EE8402 – TRANSMISSION AND DISTRIBUTION

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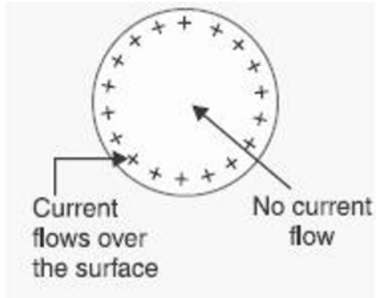
2 Marks And 16 Marks- Question Bank

UNIT I TRANSMISSION LINE PARAMETERS

Structure of Power System – Parameters of single and three phase transmission lines with single and double circuits –Resistance, inductance and capacitance of solid, stranded and bundled conductors, Symmetrical and unsymmetrical spacing and transposition – application of self and mutual

1. What is skin effect?(May/June 2014) (Nov/Dec 2012) (Nov/Dec 10) (Nov/Dec2016) State skin effect in transmission lines. Mention its effect on the resistance of the line. (April/May 2017) (NOV/DEC 2018)

When a conductor carries a steady or D.C current, this current is uniformly distributed over the whole cross section of the conductor. However the current distribution is non-uniform if the conductor carries alternating current. The current density is higher at the surface than at the center. Thus the current is concentrated near the surface of the conductor. This effect becomes predominant with increase in frequency. This behavior of alternating current to concentrate near the surface of the conductor is known as skin effect.



The skin effect causes the effective resistance of the conductor to increase at higher frequencies where the skin depth is smaller, thus reducing the effective cross-section of the conductor.

2. Define the term critical disruptive voltage. (Nov/Dec 2013)

It is the minimum phase to neutral voltage at which the electric field intensity at the surface of the conductor exceeds the critical value and generates corona.

3. What is proximity effect? (May/June 2014) (May/June 2013)(April/May 2011) (APR/MAY 2015) (APRIL/MAY 2018) (NOV/DEC 2018)

The alternating magnetic flux in a conductor caused by the current flowing in a neighboring conductor gives rise to a circulating current which cause an apparent increase in the resistance of the conductor. This phenomenon is called as proximity effect.

4. What is meant by inductive interference?

Usually, communication lines are run along the power lines; in some cases, these lines are run on the same support and the same route. Under such conditions the power lines are likely to interfere with the communication lines. The interference is mainly due to electromagnetic and electrostatic fields.

5. What are the factors that affect the skin effect?

Factors that affect the skin effect:

i. Nature of the material

ii. Diameter of wire – increases with the increase diameter of wire

iii. Frequency – increases with increase in frequency

iv. Shape of wire – less for stranded conductor than that for the solid conductor

6. Why the effective resistance is more than the static resistance of a transmission line?

Due to skin effect, the effective area of cross-section of a conductor through which current flows is reduces. Consequently, the resistance of the conductor slightly increases when carrying an alternating current. Hence the effective resistance or AC resistance of a transmission line is greater than static or DC resistance due to the skin effect.

7. Why does a transmission lines have resistance, inductance, and capacitance

A transmission line has resistance, inductance, and capacitance uniformly distributed along the whole length of the line. The each parameter is defined as follows.

Resistance: This is due to the opposition offered by the conductor to the flow of current.

Inductance: When an alternating current flows through a conductor, a changing flux is set up that links the conductor. Due to these flux linkage, the conductor possesses an inductance.

Capacitance: The conductors of an overhead transmission line are separated by air, which acts as an insulation. Therefore, a capacitance exists between any two overhead line conductors.

8. Why skin effect is absent in dc system?

When a conductor carries a steady or D.C current, this current is uniformly distributed over the whole cross section of the conductor. That is why skin effect is absent in D.C system

9. Mention the transmission voltages that are followed in Tamil Nadu.(April/May 2017)

- 400/230 kV substations.
- 230/110 kV substations.
- 110 kV substations.
- 33 kV substations.

less than this kV transmissions as 22 kV and 11 kV are used for distribution.

10. Why transmission lines are 3 phase 3-wire circuits while distribution lines are 3 phase 4 wire circuits? (Nov/Dec 13)

A Balanced 3 phase circuit does not require the neutral conductor, as the instantaneous sum of the 3 line currents is zero. Therefore the transmission lines and feeders are 3 phase 3 wire circuits. The distributors are 3 phase 4 wire circuits because a neutral wire is necessary to supply the 1 phase loads of domestic and commercial consumers.

