region (Sasaram- Pusawali)	Eastern Region	0 Km (back to Back link)	500MW	140KV
6	Connecting Northern region	Western	0 Km (back	2×250M	70KV

	(Vindhyachal)	Region	to Back link)	W	
7	Connecting Southern region (Chandrapur)	Western Region	0 Km (back to Back link)	2×500M W	140KV
8	Connecting Southern region(Vizag- Gajuwaka)	Eastern Region	0 Km (back to Back link)	500MW	140KV

h) Draw single line diagram of 11 kV/440V distribution system.

Ans: **Single line diagram of 11 kV/440V distribution system:** **(2 Marks)**



OR **Equivalent Fig.**

i) Define voltage regulation of transmission line.

Ans: **(2 Marks)**

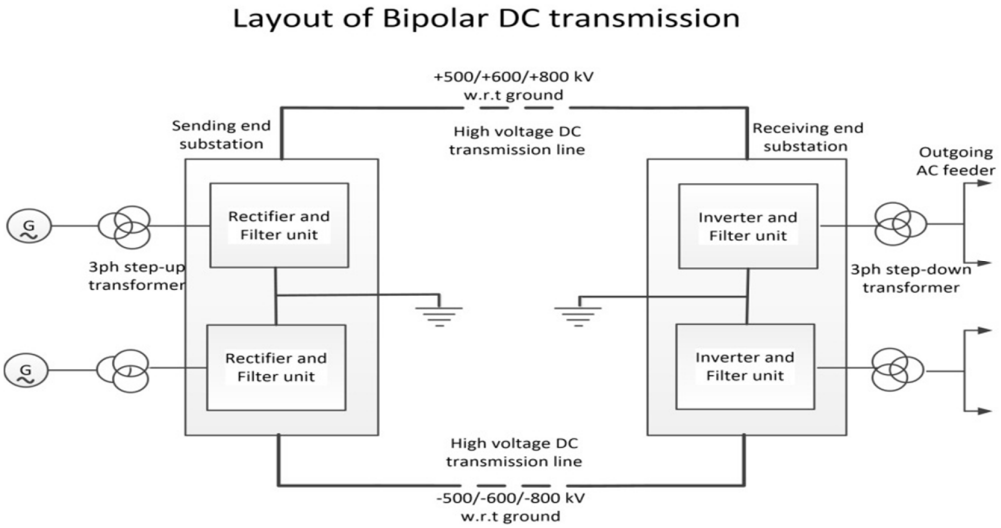
Regulation:

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

$$\textbf{\% Regulation} = \frac{Sending\ End\ Voltage - Receiving\ End\ Voltage}{Receiving\ End\ Voltage} \times 100$$

j)	**Define : (i) Feeder (ii) Distributor**
Ans:	**1. Feeders:** **(1 Marks)** It is a link between Receiving substation (or Secondary transformer substation) and distribution transformer substation (or Service transformer**)**. It is 3-Ph Three-Wire System and voltage level is 11/22/33 KV depending upon load, normally no tapping are taken from feeders. While designing the feeder its current carrying capacities are important. **2. Distributors:** **(1 Marks)** It is a link between distribution substation and Consumers. It is 3-Ph Four-Wire System (R-Y-B-N) and Voltage level 3-Ph 400 Volt, for single phase supply voltage is 230 volt, while designing the distributor voltage drop is important.
k)	**Define : (i) Primary (ii) Secondary distribution system**
Ans:	i) **Primary distribution:** **(1 Marks)** It is 3-Ph Three-Wire System and voltage level is 11/22/33 KV depending upon load. It is link between receiving substation & distribution transformer **ii) Secondary distribution System:** **(1 Marks)** It is 3-Ph Four-Wire System (R-Y-B-N) and Voltage level 3-Ph 400 Volt, for single phase supply voltage is 230 volt. It is link between distribution transformer substation & consumer
l)	**State the function of equipments used in sub-station (a) CT and PT (b) Isolator.**
Ans:	**a) Instrumental Transformer (CT & PT**):- **(1 Mark)** 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. **b) Isolator (No load Switch): -** **(1 Mark)** Its function is to connect or disconnect the circuit only when there is no load.
m)	**State the primary & secondary distribution standard voltages in our country.**
Ans:	**Primary distribution standard voltages is :-** **(1 Mark)** ➢ 11KV/22KV/33KV **Secondary distribution standard voltages is:-** **(1 Mark)** ➢ Distributor voltage is for 3-ph consumer- 400V and 1-Ph consumer- 230V

n)	**State any four advantages of H.V. transmission.**
Ans:	**Advantages of high voltage transmission : (Any four advantages expected 1/2 Mark)** 1) Cost of transmission line per kilometer reduces. 2) Performance of transmission line gets improved. (i.e. efficiency & regulation gets improved) . 3) Bulk amount of power can be transmitted over long distances. 4) For long distance it is necessary of HV transmission.
Q.2	**Attempt any FOUR of the following : 16 Marks**
a)	**Draw a neat sketch of Bipolar HVDC transmission system. State its advantages and disadvantages.**
Ans:	**Sketch of Bipolar HVDC transmission system: (2 Marks)**



OR **Equivalent Fig.**

Advantages:(Any One advantage expected) (1 Mark)

1. Power transmitting capacity is doubled as compared to monopolar link.
2. Reliability is high.
3. In the event of fault in any one pole the bipolar link is quickly switch over to monopolar link.

