Winter – 2016 Examinations

Model Answer **Subject Code: 17417: TDE**

Important Instructions 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 principal components indicated in the 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 of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7. For programming language papers, credit may be given to any other program based on equivalent concept.

1 **Attempt any TEN of the following:** 20

1 a) State the standard voltages in India for the following:
i) Generation voltage
ii) Primary Transmission voltage

Ans:

The standard voltages in India for :
i) Generation voltage: 3.3kV, 6.6kV, 11kV, 33kVetc. 1 mark
ii) Primary Transmission voltage: 132kV, 220kV, 400kV,765kV 1 mark

1 b) State the necessity of transmission of electricity any two reasons.

Ans:

Necessity of transmission of electricity :
1. Electrical load on power system is not concentrated at one place but it is widely distributed.
2. Load points are located away from generating station.
3. Due to limitation of site selection criteria of major generating stations (HPS, TPS & NPS) are located far away from load centers and hence the electricity needs to be transmitted from generating stations to the point of actual utilization of it (consumers) for this purpose transmission of electricity is necessary.

Any two reasons 1mark each

1 c) State any four trade names of ACSR conductor.

Ans:

Following are the trade names of ACSR conductor:

Sr.No.	Brand/Trade name	Sr.No.	Brand/Trade name
1	Mole	15	Weasel
2	Squirrel	16	Ferret
3	Gopher	17	Rabbit
4	Mink	18	Horse
5	Beaver	19	Raccoon
6	Otter	20	Cat
7	Leopard	21	Coyote
8	Dog	22	Tiger
9	Wolf	23	Lynx
10	Panther	24	Lion
11	Bear	25	Goat
12	Sheep	26	Koo Doo
13	Deer	27	Elk
14	Moose	28	Camel

(Any Four expected:1/2 mark each Total 2 Marks)

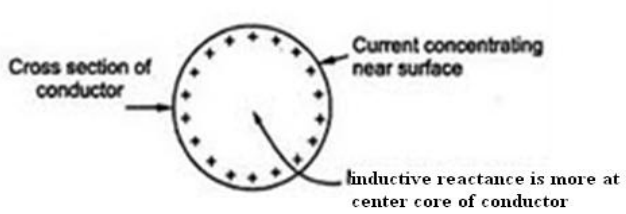
1 d) State the function of following layer in construction of a cable:
i) Armouring
ii) Metallic sheathing

Ans:

i) Armouring: To protect the cable from mechanical injury while laying it and during 1 mark

the course of handling.
ii)Metallic sheathing: To protect the cable from moisture,gases or other damaging liquids in soil and atmosphere. 1 mark

1 e) State the skin effect in transmission line conductor.
Ans:



Meaning of Skin effect:
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) 2 marks.

OR

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

1 f) What is meant by transposition of conductors and why it is necessary?
Ans:
Transposition of line conductors means changing the positions of 3- phases on the line supports twice over the total length of the line. 1 mark

Necessity of transposition :-
1. Due transposition of conductor the inductances of all lines get equalised ($L_A = L_B = L_C$) , So drop due to inductive reactance in each line is identical, so voltage at receiving end between any two lines 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.

Any Two points expected 1/2 Mark each

1 g) Define voltage regulation of transmission line.
Ans:
Voltage regulation of transmission line:
The difference in voltage at the receiving end of a transmission line between conditions of no load and full load is called voltage regulation of transmission line and is expressed as a percentage of the receiving end voltage.

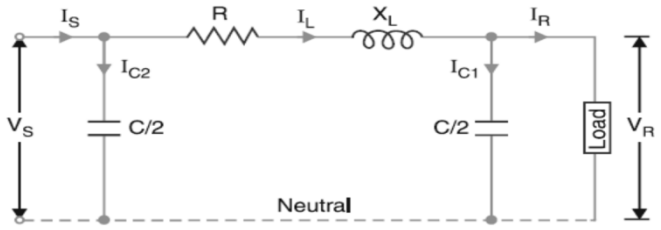
2 marks

% Voltage Regulation = $\{ (V_s - V_R) / V_R \} X 100$ ---------- **for 1-phase**
Where, V_R = receiving end voltage V_S = Sending end voltage

1 h) Draw equivalent circuit diagram of medium transmission line with nominal 'π' method.

1 h) **Ans:**

Nominal `π' representation of medium transmission line:



2 marks for labeled diagram

1 i) State any two routes of HVDC transmission line network in India.

Ans:

Sr. No.	From	To
1	Rihand (U.P) (from 1990)	Dadri (near Delhi)
2	Chandrapur- Padghe (Maharashtra)	Padghe (Maharashtra)
3	Bersoor (M.P.)	Lower Sileru (Arunachal Pradesh)
4	Talcher- is the biggest HVDC transmission passes through Orissa (A.P) Tamilnadu& Karnataka	Kolar
5	Connecting Northern region (Sasaram-Pusawali)	Eastern Region
6	Connecting Northern region (Vindhyachal)	Western Region

1 Mark for each Total 2 Marks

(Any Two Lines are Expected)

1 j) State the output voltage of distribution transformer.

Ans: 2 marks

Output voltage of distribution transformer: Three-phase line voltages = 415 V,
Single phase voltage (line to neutral) = 240 V

1 k) Why radial distribution system is used for short distances?

Ans:

Radial distribution system is used for short distances:

Since there is only one feeder to distribution transformer center (DTC) fed at one point so, 2 Marks

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.