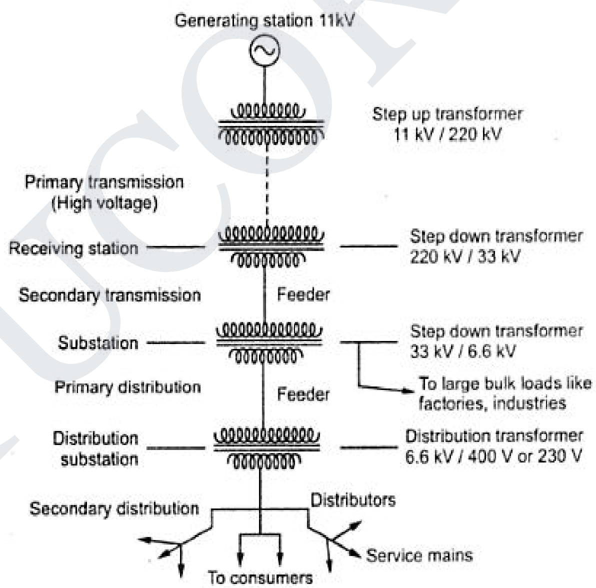
11. List out the practical transmission and distribution voltage levels commonly used.

GENERATION		6.6 KV, 10.5 KV, 11 KV, 13.8 KV, 15.75 KV
TRANSMISSION	PRIMARY	220KV, 110 KV, 132 KV, 765 KV
	SECONDARY	33 KV or 66 KV
DISTRIBUTION	PRIMARY	11 KV or 6.6 KV
	SECONDARY	415 V for 3ϕ
		230 V for 1ϕ

12. Name any four types of line supports.

Wooden poles, RCC poles, Steel tubular poles, Steel towers

13. Draw a single line diagram of a modern electric power system.



14. Why high voltage is preferred for power transmission? (APR/MAY 2015) (Nov/Dec2015)

The power that is generated will be of high current. In order to reduce the current voltage is increased so that the copper usage will be reduced.

Another reason for high voltage transmission is that losses can be reduced.

15. What are the components of Power System? (May/June 2014)

- Generators,
- Transformer
- Transmission Lines,
- Control Equipments,

16. What are the factors on which conductor spacing and ground clearance depend? (Nov/Dec 14)

- Nominal system Voltage,
- Maximum Voltage,
- Size of the conductor,
- Sag and Tension,
- Diameter and shape of conductor.

17. State the advantages of interconnected systems.

Any area fed from one generating station during overload hours can be fed from another power station and thus reserved capacity required is reduced, reliability of supply is increased and efficiency is increased.

18. Mention the disadvantages of a 3 wire system

In 3 wire system a third wire is required .The safety is partially reduced .A balancer is required and therefore cost is increased.

19. Why the concept of self GMD is not applicable for capacitance calculation? (NOV/DEC 2017)

Self-GMD of a conductor depends upon the size and shape of the conductor and is independent of the spacing between the conductors so it is not applicable for capacitance calculation.

20. What is meant by transposition of line conductors? (April/May 2011) (APR/MAY 2016) (NOV/DEC 2017)

It is the exchange of position of the power conductors at regular intervals along the line so that each conductor occupies the original position of every other conductor over an equal distance.

21. Mention the advantages of using bundled conductors. (Nov/Dec2016)

i. Reduced reactance

ii. Reduced voltage gradient

iii. Reduced corona loss

iv. Reduced radio Interference

v. Reduced surge impedance.

22. Differentiate the stranded conductor and bundled conductor.

S.NO	STRANDED CONDUCTOR	BUNDLED CONDUCTOR
1	It is the conductors made of thin wires of small cross section and bunched together	It is a conductor made up of two or more conductors called sub conductors, per phase in close proximity compared with space between phases
2	Reactance is more	Reactance is less
3	More corona loss	Less corona loss
4	More interference with communication lines	Less interference with communication lines

23. List out the advantages of double circuit lines.

Advantages of double circuit lines:

i. Half of the load is shared by the other line

ii. The increase in load current can be easily handled

iii. In case of power failure in one circuit, the power will be supplied by the other lines

24. Define - Self and mutual – G.M.D.(NOV/DEC 2015)

Self -GMD (GMR): The self-GMD means self-geometrical mean distance. It reduces the complexity of inductance calculation.

GMR = 0.7788 r

Mutual GMD: The mutual GMD is the geometrical mean of the distances from one conductor to the other.