Disadvantages:- (1 Mark)

1. High initial cost

b)	**State any four causes of failure of line insulators.**
Ans:	**The Reasons for the Failure of Insulators: -** **(Any four causes expected: 1 Mark each Total 4 Marks)** **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 eg: 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.
c)	**State factors on which proximity effect depends ? How it can be reduced ?**
Ans:	**Proximity effect depends on following points:-** **(2 Marks)** 1. Magnitude of frequency. 2. Distance between to conductor 3. Size of conductor. 4. Resistivity conductor material. 5. Permeability of conductor material. **Proximity effect can be reduced:-** **(2 Marks)** 1. By increasing the distance between two conductors i.e. by using longer cross arm 2. By using overhead transmission system instead of underground. 3. Effects are negligible for small size, small current carrying conductor **4.** Use DC transmission system instead of AC transmission system to avoid proximity effect, Since frequency of DC supply is Zero
d)	**State advantages and disadvantages of corona. (any two each)**
Ans:	**Advantages of Corona:-** **(Any Two Advantages expected: 1 Mark each)** 1. Due to formation of corona air around the conductor gets ionized. Hence effective diameter of conductor increases. So its resistance decreases. ($Since\ R = \rho \frac{l}{A}$) 2. It reduces electrostatic stresses as cross section of conductor's increases. 3. It provides safety valve against over voltage due to lighting stroke. 4. It reduces effect of transient produced by surge.

Disadvantages of Corona:- **(Any Two Advantages expected: 1 Mark each)**

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.

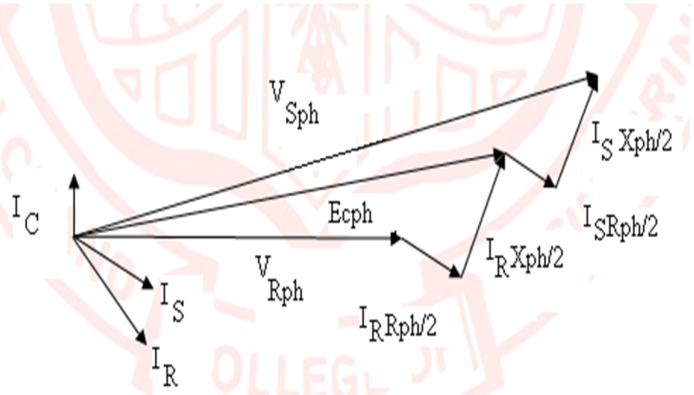
e) State assumption made and draw phasor diagram for transmission line represented as a nominal `T' network.

Ans:

Assumptions: **(2 Marks)**

1. It is assume that line capacitance is connected at centre of transmission line.
2. It is assume that half of the resistance & reactance per phase are divided in either side of capacitance.

Phasor diagram for nominal `T' network:- **(2 Marks)**



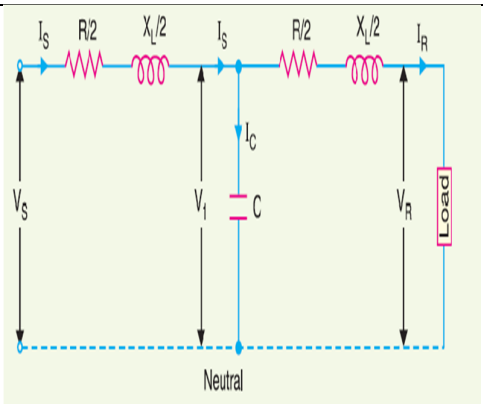
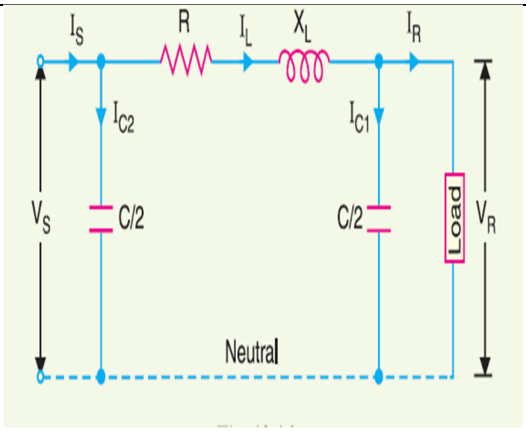
or equivalent Vector Diagram

f) Compare between nominal "T" and nominal "π" transmission line network. (any four points)

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

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

a) **Define skin effect. State methods to reduce it.**

Ans: **Define 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.(Since the inductive reactance (X_L) at the center 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 reduced by: **(2 Marks)**

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.

b) State Ferranti effect. When these effects occur ?

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

When receiving end voltage (V_R) is found to be greater than sending end voltage (V_S). This phenomenon is known as Ferranti effect

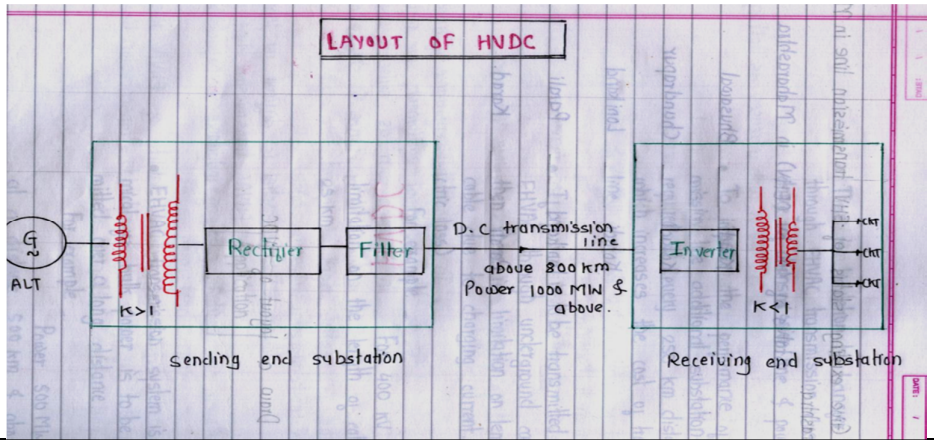
When these effects occur:- **(2 Marks)**

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.