If the system is used for long distance then it takes more time for troubleshooting and repairs. Hence radial distribution system is not used for long distance even though it's initial cost is low.

1 l) State the function of following components in distribution sub-station:

i) Lighting arrester

ii) Drop out fuse / drop down fuse

Ans:

i) Lightning Arrester: -

It is provided for protection of substation against lightning stroke.

ii) Drop out fuse / drop down fuse:-

It is provided for protection of Distribution transformer against fault.

1 Mark each

2 Attempt any FOUR of the following: 16

2 a) Study the Figure No. 1 and answer the following questions:

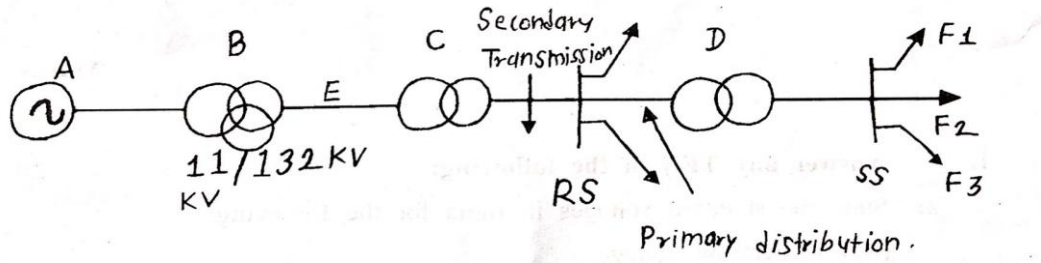


Fig. No. 1

i) Which part is shown by 'A'?
ii) State the meaning of symbol shown at 'B' point
iii) State the voltage rating of equipment at point 'D'.
iv) Which part is shown by 'E'?

Ans:

i) The part shown by 'A' is Generating station.
ii) Meaning of symbol shown at 'B' point is three-phase, three-winding transformer.
iii) Voltage rating of equipment at point 'D' is 11kV/415V
iv) Part shown by point 'E' is Primary transmission line.

1 mark each

2 b) Write any four desirable properties of transmission line conductor.

Ans:

Desirable properties of transmission line conductor:

i) High conductivity :

Material should have high conductivity, So that

- Cross section of conductor (size) reduces,
- Copper losses reduces,
- So Efficiency increases
- Voltage drop reduces,
- So Regulation gets improved

(Any Four Requirements are expected: 1 Mark each)

ii) High mechanical strength:

Material should have sufficiently high mechanical strength to with stand against

- Rough handling during transportation & Stringing,

- Wind Pressure,
  - Ice loading and
  - Severe climatic condition

iii) Flexibility: Material should be flexible for
- Easy handling and
- Storage

iv) Weight: Material should be light in weight to reduce
- Transportation & handling cost.

v) High resistance to corrosion:
Material should have high resistance to corrosion
- To avoid rusting

vi) Brittleness: Material should not be brittle.
- So that it will not easily cut after twisting.

vii) Temperature coefficient of resistance: Material should have low temperature coefficient of resistance.
viii) Availability & cost: Material should be easily available & less costly.
ix) Scrap Value: Material should have high scrap value.

OR

Following are the properties of conductor:-

1. Material should have high conductivity :
2. Material should have sufficiently high mechanical strength
3. It should be flexible for easy handling & storage
4. It should be light in weight to reduce transportation and handling cost.
5. It should high resistance to corrosion to avoid rusting.
6. It should not be brittle.
7. Material should have low temperature coefficient of resistance.
8. Material should be easily available & less costly.
9. It should have high scrap value.

2 c) Compare overhead transmission line with underground cable on the basis of public safety, flexibility, fault location and cost of installation.

Ans:

Sr.No.	Particulars	Overhead transmission line	Underground cable
1	Public safety	Less	More
2	Flexibility	More flexibility	No flexibility
3	Fault location	Easier	Difficult
4	Cost of installation	Less	More

1 Mark each

2 d) What is meant by double circuit line? State the types of line support.

Ans:

Double circuit line: The line which consist six conductors on the same tower or support is called Double-circuit line (R-Y-B & R-Y-B) 1 Mark

Types of line support:

1. Wooden poles
2. Steel poles

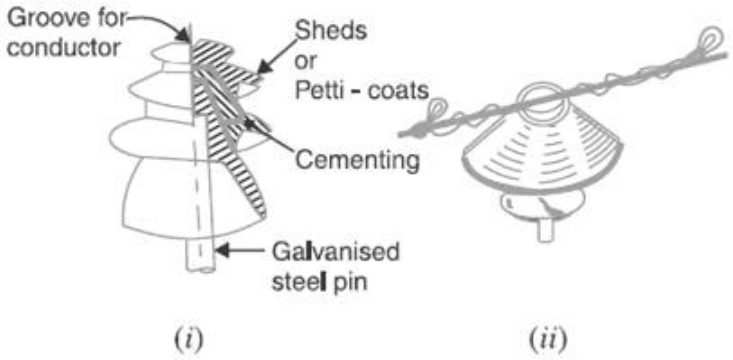
1 mark for each of any

3. R.C.C. poles three
4. Lattice steel towers

2 e) Draw a neat labeled digram for the following:
i) Pin type
ii) Insulator

Ans: Labeled diagram 4 marks

Students are expected to draw only diagram for Pin type insulator.



Unlabeled diagram 2 marks

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

Ans:

Given: n = 3, V_1= 9kV, V_2= 12kV, Find Line voltage and η_{string} = ?