25. State different types of overhead conductors. (April/May 2017

- AAC : All Aluminium Conductor
- AAAC : All Aluminium Alloy Conductor
- ACSR : Aluminium Conductor, Steel Reinforced
- ACAR : Aluminium Conductor, Alloy Reinforced

26. State why transposition of line conductors are needed? Or What is the need of transposition? (Nov/Dec 2011)

In order to make voltage drops equal in all conductors, generally we interchange the positions of the conductors at regular intervals along the line so that each conductor occupies the original position of every other conductor over an equal distance. Such an exchange of conductor position is called transposition.

27. List the factors that governing the capacitance of a transmission line.

Factors that governing the capacitance of transmission line:

i. The potential of the conductor

ii. Spacing between the lines

iii. Distance between the line and earth

iv. The length of lines

v. Number of conductors per phase

28. Write the advantages of ACSR conductor when used for overhead line.

i. Line span can be increased

ii. They have low corona loss

iii. Skin effect is less

iv. They are inexpensive

29. What is the effect of bundled conductors on transmission line inductance?

With the use of bundled conductors, there is increase in GMR. The formula for inductance contains the term GMR in the denominator. Hence the inductance of a bundled conductor line is less than the inductance of the line with one conductor/ph.

30. Give the minimum ground clearance required for 33 KV, 66 KV, 110 KV, 220 KV lines.

$$x\ KV = 5.18 + \left[\frac{x - 33}{33} \times 0.3048\right]$$

For 33 KV – 5.18 m

66 KV – 5.4848 m

110 KV – 5.89 m

220 KV – 6.9 m

31. Give the advantages of bundled conductors. (Nov/Dec 14)(Nov/Dec 10)

- Reduced reactance, Reduced voltage gradient,
- Reduced corona loss, Reduced Interference

32. Write the expression for capacitance of single phase line.(Nov/Dec 2012)

$C=2\pi\varepsilon_0 / \log(d/r)$ F/m

33. A three phase transmission line has its conductor at the centers of an equilateral triangle with side 3m.The diameter of each conductor is 1.63cm.Find the inductance per km per phase of the line. (APR/MAY 2015)

34. What is the need of transposition? (Nov/Dec 2011) (NOV/DEC 2017)

To make voltage drops equal for all the phases

Reduce the disturbance to nearby communication circuits

Effect of unbalanced current is neutralized.

35. Define: Visual Critical Voltage.(May/June 2013) (Nov/Dec 2011)

It is the critical voltage at which the corona is viewed as faint violet luminescence glow to our naked eyes.

36. Define Ferranti effect. (Nov/Dec 13) (Nov/Dec 10) (APR/MAY 2015) (April/May 2017) (May/June 13) (Nov/Dec 2011) (APR/MAY 2016) (APRIL/MAY 2018)

For along transmission line under no load condition, the voltage at the receiving end is more than that at sending end because of the effect of the line capacitance. This effect is called as Ferranti effect.

37.

Unit 1-Structure of Power System

Descriptive type Questions

1. Draw and explain the structure of typical electric power system with various voltage levels. (May/June2013) **(Nov/Dec 2013) (Apr/May 2011) (April/May 2017) (NOV/DEC 2017)**(May/June2014) **(Apr/May 2018)**

2. Explain with a neat layout the modern EHV system. What is the highest

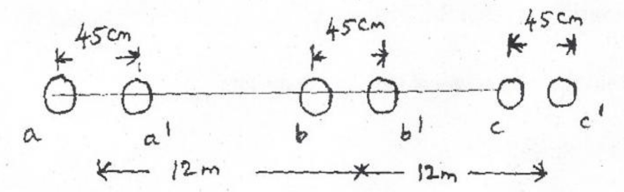
3. From the fundamentals derive an expression for inductance of a single-phase transmission system. **(NOV/DEC 2017) (NOV/DEC 2018)**

4. Derive an expression for capacitances of a single-phase transmission system and discuss the effect of earth on capacitance with suitable equation.