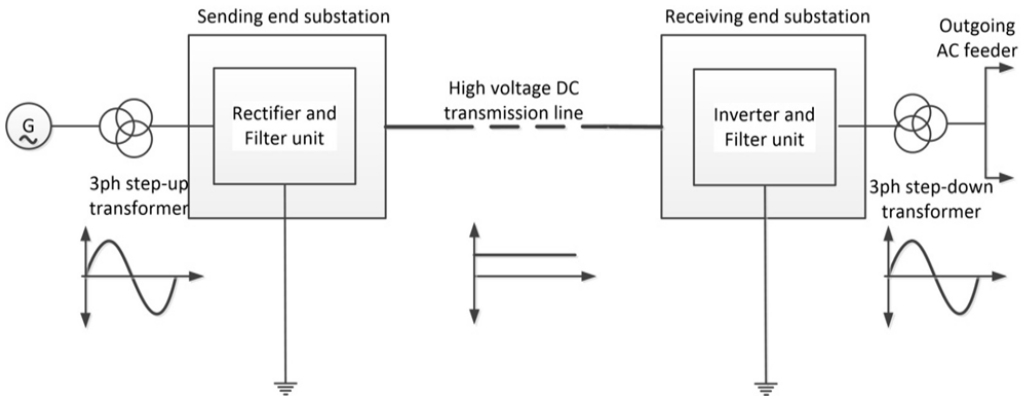
c) Draw block diagram for HVDC transmission starting from generator.

Ans: **block diagram for HVDC transmission line:** ---------- **(4 Marks)**



OR

Basic Layout of DC transmission



OR **Equivalent Fig.**

d) Compare HVAC and HVDC transmission system. (any eight points)

Ans:

(Any Eight Point Expected : 1/2 Mark each)

S.No	Points	EVAC	EVDC
1	Number of conductor required for single circuit	Three conductors (R.Y.B)	One conductor.& Ground is used as a return path
2	For double circuit	Six conductors (R,Y,B & R,Y,B)	Two conductors.& Ground is used as a return path
3	Design of Tower	Heavy	Light
4	Intermediate substation	Required at every 250 Km	Not required
5	Capital cost of S/S	Less	More
6	Transmission line cost/km for long distance. (Above 500km.)	More	Less
7	Ground return	Not possible	Possible
8	Frequency	Present	Absent
9	Skin effect	Present	Absent

10	Proximity effect	Present	Absent
11	Ferranti effect	Present	Absent
12	Corona losses	More	Less
13	Radio interference	Present	Absent
14	Effect of L &C	Present	Absent
15	Value of resistance	More 1.6 times than DC	Less
16	Copper loss	More	Less
17	Transmission Efficiency	Less	More
18	Voltage drop in transmission line	More	Less
19	% Regulation	Good	Better
20	Limitation on length of cable	Due to charging current there is limitation on length of cable	Charging current is absent so no limitation on length of cable
21	String efficiency	Less than 100 %	100 %
22	Losses in S/s	Less	More
23	Maintenance cost of S/S	Less	More
24	Asynchronous tie	Not possible	Possible
25	Reliability & availability	AC Double circuit are necessary	One bipolar line is sufficient
26	Control system	Simpler cheaper	Difficult, costly
27	Power handling capacity	There is limit due to inductance & power angle	No limit
28	Voltage control for long distance lines	Difficult for long distance lines due to presence of L &C	Easier as L&C are not effective
29	Stability limit	EHVAC limits due to inductance & power angle	No limit due to absent of inductance & power angle
30	Power flow control	Power flow cannot be easily controlled, (slow)	Power can be quickly(fast) controlled,

31	Power transfer ability	Lower	High
32	Transient performance	Poor	Excellent
33	Back to Back conversion stations	Not Possible	Possible
34	Short-circuit current level	More	Less
35	Reliable circuit breaker	Available	Not available
36	Fault levels	Get added after interconnection	Remains unchanged
37	Frequency conversion	Not possible	Possible
38	Cascade tripping of circuit	Likely	Avoided
39	Spinning reserve	Not much reduced	Reduced
40	Frequency of fault	More	Less

e) Compare indoor and outdoor sub-station. (any eight points)

Ans: **(Any Eight points are expected: 1/2 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	Natural light is available in day time, so there is no need of illumination during day time. So it saves electrical

			increases energy consumption charges due to indoor installation	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) Classify sub-station on the basis of (i) service requirements (ii) constructional features

Ans:

1. Classification According to service requirements :-

(Any Two point expected :1 Mark each)

1. **Transformer Sub-station:-** Those sub-station which change the voltage level of electric supply is called transformer sub-station.
2. **Switching sub-station:-** This sub-station does not change the voltage level.
3. **Power Factor correction sub-station:-** These sub-station which improve the power factor

of the system. It is located at receiving substation.