$V_2 = V_1(1+K)$ 1 Mark

Therefore $K = (V_2 / V_1) - 1$

$K = 0.333$ 1 Mark

$V_3 = V_1(1+3K+K^2) = 19$ kV

Line voltage, $V = V_1 + V_2 + V_3 = 40$ kV. 1 Mark

String Efficiency $\eta_{string} = V / (n \times V_3) = 70.175\ \%$ 1 Mark

3 Attempt any <u>FOUR</u> of the following: 16

3 a) State the effect of use of high voltage in transmission of Electrical Power on following parameters:
i) Line loss
ii) Supporting structure weight

Ans:

Effect of use of high voltage in transmission:

A) On Line loss: 2 marks

1. As transmission voltage increases, the current decreases, so copper losses in transmission line get reduced.
2. As copper losses reduce, transmission efficiency increases.
3. As current reduces, voltage drop in transmission line reduces.
4. As voltage drop in transmission line reduces, voltage regulation becomes better.

B) On Supporting structure weight:

1. As Transmission voltage increases, current decreases**.** (as I α 1/V for same power)
2. As current decreases, cross section of conductor decreases. [as cross-section of conductor depends upon the current]
3. As cross section of conductor decreases, its weight decreases.
4. As weight of the conductor decreases, required strength of tower get reduced.
5. The weight of tower also get reduced.

2 marks

3 b) State any four desirable properties of insulating material for tranmission line insulator.

Ans:

Desirable properties of insulating material for tranmission line insulater:

A) Electrical Properties of insulating material:-

a) It should have high resistance.
b) It should have high breakdown voltage.
c) It should have high dielectric strength.
d) It should have low dielectric constant.
e) It should have low dielectric loss.

B) Mechanical Properties of insulating material:-

a) It should have high mechanical strength.
b) It should be tough and flexible.
c) It should be light in weight.
d) It should not be porous otherwise it increases moisture holding capacity which reduces insulating property.

C) Chemical Properties of insulating material:-

a) It should not be hygroscopic (which absorbs moisture).
b) It should have high resistance to acid & alkaline.
c) It should have high resistance to oil.

D) Thermal Properties of insulating material:-

a) It should have high thermal conductivity.
b) Co-efficient of thermal expansion should be low.
c) It should be non -inflammable.
d) It should withstand at high temperature.
e) Ii should have thermal Stability.

Any Four properties expected 1 Mark each

E) General Properties of insulating material:-

a) It should have longer life.
b) It should have low cost.

OR

Desirable properties of insulating material for tranmission line insulater:

1. It should have high resistance
2. It should have high breakdown voltage.
3. It should have high dielectric strength.
4. It should have low dielectric constant.
5. It should have low dielectric loss.
6. It should have high mechanical strength.
7. It should be tough and flexible.
8. It should be light in weight.

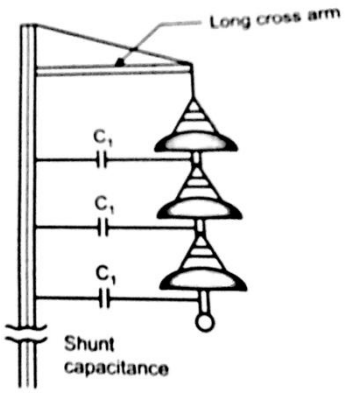
9. It should not be porous.
10. It should not be hygroscopic.
11. It should have high resistance to oil, acid.
12. It should have high thermal conductivity.
13. Co-efficient of thermal expansion should be low.
14. It should be non -inflammable.
15. It should have thermal Stability.
16. It should have longer life.
17. It should have low cost.

3 c) State and explain any one method for improving string efficiecy.

Ans:

Methods of improving string efficiency:

i) By using longer cross arm:



The value of string efficiency depends upon the value of K i.e. ratio of shunt capacitance to mutual capacitance. The lesser the value of K, the greater is the string efficiency. Voltage distribution is more uniform. The value of K can be decreased by reducing the shunt capacitance.

In order to reduce shunt capacitance, the distance of conductor from tower must be increased i.e. longer cross-arms should be used.

However, limitations of cost and strength of tower do not allow the use of very long cross-arms. In practice, K = 0.1 is the limit that can be achieved by this method.

(any one method expected)

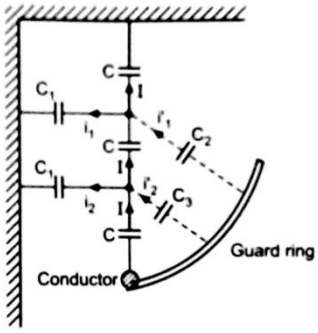
1Mark for name of method

3 marks for explanation of that method

ii) By grading the insulators:

In this method, insulators of different dimensions are so chosen that each has a different capacitance. The insulators are capacitance graded i.e. they are assembled in the string in such a way that top unit has the minimum capacitance, increasing progressively as the bottom unit (i.e. nearest to conductor) is reached.

Since voltage is inversely proportional to capacitance, this method tends to equalize the potential distribution across the units in the string.



The disadvantage of this method is that a large number of different-sized insulators are required. However, good results can be obtained by using standard insulators for most of the string and larger units for that near to the line conductor.

iii) By using a guard ring:

The potential across each unit in a string can be equalized by using a guard ring which is a metal ring electrically connected to the conductor and surrounding the bottom

insulator as shown in figure .
The guard ring introduces capacitance between metal fittings and the line conductor. The guard ring is connected in such a way that shunt capacitance currents i_1, i_2 etc. are equal to metal fitting line capacitance currents i_1', i_2' etc.
The result is that same charging current I flows through each unit of string. Consequently, there will be uniform potential distribution across the units.