5. Derive expressions for the inductance of three-phase line with conductors un transposed (symmetrical). What is the significance of imaginary term in the expression for inductance? Hence derive the expression for inductance for a completely transposed line. **(NOV/DEC 2017) (NOV/DEC 2018)**

6. Derive the expression for capacitance of three-phase transmission line with symmetrical & unsymmetrical spacing. **(Nov/Dec 13) (NOV/DEC 2018)**

7. A 400 KV, 3-phase bundled conductor line with two sub-conductors per phase has a horizontal configuration as shown in Fig. The radius of each sub-conductors is 1.6 cm. (1) Find the inductance per phase per km of the line (2) Compute the inductance of the line with only one conductor per phase having the same cross-sectional area of the conductor of each-phase.



8. A 220 KV 50 HZ 200 Km long three phase line has its conductors on the corners of a triangle with sides 6m, 6m and 12m. The conductor radius is 1.81 cm. Find the inductance & capacitance per phase per Km. **(Nov/Dec 10)**

9. A single phase transmission line has two parallel conductors 3 m apart, the radius of each conductor being 1 cm. Calculate the loop inductance per km length of the line if the material of the conductors is (1) copper (2) steel with relative permeability of 100.

10. Derive the capacitance of a three-phase overhead line. **(May/June 2014)**

11. Estimate the corona loss for a three-phase, 110 KV, 50 Hz, 150 Km-long transmission line consisting of three conductors each of ld mm diameter and spaced 2.5m apart in a equilateral triangle" formation. The temperature of air is 300 C and the atmospheric pressure is 750 mm of mercury. Assume irregularity factor as 0.85. Ionization of air may be assumed to take place at a maximum voltage gradient of 30Kv/cm. **(May/June 2014)**

12. Derive an expression for the flux linkages of one conductor in a group of n-conductors carrying currents whose sum is zero. Hence derive an expression for inductance of composite conductors of a single phase consisting of m-strands in one conductor and n-strands in the other conductor.**(Nov/Dec 14)**

13. Explain the concept of self GMD and mutual GMD for evaluating inductance of transmission line. **(Nov/Dec 14)**

14. Derive an expression for capacitance per phase for a 3 phase overhead line when the conductors are unsymmetrical placed but completely

transposed. **(Nov/Dec 12) (Apr/May 2011) (Nov/Dec 14)**

15. Derive an expression for inductance per phase for a 3 phase overhead line when the conductors are unsymmetrical placed but completely transposed. **(Nov/Dec 10) (May/June2013)**

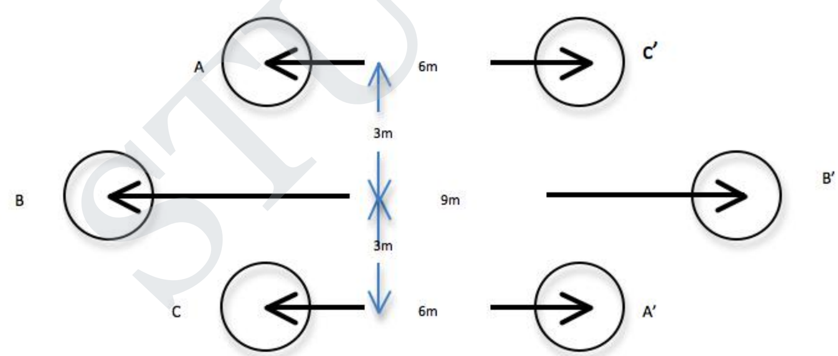
16. Determine the capacitance and charging current per unit length of the line. The line is completely transposed and diameter is 15mm and operating voltage is 220kV. **(Nov/Dec 14)**

17. Derive the capacitance of a single-phase overhead line.**(May/June 2013)**

18. Derive n expression for loop inductance of a single phase transmission system(16) **(Nov/Dec 15)**

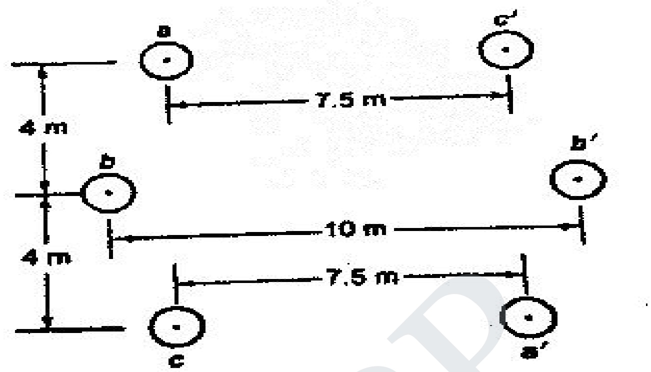
19. Derive from first principles the capacitance per km to neutral of three phase overhead transmission line with overhead transmission line with unsymmetrical spacing of conductors assuming transportation(16)**(Nov/Dec 15)**