4. **Frequency changer sub-station:-** These sub-station which change the supply frequency.
5. **Converting sub-station:-** These sub-station which change AC power into DC power or DC power into AC power
6. At receiving end, this DC supply is again converted into AC supply with the help of
7. **Industrial Sub-station (Bulk Supply Industrial Consumer Substation):-** These sub-station which supply power to individual industrial consumer. It is located in premises of industry
8. **Traction substation:** These sub-station which supply power to electric railway only.
9. **Mining Substation:** The mining substations are very special type of substation & they need special design construction because of extra precautions for safety needed in the operation of electric supply
10. **Mobile Substation:** The mobile sub stations are also very special purpose substation temporarily required for big construction purpose this substation fulfils the temporary power requirement during construction work, exhibition, Remote place need supply for any type of activity etc.

2. Classification According to Construction features:-

(Any Two point expected :1 Mark each)

1. **Indoor Substation:** In this substation all equipments including transformer are installed under closed construction building is called indoor substation.
2. **Outdoor Substation:** In this substation all equipments including transformer are installed in air (Open to sky) only control room is constructed is called outdoor substation
3. **Gas insulated Substation:** Where Space available is very less then GIS substation are used (e.g. substation is preferred in thickly populated area, Space available for building & equipments is limited and where cost of land is very high.).
4. **Underground Substation:** In underground substation all equipments including transformer are installed under closed construction in underground.
5. **Pole mounted substation:** Generally distribution transformer substation are pole

	mounted. 6. **Plinth Substation:** Generally large capacity transformers are plinth mounted because its weight is high. Transformer 315 KVA & above are generally plinth mounted. 7. **Compact/prefabricated substation:** Nowadays compact or prefabricated distribution substations are more popular. Its appearance is better than pole mounted and plinth mounted distribution substation.
Q.4	**Attempt any FOUR of the following : 16 Marks**
a)	**Write any four advantages of Disc insulators.**
Ans:	**Advantages Of Disc Insulators: (Any Four point expected :1 Mark each Total 4 Marks)** 1. **Protection against lighting stroke:** As conductor is below the suspension insulator the conductor is protected against lighting stroke 2. **Possibility of flash over:** 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. 3. **Flexibility:** 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 4. **Reaction on cross arm:** It is less as contact area between cross arm & insulator is less as compared to pin type insulator. 5. **Maintenance /replacement cost:** 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. 6. **Improvement of voltage level in existing line:** 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 7. **Design/Limitation:** No limitation Can be used For Any higher Voltages by adding number of disc in a string of suspension insulator 8. **Life:** Life is more as it is flexible & suspended 9. Suspension type insulators are cheaper than pin type insulators for voltages beyond 33 kV.

10. **Protection against lighting stroke:** As conductor is below the suspension insulator the conductor is protected against lighting stroke
11. **Possibility of flash over:** 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.
12. **Flexibility:** 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
13. **Reaction on cross arm:** It is less (As contact area) between cross arm & insulator is less as compared to pin type insulator.
14. **Maintenance /replacement cost:** 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.

b) Write any four properties of conductor material used for transmission line.

Ans: **(Any FourTwo point expected :1 Mark each Total 4 Marks)**

Following are requirements of conductor:-

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. **Temperature coefficient of resistance:-**
   Material should have low temperature coefficient of resistance.
8. **Availability & cost:-**
   Material should be easily available & less costly.
9. **Scrap Value:-**
   Material should have high scrap value.

c) An overhead three phase transmission line delivers 5000 kW at 22 kV at 0.8 lagging P.F. The resistance and reactance of each conductor is 4 ohm and 6 ohm respectively. Determine sending end voltage and regulation.

Ans:

Given Data:-

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

Step 1: To calculate current:

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

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

$$I \equiv 164.01996 amp$$ ---------- **(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 = $\therefore V_{SL} = \sqrt{3} \times V_{sph}$

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

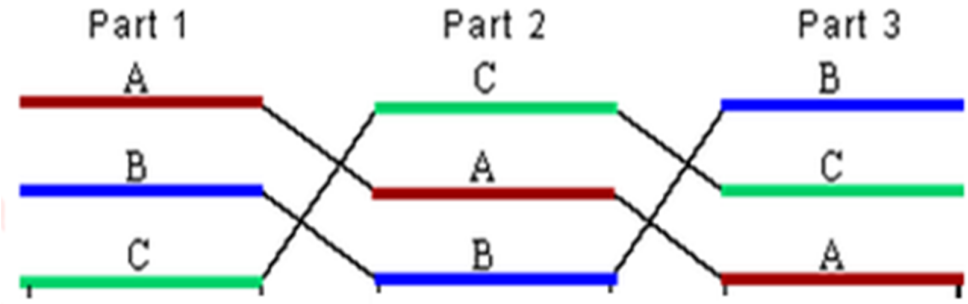
$= 23.9317$ KV ---------- **(1/2 Mark)**

Step 4:To calculate voltage regulation:

% 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)	**Define transposition of conductor with the help of diagram.**
Ans:	**(Definition transposition 2 Marks and Figure of transposition 2 Marks, Total 4 Marks)** **Meaning of Transposition of conductor** : 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 **Figure of transposition of conductor:** **(2 Mark)**  **OR Equivalent Figure**
e)	**Define sub-station. State factors to be considered for its site selection.**
Ans:	**Define sub-station** :- **(1 Mark)** Sub-station is a link between generating station and consumers. **OR** The assembly of apparatus used to change some characteristic of electric supply is called substation. & it is important part of power system. **OR** A substation is a part of an electrical generation, transmission and distribution system. The assembly of apparatus used to change some characteristics (e.g. voltage, A.C to D.C etc) of an electrical supply is called a substation. **Following factors should be considered while deciding location of site for sub-station:-** **(Any six point expected : 1/2 each)** **1. Near load centre :** Sub-station should be located near load centre to reduce cost of Transmission and

distribution lines and to reduce losses in it**.**

2. Easy access for transmission Line :

There should be easy access for incoming and outgoing line.