3 d) State the effect of indutance and capacitance on performance of transmission line.

Ans:

1. Effect of indutance on performance of transmission line:

The transmission line possesses inductance.

Inductance, $L \alpha \Phi / I$ …. henry 2 marks

where Φ = flux linkages in weber

I = current through conductor in A.

The inductance causes the the voltage drop ($I X_L$) due to its reactance and reduces the voltage at receiving end.

2. **Effect of capacitance on performance of transmission line:**

The transmission line possesses capacitance between lines as well as between line and earth.

When an A.C. voltage is applied on a transmission line, the charge on the condutors at any point increases and decreases with increase and decrease in the instantaneous value of the voltage.

This results in flowing of charging current between conductors even when line is open. With the increase in length of the transmission lines, the line charging currents and the shunt admittance become more and more dominant, hence due to this line capacitance the magnitude of receiving end voltage at no-load or lightly loaded conditions becomes greater than the magnitude of sending end voltages. 2 marks

This charging current causes the capacitive voltage drop along the line and also affects the efficiency and power factor of the line.

3 e) State two advantages and two disadvantges of corona effect.

Ans:

Advantages of corona:

1. Due to corona formation, the air surrounding the conductor becomes conducting and hence virtual diameter of conductor is increased. The increased diameter reduces the electrostatic stress of the condutor. 1 Mark for each of any two
2. Corona reduces the effects of transients produced by surges.
3. It acts as safety valve against over voltage due to lighting stroke.

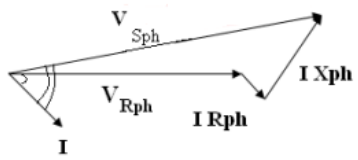
Disadvantages of corona:

1. Corona is accompained by loss of energy. Due to more losses transmission efficiency get reduced.
2. The current drawn by corona is non-sinusoidal which causes non-sinusoidal voltage drops in the line. This may cause inductive interference with neighbouring communication lines. 1 Mark for each of any two
3. Ozone is produced, which causes corrosion of the conductor due to chemical action.
4. Harmonics are produced which will cause radio interference.

3 f) State the effect of lag, lead and unity power factor on regulation of transmission line with phasor digram.

Ans:

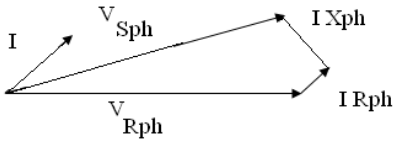
Phasor diagram at lagging power-factor in transmission line:



Effect on regulation:

At lagging power factor, receiving end voltage is less than sending end voltage, hence regulation is positive. 1 mark

Phasor diagram at leading power-factor in transmission line:

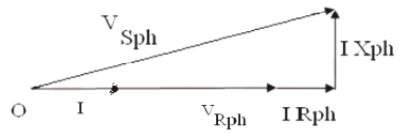


1 mark

Effect on regulation:

At leading power factor, receiving end voltage is more than sending end voltage, **hence regulation is negative.**(V_R greater than V_S) 1 mark

Phasor Diagram for Unity Power Factor:



1 mark

Effect on regulation:

At UPF receiving end voltage is less than sending end voltage, hence regulation is positive

4 Attempt any <u>FOUR</u> of the following: 16

4 a) Define the disruptive critical voltage and visual critical voltage.

Ans:

i) **Disruptive Critical voltage (DCV):**
It is the minimum phase to neutral voltage at which formation of corona just starts.

ii) **Visual Critical voltage (VCV):**
It is the minimum phase to neutral voltage at which corona just becomes visible. i.e. voltage glow occurs around the conductor.

2 marks each

4 b) State the values of generalized circuit constants A, B, C and D for short transmission line.

Ans:

A, B, C and D constants for short transmission line:

The values of ABCD constants are as follows:

A=1, B = Z = Impedance of transmission line, C = 0 and D = 1

1 Mark for each constant

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

Ans:

Load power factor $\cos\phi_R = 0.8$ lag, hence $\sin\phi_R = 0.6$

Total line resistance for 20km $R = 0.2 \times 20 = 4\ \Omega$

Total line inductive reactance for 20km $X = 0.5 \times 20 = 10\ \Omega$

Receiving end voltage $V_R = 11000$ volt

$\therefore$ Line current $I = \frac{VI}{V} = \frac{kVA \times 1000}{kV \times 1000} = \frac{750 \times 1000}{11 \times 1000} = 68.1818\ amp$ — 1 Mark

Sending end voltage $V_s = V_R + I(R cos\emptyset_R + X sin\emptyset_R)$

$= 11000 + 68.18(4 \times 0.8 + 10 \times 0.6)$

$= 11627.25$ volt — 1 Mark

Total line losses $= I^2R = (68.18)^2 \times 4 = 18594$ watts — 1 Mark

Output delivered = kVA × 1000 × $cos\emptyset_R$ = 750×1000×0.8 = 600000 watts

$\therefore$ Efficiency = $\frac{Output\ delivered}{Output\ delivered + Losses} = \frac{600000}{600000 + 185.94} = 0.9699\ or\ 96.99\%$ — 1 Mark

4 d) Define EHV line. State its necessity any four points.