20. A three phase circuit consists of 7/4.5mm hard drawn copper conductors. The arrangement of the conductors is shown in Figure.12.b.The line is completely transposed. Calculate inductive reactance per phase per km of the system(16) **(APR/MAY 2015)**



21. (a)Derive the expression for the capacitance of a three phase transmission line with unsymmetrical spacing.(16) **(APR/MAY 2016) (NOV/DEC 2017)**

22. (b)Determine the inductance per km of a double circuit 3ϕ line as shown in Fig.Q.12 (b).The transmission line is transposed within each circuit and each circuit remains on its own side. The diameter of each conductor is



15mm.(16) **(APR/MAY 2016)**

Fig. Q. 12 (b)

23. (a)(i)Derive the expression for the inductance of a three phase transmission line with unsymmetrical spacing.(8) **(Nov/Dec 16)**

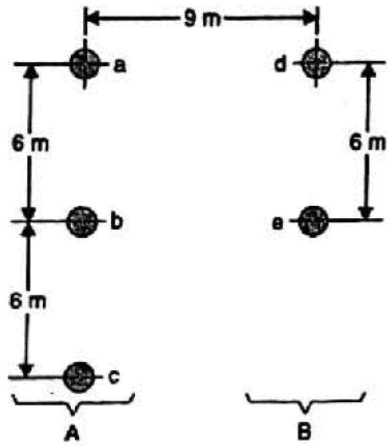
(ii) A 220kV,50Hz, 200km long transposed three phase line has its conductors on the corners of triangle with sides 6m, 6m and 10m.The conductor radius is 1.81cm. Find the capacitance per phase per km of the line.(8)

24. (i) Explain the advantages of bundled conductors when used for overhead lines (4) **(April/May 2017)**

(ii) Determine the inductance of 3 phase line operating at 50 Hz and the conductor are arranged as shown below. The conductor diameter is 0,.7cm (9) **(April/May 2017)**

25. Explain about skin and proximity effects. (Nov/Dec 13)

26. Determine the inductance of a single phase transmission line consisting of three conductors of 2.5 mm radii in the 'go' conductor and two conductors of 5 mm radii in the, return, conductor. The configuration of the line is as shown in Figure below. (APRIL/MAY 2018)



27. A three- phase, 50 Hz, 132 kV overhead transmission line has conductors placed in a horizontal plane 4 m apart. Conductor diameter is 2 cm. If the line length is 100 km, calculate the charging current per phase assuming complete transposition. (APRIL/MAY 2018)

28.

Unit 2- MODELLING AND PERFORMANCE OF TRANSMISSION LINES

Performance of Transmission lines - short line, medium line and long line - equivalent circuits, phasor diagram, attenuation constant, phase constant, surge impedance - transmission efficiency and voltage regulation, real and reactive power flow in lines - Power Circle diagrams - Formation of Corona – Critical Voltages – Effect on Line Performance.

Two marks

1. Define voltage regulation of transmission line. (Nov/Dec 13)

(Nov/Dec 12)

Voltage regulation is defined as the change in voltage at the receiving (or load) end when the full-load is thrown off, the sending-end (or supply) voltage and supply frequency remaining unchanged

Where V_s is the voltage at the sending end

V_r is the receiving end voltage.

2. What is shunt compensation? (Nov/Dec 10)

Shunt compensation is the uses of shunt capacitors and shunt reactors in the line to avoid voltage instability.

3. Distinguish between attenuation and phase constant. (Nov/Dec 2011)

S.NO	ATTENUATION CONSTANT.	PHASE CONSTANT.
1	The real part of propagation constant	The imaginary part of propagation constant
2	It is denoted by α	It is denoted by β
3	It is the change in the magnitude per unit length of the line	It is the change in the phase per unit length of the line
4	It is expressed in nepers per unit length	It is expressed in radians per unit length

4. What are the factors which govern the performance of transmission line?(April/May 2011)

i. Series resistance

ii. Series inductance

iii. Series capacitance

iv. Series conductance.