3. Easy access towards sub-station :-

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

4. 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. e.g.

For 400KV substation area required @ 50 acres

For 220KV substation area required @ 25 acres

For 132KV substation area required @ 10 acres

5. Atmospheric conditions :

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

6. Cost of land :

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

7. Municipal restriction :

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.

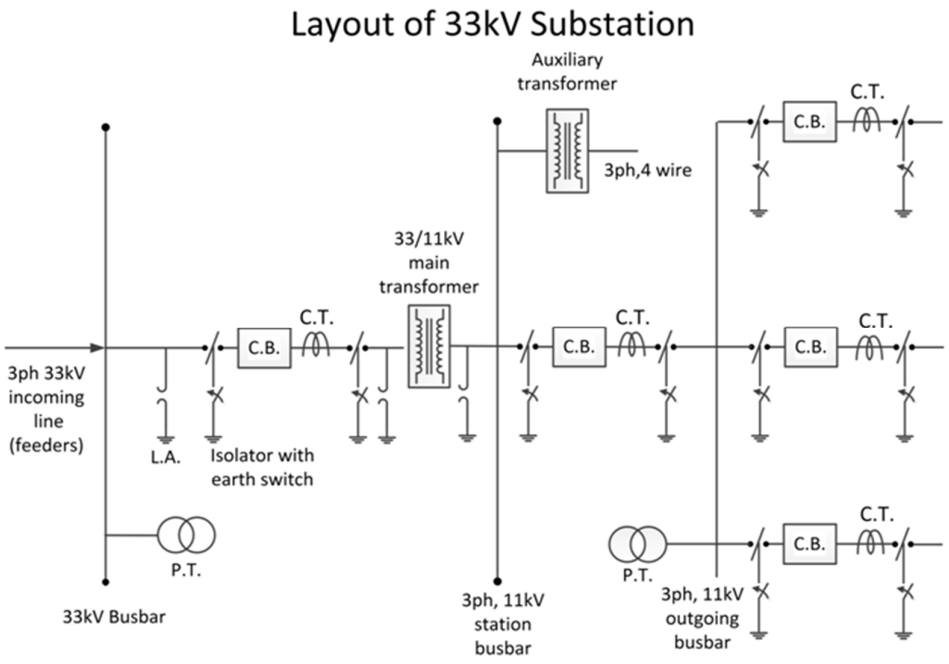
9. Bearing capacity of land (Hard land):

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

10. Area free from earthquake :

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

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

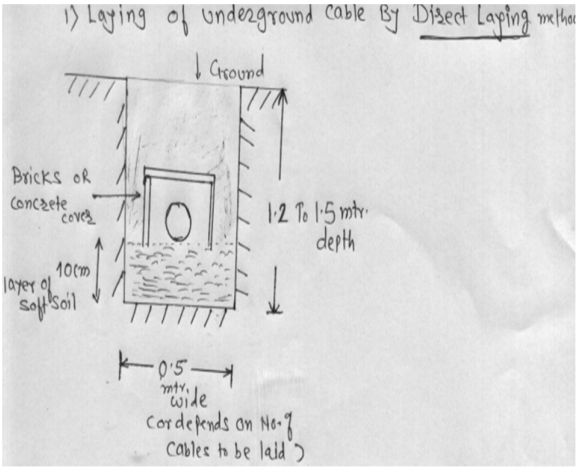
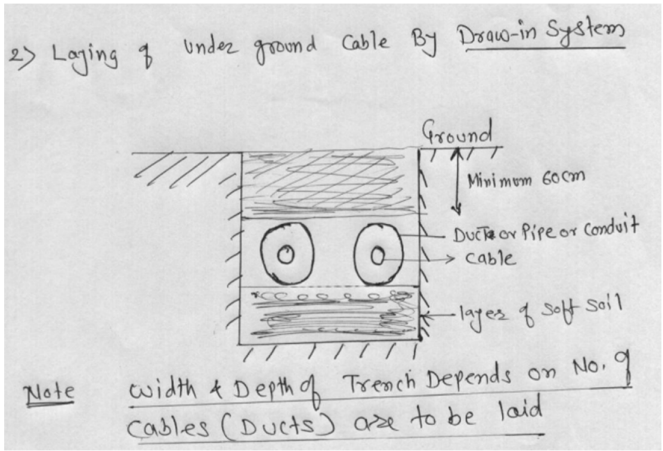


OR Equivalent figure

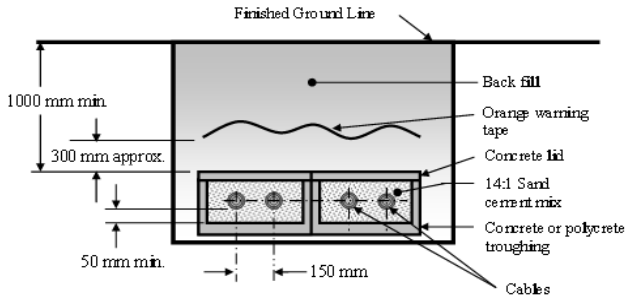
Q.5	**Attempt any FOUR of the following :** **16 Marks**
a)	**State (any eight points) the advantages of underground system of transmission over overhead system.**
Ans:	**(Any Eight advantages are expected: 1/2Mark each)**

Following are the advantages of underground system over overhead system.