Ans:

EHV line: The line whose voltage ranges above 220 kV. — 2 marks for definition

Necessity of EHV:

- **i)** To transmit same amount of power at same power factor if line voltage increases, magnitude of current reduces which reduces cross section area of conductor.
- **ii)** As magnitude of current reduces the total line losses reduces which increases transmission efficiency.
- **iii)** E.H.V. transmission is very helpful for interconnections of power systems on large scale, hence it is adopted.
- **iv)** Power transmission capacity of line is in square proportion (V^2) of the transmission voltage, hence it is beneficial.
- **v)** Transmission of huge block of power over a very long distance is economically feasible in case of E.H.V.
- **vi)** For maximum flexibility for future system growth EHV is adopted.
- **vii)** It will provide better voltage regulation.

— ½ mark for each of any four

(OR equivalent points)

4 e) Which are the factors to be considered while designing feeder?

Ans:

Following factors are to be considered while designing the Feeder:

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). — 1 mark for each point

2) Need:

Depending upon application, distribution system is designed i.e.

whether continuity of supply is important or not so important.

Example:

1) Use Radial distribution system in not so critical areas eg. Some rural areas.
2) Use Ring main distribution system in critically important areas as urban area.
3) Use Grid distribution system where continuity of supply is extremely important. e.g. Supply to - electric traction, TV broadcasting centre, 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.

4 f) State any four disadvantages of extra high voltage AC transmission system.

Ans:

Disadvantages of extra high voltage AC transmission system:

1. Skin effect is present due to which effective resistance of conductor increases which causes more power loss and voltage drop in the line.
2. It requires 3 conductors which increases conductor material. Ultimately cost of transmission increases.
3. Corona effect is more than DC transmission
4. Due to presence of inductance, drop in voltage increases.
5. Height of tower has to be increased in order to provide sufficient clearance between earth and conductor.
6. Due to EHV, design of switches, circuit breakers, CT, PT becomes complicated.
7. Due to increase in line voltage, insulator has to be increased and also insulation of all components connected to the system should be increased.
8. Transmission line must be made wind resistant to avoid damage of conductors, insulators, frame work etc. in case of storms.

1 mark for each of any four

5 Attempt any <u>FOUR</u> of the following: 16

5 a) Give classification of substation on basis of :
(i) Service requirement
(ii) Construction

Ans:

1. According to service requirement:

1. Transformer Sub-station
2. Switching sub-station
3. Power Factor correction sub-station
4. Frequency changer sub-station
5. Converting sub-station
6. Industrial Sub-station (Bulk Supply Industrial Consumer Substation)
7. Traction substation
8. Mining Substation
9. Mobile Substation

½ mark for each of any four

2. According to Construction:

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

½ mark for each of any four

5 b) List two advantages and two disadvantages of indoor substation.

Ans:

Advantages of Indoor substation:

i) Space Required : Less
ii) Effect of atmospheric condition: Switching operation is not difficult in rainy season & it is more safe due to indoor installation.
iii) Chances of leakage current : Less due to indoor installation
iv) Maintenance cost : Less due to indoor installation

1 Mark for each of any two

Disadvantages of Indoor substation:

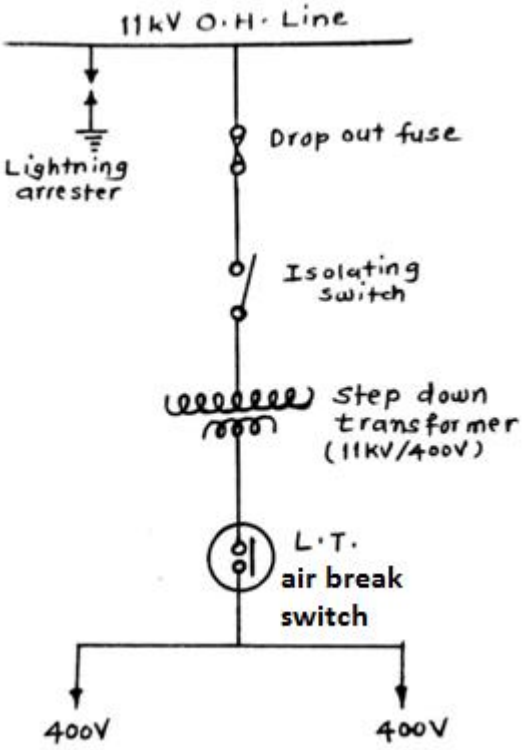
i) Capital cost: High, as construction work cost is more.
ii) Time required for completion: More, as construction work is more.
iii) Distance between two equipments: Less, this will increase possibility of fault & safety reduces.
iv) Access for incoming & outgoing line: Difficult access for incoming & outgoing lines because of indoor installation.
v) Cooling arrangement: Natural cooling is not available so artificial cooling arrangement is required which increases energy consumption charges due to indoor installation.
vi) Availability of natural light: Natural light is not available in day time, so there is need of illumination even during a day time, which increases energy consumption charges due to indoor installation
vii) Detection of fault: Difficult, as all equipment are not easily viewed.
viii) Replacement of equipment: Difficult, due to indoor installation.
ix) Future expansion: Expansion of substation is not easily possible whenever needed because of construction work. Also it require more time & cost.
x) In case of accident: In case of accident there is more risk & damage to other equipment than outdoor substation.

1 Mark for each of any two

5 c) Draw a single line diagram for 11 kV/400V distribution substation.

Ans:

Single line diagram for typical 11 kV/400V distribution substation:



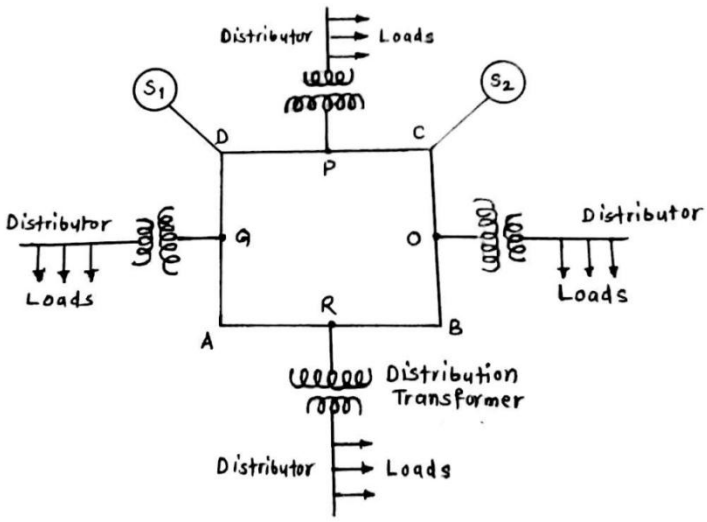
4 marks for labeled diagram

2 marks for unlabeled diagram

Equivalent diagram may be considered

5 d) Draw the connection diagram of grid distribution system and give any two advantages of system.

Ans:



2 Marks for labeled diagram

Advantages:

i) Supply to distribution transformer centre is given through two different generating stations or major generating stations.

ii) It has highest reliability to maintain supply even when there is a fault on any one feeder.

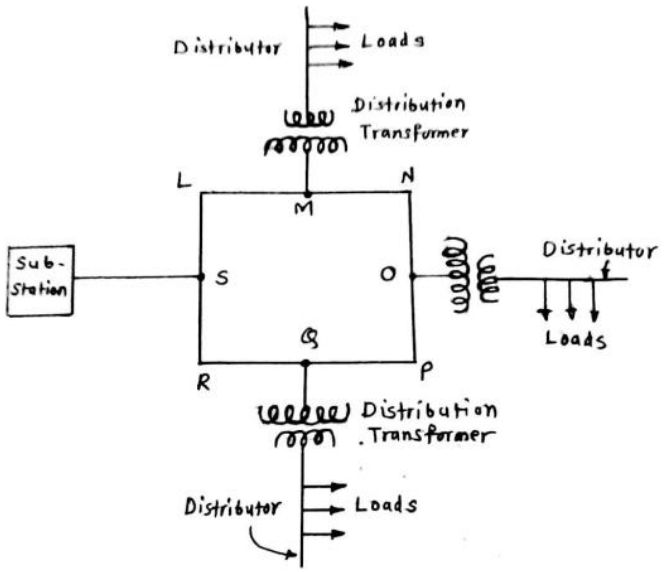
iii) It has highest reliability to maintain supply even when there was maintenance on any one feeder.

1 Mark for each of any two advantages

iv) This reduces reserve power capacity.

5 e) Draw the layout of ring distribution scheme and write any two advantages of the same.

Ans:



2 Marks for labeled diagram

Advantages:

1 Mark for each of any two advantages

i) Supply to distribution transformer center is given through two different Feeders
ii) Reliability to maintain supply is more even when there is a fault on any one feeder.
iii) Reliability to maintain supply is more even when there was maintenance on any one feeder.
iv) There are less voltage fluctuations at consumer's terminals.

5 f) A single phase AC distributor of 900 m length of total impedance of (0.02 + j0.04) ohm and is feed from one end at 250 V. If it loaded as in Figure No.2. Calculate the voltage drop and voltage at far end.

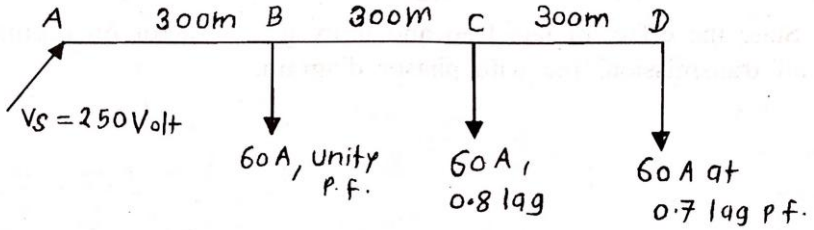


Fig. No. 2

Ans:

Z = (0.02+j0.04) Ω

Section impedances:

$$Z_{AB} = Z_{BC} = Z_{CD} = \frac{300}{900}(0.02 + j0.04) = (6.67 \times 10^{-3} + j0.0133)\Omega$$

1 Mark

$= (0.0149\angle 63.43°)\Omega$

Section Currents:

$I_D = 60\ A\ at\ 0.7\ lag$ or $I_D = 60\angle -45.57° = (42 - j42.846) amp$

$I_C = 60\ A\ at\ 0.8\ lag$ or $I_C = 60\angle -36.87° = (48 - j36) amp$

$I_B = 60\ A\ at\ UPF$ or $I_B = 60\angle 0° = (60 - j0) amp$

Now

$$I_{CD} = I_D = 60\angle -45.57° = (42 - j42.846) amp$$

$$I_{BC} = I_C + I_D = (48 - j36) + (42 - j42.846) = (90 - j78.84) amp$$
$$= 119.648\angle -41.22° amp$$

$$I_{AB} = I_B + I_C + I_D = (60 - j0) + (48 - j36) + (42 - j42.846) = (150 - j78.84)$$
$$= 169\angle -27.72° amp$$