1. **Chances of fault :** Less
2. **Chances of accident :** No chances of accident
3. **Safety :** More
4. **Radio interference :** Not produces radio interferences
5. **Short cute route :** Possible
6. **Theft Of energy :** Less possibility
7. **Voltage drop :** less
8. **Power factor :** More
9. **Reliability :** More
10. **Life :** More
11. **Space Required:** No space is consumed in underground system as against overhead system.
12. **Appearance:** Very good.

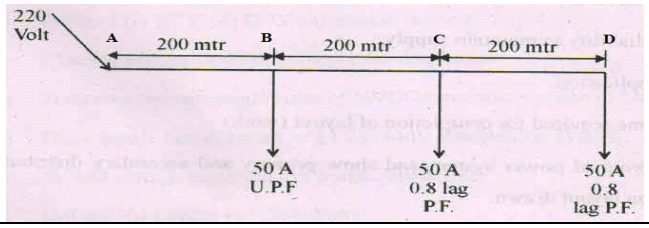
b)	**State the different methods of laying underground cable. Draw figure of any one type.**
Ans:	**Following are the different methods of Laying of under- ground cable:-** **(Any two Method expected : 1 Mark each)** 1. Direct laying cable 2. Draw- in system 3. Solid System 4. Cable laid in tray **Figure of Cable laying : -** **(Any One Figure expected : 2 Mark each)** **1) Direct laying Cable:**  **or equivalent figure** **2) Draw in cable laying System or Duct laid cable laying system:**  **or equivalent figure**

3) Solid Cable laying system:



or equivalent figure

c) A single phase AC distributor of 600 mtr length has total impedance of (0.02 j 0.04) ohm and is fed from one end at 220 volt. If it is loaded as shown in fig. Calculate the voltage drop and voltage at far end.



Ans:

$$Z = 0.02\ \Omega + j0.04\ \Omega$$

To find section impedance:

$$Z_{AB} = \frac{200}{600}(0.02 + j0.04)$$

$$Z_{AB} = 6.6666 \times 10^{-3} + j\ 0.013333\ \Omega \quad = 0.0149\ \angle 63.4346\ \Omega$$

Calculate Section Current:

Given $I_D = 50\ A\ at\ 0.8\ lag.$

$= 50\angle -36.87^0$ ----------

(1/2 Marks)

$I_D = 40 - j\ 30\ A$

Given $I_C = 50\ A\ at\ 0.8\ lag.$

$= 50\angle -36.87^0$ ----------

(1/2 Marks)

$I_C = 40 - j\ 30\ A$

Given $I_B = 50\ A\ at\ unity$

$= 50\angle 0^0$

$I_B = 50 - j\ 0\ A$

To calculate the section current:

$I_{CD} = I_D$

$I_{BC} = I_C + I_D$

$I_{BC} = (40 - j30) + (40 - j30)$

$I_{BC} = 80 - j\,60\ A$

$I_{BC} = 100 \angle -36.869^0\ A$ ----------

(1/2 Marks)

$I_{AB} = I_B + I_C + I_D$

$I_{AB} = I_B + I_{BC}$

$I_{AB} = (50 - j0) + (80 - j60)$

$I_{AB} = 130 - j60$

$I_{AB} = 143.1782 \angle -24.7751^0$ ----------

(1/2 Marks)

Calculate Voltage drop: $CD\ (V_{CD})$

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

$= (50 \angle -36.87^0)\ (0.0149 \angle 63.4349^0)$

$= 0.745 \angle 26.5649$

$V_{CD} = 0.66634 + j0.33317$

Voltage drops in section BC (V_{BC}):

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

$= (100 \angle -36.869^0)\ (0.0149 \angle 63.4349^0)$

$= 1.49 \angle 26.5659$

$V_{BC} = 1.333268 + j0.66636\ volt$ ----------

(1/2 Marks)

Calculate Voltage drop Section AB:

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

$= (143.1782 \angle -24.7751^0) \times (0.0149 \angle 63.4346^0)$

$= 2.13335 \angle 38.6595$

$V_{BC} = 1.66587 + j1.33268\ \ volt$ ----------

(1/2 Marks)

Total Voltage Drop:- =

$V_{BC} + V_{CD} + V_{AB}$

$= (0.6634 + j0.33317) + (1.33268 + j0.66636) + (1.66587 + j1.33268)$

$= 3.6649 + j2.3322\ V$

$= 4.3432 \angle 32.4774^0\ V$ ----------

(1/2 Marks)

Voltage at far end (V_D) = V_A – Total voltage drop

= (220+j 0) – (3.6649+ j2.3322)

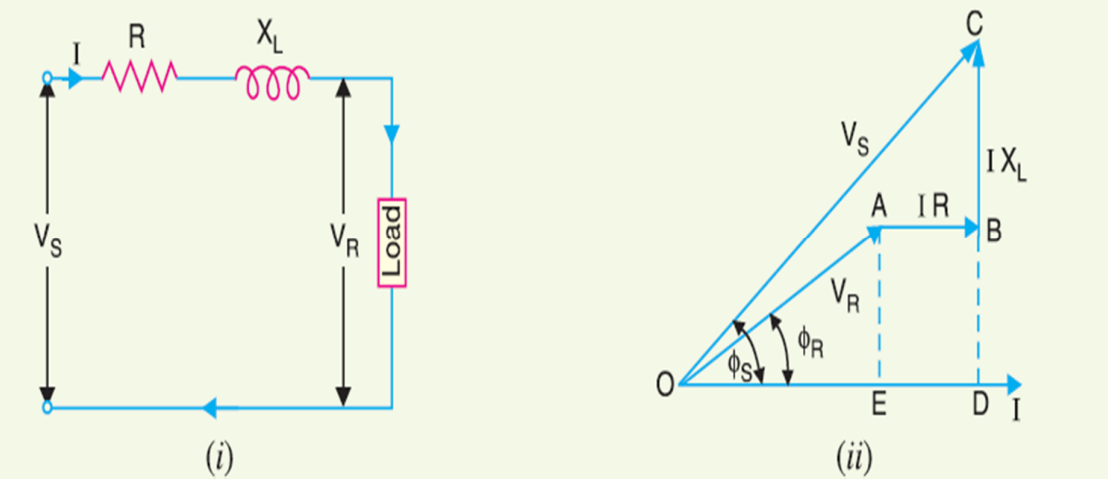
= 216.335- j 2.3322

= 216.3476 ∠-0.6176^0 volt ----------

(1/2 Marks)

d) Derive an expression for voltage regulation of short transmission line

Ans: **Derive an expression for voltage regulation of short transmission line:** **(4 Marks)**



Let, I = Load current,

R_T = Total resistance / Loop resistance/i.e. resistance of both conductor

X_T = Total reactance/ Loop reactance

V_R = Receiving end voltage

Cos $Ø_R$ = Receiving end power factor (lagging)

V_S = Sending end voltage

Cos $Ø_S$ = Sending end power factor

The vector diagram of the line for lagging load power factor is shown in figure. From the right angled triangle ODC, we get,

From vector diagram:

$$(OC)^2 = (OD)^2 + (DC)^2$$

$$V_S^2 = (OE+ED)^2 + (DB+BC)^2$$

$$V_S^2 = (V_R Cos\phi_R + I R_T)^2 + ((V_R Sin\phi_R + I X_T)^2$$

$$V_S = \sqrt{(V_R Cos\phi_R + I R_T)^2 + ((V_R Sin\phi_R + I X_T)^2}$$

After solving above equation and neglecting the higher order terms, we obtain

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

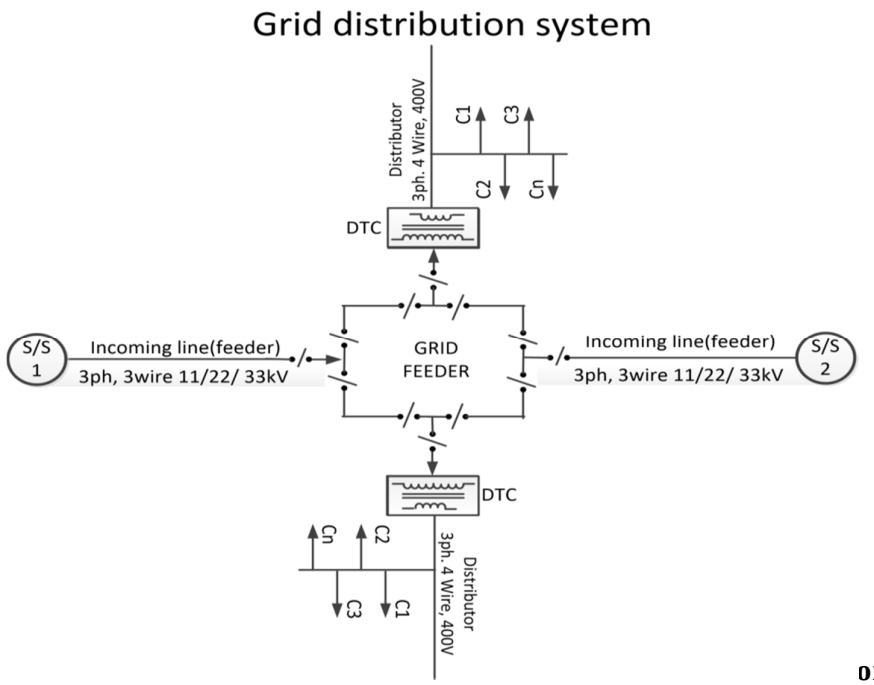
$$\% \text{ age Voltage Regulation} = \frac{V_S - V_R}{V_R} \times 100$$

e) State the 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 ($\pm 6\%$).
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.

f)	**Draw Grid A.C. distribution system scheme of connection and state its two advantages.**
Ans:	**(Layout 2 Marks, Advantages 2 Marks)**  **or equivalent figure** **Advantages:** **(Any Two advantages 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.
Q.6	**Attempt any FOUR of the following : 16 Marks**
a)	**State any eight characteristics or properties of line support.**
Ans:	**Following are the characteristics or properties of the line support :-** **(Any Eight properties are expected: 1/2 Mark each)** **1. High mechanical strength:-** It should have high mechanical strength

2. **Light in weight:-**
   It should be light in weight to reduce
3. **Effect of atmospheric conditions:** It should be withstand even at bad atmospheric condition.
4. **High resistance to corrosion:** It should have high resistance to corrosion to avoid rusting.
5. **Initial & Maintenance cost:** It should be less.
6. **Easy access:** It should be easily accessible for wireman for line work and maintenance work. or They must be easily accessible for point and erection of line conductors
7. **Life:** It should have longer life.
8. **Appearance:** It should have good appearance or They must be of pleasing shape

b) State on any four points comparison between AC distribution and DC distribution system.