1 Mark

Calculation of voltage drops:

$V_{CD} = I_{CD} \times Z_{CD} = (60\angle -45.57°)(0.0149\angle 63.43°) = 0.894\angle 17.86°$ volt
= (0.8509+j0.2741) volt

$V_{BC} = I_{BC} \times Z_{BC} = (119.648\angle -41.22°)(0.0149\angle 63.43°) = 1.7827\angle 22.21°$ volt
= (1.6504+j0.6738) volt

$V_{AB} = I_{AB} \times Z_{AB} = (169\angle -27.72°)(0.0149\angle 63.43°) = 2.5181\angle 35.71°$ volt
= (2.0446+j1.4697) volt

1 Mark

Total voltage drop = $V_{AB} + V_{BC} + V_{CD}$
=(2.0446+j1.4697)+ (1.6504+j0.6738)+ (0.8509+j0.2741)
= (4.5459 + j 2.4175) = $5.1487\angle 28°\ volt$

∴ **Voltage at far end** $V_D = V_A$ – Total voltage drop
= (250 + j 0) - (4.5459 + j 2.4175) = (245.454 - j 2.4175)
= $245.465\angle -0.56°\ volt$

1 Mark

6 Attempt any <u>FOUR</u> of the following: 16

6 a) Suggest suitable sub-station for following applications with suitable reasons:
i) Urban area
ii) Rural area

Ans:

i) Sub-station for urban area: Indoor/GIS/ Underground substation is used since space available is less and for safety reasons. 2 marks

ii) Sub-station for Rural area: Outdoor substation is used since space available is more. 2 marks

6 b) State advantages and disadvantages of radial distribution system.

Ans:

Advantages of Radial distribution system:

1. Design of layout is simple.
2. Capital cost & Erection cost is less as there is only one feeder.
3. Time required for completion of work is less.
4. This system is suitable for small length line.

Disadvantages Radial distribution scheme :

1. No reliability to maintain supply to consumers when there is fault on feeder.
2. No reliability to maintain supply to consumers when there is maintenance on feeder.

1 mark for each of any two advantages and any two disadvantages

3. Voltage fluctuations are more.
4. Last consumer suffers from low voltage due to voltage drop in the line.

6 c) A three phase line of 5 km length delivers 5000 kW at a P. F. of 0.8 lagging to load. The resistance and reactance per km of each conductor are 0.2 ohm and 0.5 ohm respectively. If the voltage at the supply end is maintained at 11kv, calculate the sending voltage and efficiency of line.

Ans: Stepwise solution

Power factor $\cos\phi_R = 0.8$ lag, hence $\sin\phi_R = 0.6$

Total line resistance for 5km $R = 0.2\times5 = 1\ \Omega$

Total line reactance for 5km $X = 0.5\times5 = 2.5\ \Omega$

Supply end voltage = Receiving end voltage $V_R = 11000$ volt

$P = \sqrt{3}V_L I_L cos\emptyset_R$ 2 marks for V_s

$\therefore$ Line current $I_L = \frac{P}{\sqrt{3}V_L cos\emptyset_R} = \frac{5000\times1000}{\sqrt{3}\times11\times1000\times0.8} = 328\ amp$

Sending end voltage $V_s = V_R + I_L(Rcos\emptyset_R + Xsin\emptyset_R)$ 2 marks for η

$= 11000 + 328(1\times0.8 + 2.5\times0.6)$

$= 11754$ volt

Total line losses = $3I^2R = 3(328)^2\times1 = 322752$ watts

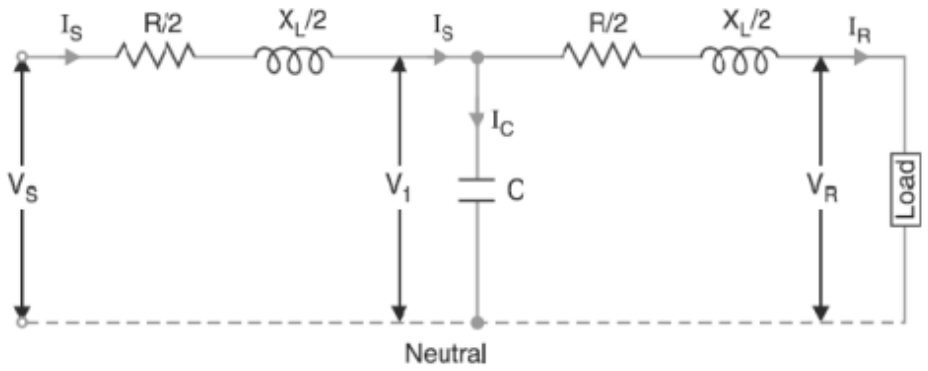
Output Power = 5000000 watts

$\therefore$ Efficiency = $\frac{Output\ Power}{Output\ Power+Losses} = \frac{5000000}{5000000+322752} = 0.9393\ or\ 93.93\%$

6 d) Draw equivalent circuit of medium transmission line with nominal T method with phasor diagram.

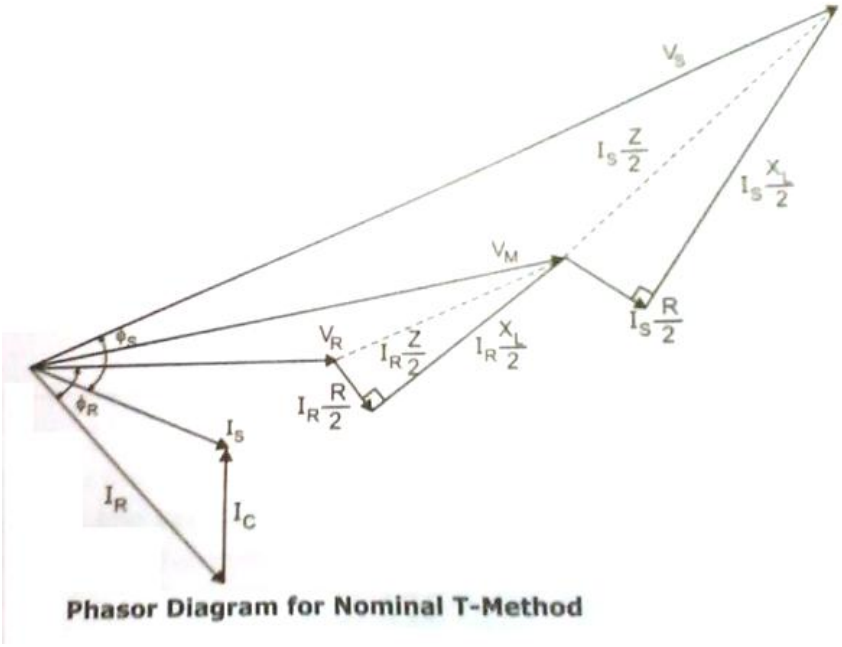
Ans:

Equivalent circuit & Phasor Diagram of medium transmission line with nominal T method:



2 marks

2 marks



Phasor Diagram for Nominal T-Method

6 e) Classify transmission line as per length and voltage level.

Ans:

Transmission lines are classified as below:

A) According to Voltage level:

a) High voltage Transmission Line (HV) up to 33 KV
b) Extra High Voltage Transmission Line (EHV) up to 400 KV
c) Ultra High voltage Transmission Line (UHV) above 400 KV

B) According to Length of Transmission line:

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)

2 marks for classification according to length

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 upto **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**

2 marks for classification according to voltage level

OR

1. **Short Transmission Line: -** The length of Short transmission Line is up to **80KM** and its line voltage **is less than 20 KV**
2. **Medium Transmission Line: -** The length of Medium transmission Line is up to **80KM- 200KM** and its line voltage is between **20KV to 100 KV**
3. **Long Transmission Line: -** The length of Long transmission Line is above **200KM** and its line voltage is above **100KV**

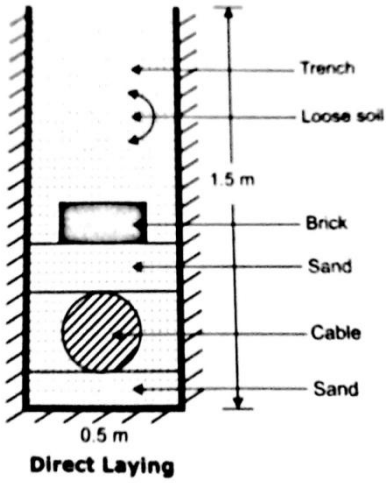
6 f) With neat sketch explain briefly any one method of cable laying in distribution system.

Ans:

Methods of Laying of under- ground cables:

1. Direct laying cable
2. Draw- in system
3. Solid System

1) Direct laying –This is the simple and economic method of cable laying. For this, a trench of 0.5 meter width and 1.5 meter deep is dug in the ground as per cable route. Soil is taken out. A layer of sand of 10cm is spread at the bottom of trench then cable is laid on this sand, again a layer of sand over the cable and over it a layer of bricks along the length of cable is provided. The remaining portion is covered by soil. By this the cable is protected mechanically and possibility of moisture is avoided by use of sand layers. If two or more cables are to be laid in same trench, sufficient space should be provided between them to avoid transfer of fault from one cable to other.

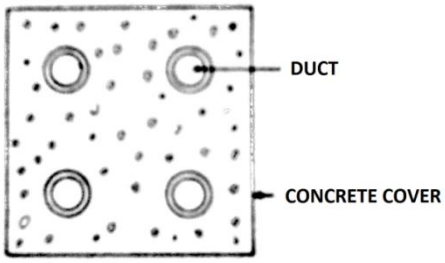


Direct Laying

2 marks for sketch

2 marks for explanation

2) Draw in system-In this method, conduit or duct of glazed stone or cast iron or concrete are laid in the ground with manholes at suitable positions along the cable route. The cables are then pulled into positions from manholes. Figure shows section through four way underground duct line. Care must be taken that where the duct line changes direction, depths, dips and offsets be made with a very long radius or it will be difficult to pull a large cable between the manholes. The distance between the manholes should not be too long so as to simplicity for the pulling of the cables. The cables to be laid in this way must be provided with Serving of hessian and jute in order to protect them when being pulled into the ducts.



3) Solid System-In this method of laying, the cable is laid in open pipes or through dug out in earth along the cable route. The throughing is of cast iron, stoneware, asphalt treated wood. After the cable is laid in position, the throughing is filled with bituminous or asphaltic compound and covered over. Cables laid in this manner are usually plain lead covered because throughing affords good mechanical protection.