Ans: **(Any Four points are expected: 1 Mark each)**

Sr.No	A.C Distribution System	D.C Distribution System
1	It require Four conductor	It require Two / Three conductor
2	More complicated system	It is simple system
3	Presence of skin effect	No skin effect
4	Effective resistance of conductor is more	Effective resistance of conductor is less
5	Losses are more	Losses are less
6	Distribution Efficiency is less	Distribution Efficiency is more
7	Effect of L & C Present	Effect of L & C Zero (absent)
8	Voltage regulation is poor	Voltage regulation is better

c) **A three phase overhead line is being supported by three disc insulators. The potential across line unit is 17.5 kV. Assume that shunt capacitance between each insulator and each metal work of tower to be 1/10th of capacitance of insulator. Calculate : (i) Line voltage (ii) String efficiency**

Ans: **V_n = 17.5 KV** **(Give stepwise Marks as mention below)**

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

$$m = \frac{1}{10}$$

$$m = 0.1$$

k = m = 0.1 ---------- **(1/2 Mark)**

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

$17.5 = V_1 (1+3 \times 0.1 + 0.1^2)$

V_1 = 13.35 KV ---------- **(1/2 Mark)**

$V_2 = V_1 (1+m)$

$= 13.35 (1+ 0.1)$

V_2 = 14.68 KV ---------- **(1/2 Mark)**

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

$= 13.35+14.68+17.5$

$= 45.53$ KV ---------- **(1/2 Mark)**

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

$V_L = \sqrt{3} \times 45.53$

V_L = 78.86 KV---------- **(1/2 Mark)**

ii) String efficiency:-

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

$$\text{String } \eta\% \equiv \frac{45.53}{3 \times 17.5} \times 100$$

String $\eta\%$ **= 86.72%.** ---------- **(1 Mark)**

d) State any four factors to be considered while designing the feeders.

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

(Each Point : 1 Mark, Total 4 Marks)

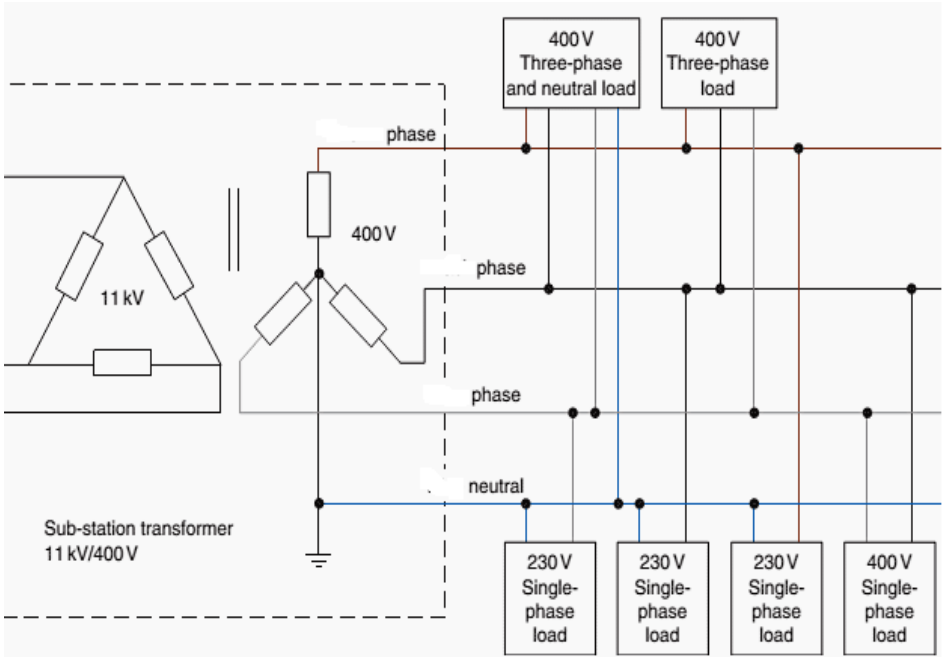
1) **Current carrying capacity of conductor:-**
Conductor should have high current carrying capacity. While voltage drop consideration is relatively not so important
It is because voltage drop in feeder can be adjusted with the help of tapings of distribution transformer manually or by using AVR (Automatic Voltage Regulator)
2) **Need:**
Depending upon application design of distribution system should be selected i.e. whether continuity of supply is important or not so important
Example: 1) Use Radial distribution system in rural area
2) Use Ring main distribution system in urban area
3) Use Grid distribution system where continuity of supply is important. e.g. Supply to - electric traction, TV broadcasting center, AIR, telephone exchange, major hospitals, important government buildings and major industries
3) **Availability of power:** It should be available whenever needed
4) **Maintenance:** It should be low, easy, less costly & less time consuming.

e) Compare radial distribution system and ring distribution system on the basis of (i) Initial cost (ii) Reliability to maintain supply (iii) Application (iv) Time required for completion of layout (work)

Ans: **(Each Point: 1 Mark, Total 4 Marks)**

Sr.No	Parameters	Radial distribution System	Ring distribution system
(i)	**Initial cost**	Less	More
(ii)	**Reliability to maintain supply**	Less	More
(iii)	**Application**	For short distance e.g. in rural area	For long distance e.g. in urban area
(iv)	**Time required for completion of layout (work)**	Less	More

f)	**Draw layout of power system and show primary and secondary distribution system on layout drawn.**
Ans:	**layout of power system and show primary and secondary distribution system: (4 Marks)**



Primary Distribution **Secondary Distribution**

OR Equivalent Layout should be consider

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