5. What is surge impedance loading? (April/May 2011) (APRIL/MAY 2018)

Surge impedance loading of a line is the power delivered by a line to a purely resistive load equal to its surge impedance.

$$\text{surge impedance loading, } SIL = \frac{Vr^2}{Z_c}$$

6. Classify transmission line based on its length. How are transmission line classified? .(Nov/Dec 2017)

i. Short transmission

ii. Medium transmission

iii. Long transmission

7. Define transmission efficiency.(Nov/Dec 2015)

Efficiency defined as the ratio of power delivered at the receiving end to the power sent from the sending end.

$$transmission\ efficiency = \frac{receiving\ end\ power}{sending\ end\ power} \times 100$$

8. Give the formula for surge impedance(Nov/Dec 2015)

$$Z_c = \sqrt{\frac{Z}{Y}}\ or \qquad Z_c = \sqrt{Z_{oc}Z_{sc}}$$

Where Z_{oc} and Z_{sc} are impedances measured at sending end with the receiving open circuited and short circuited.

9. What is the use of power circle diagram?

Circle diagram helps us to study various aspects of power transmission at sending end and receiving end.

PR, PS, QR, Qs, ,δ,α,βcan be calculated.

10. List out the methods of representation of medium line.

i. Nominal T method

ii. Nominal π method

iii. End condenser method

11. Mention the factors affecting corona.

i. Atmosphere

ii. conductor size

iii. spacing between conductors and line voltage.

12. Define critical disruptive voltageNov/Dec 2011)

It is defined as the minimum phase voltage at which corona occurs.

13. What are the main advantages of corona?

Due to corona formation, the air surrounding the conductor becomes conducting and hence virtual diameter of the conductor is increased. The increased diameter reduces the electrostatic stresses between the conductors.

Corona reduces the effects of transients produced by surges.

14. Define corona. (APR/MAY 2016) (NOV/DEC 2018)

When an alternating potential difference is applied across two conductors whose spacing is large as compared to their diameters, there is no apparent change in the condition of atmospheric air surrounding the wires if the applied voltage is low. However, when the applied voltage exceeds a certain value, called critical disruptive voltage, the conductors are surrounded by a faint violet glow called corona.

The phenomenon of corona is accompanied by a hissing sound, production of ozone, power loss and radio interference. This phenomenon happens due to ionization of air and it is called corona.

15. What is the cause of Ferranti effect?

Under light load condition or no load condition of a long transmission line, Ferranti effect exists.

16. What are the different methods of reducing corona loss? (APRIL/MAY 2018)

i. By increasing the conductor size

ii. By increasing the conductor spacing.

iii. By using hollow and bundled conductors.

17. What are the main disadvantages of corona?

i. Corona is accompanied by a loss of energy. This affects the transmission efficiency of the line.

ii. Ozone is produced by corona and may cause corrosion of the conductor due to chemical action.

iii. The current drawn by the line due to corona is non-sinusoidal and hence non-sinusoidal voltage drop occurs in the line. This may cause inductive interference with neighbouring communication lines.

18. Why series compensation is used in long series?

i. To increase transmission capacity

ii. To improve system stability.

iii. To obtain correct load division between parallel circuits.

19. Give any two reasons to minimize the reactive power transfer in lines.

i. Leads to voltage stability.

ii. Results in greater real and reactive losses.

20. Define Voltage Regulation of a Transmission Line. (Nov/Dec 13) (Nov/Dec 12) (May/June 2014)

Voltage regulation is defined as the change in voltage at the receiving end (load) and when the full load is thrown off, the sending end (supply) voltage and supply frequency remains unchanged.

% Voltage Regulation = ((Vs-Vr)/Vr)*100

Where Vs=Sending End Voltage,

Vr=Receiving End Voltage.

21. What is the difference between nominal T and nominal π methods? (May/June 2014)

In nominal T method, the total capacitance of each conductor is concentrated ***at the centre of the line*** and half the line impedance is lumped on its either side.

Which is used for obtaining the performance calculation of medium lines.

In nominal π method, one half of the total capacitance of each conductor is lumped ***at both the ends.*** Which is used for obtaining the performance calculations of a medium line.

22. What is meant by 'natural loading' of a transmission lines? (Nov/Dec 14)

The natural or surge impedance loading or SIL of a transmission line is the MW loading of a transmission line at which a natural reactive power balance occurs. It is the maximum power transmitted when a lossless line operating at its nominal voltage, is terminated with a resistance equal to surge impedance of the line.

23. Why the control of reactive power is essential for maintaining a desired voltage profile? (Nov/Dec 14)

- To produce substantially flat voltage profile,
- To improve the system stability,
- To increase the power transfer capacity.

24. What is the range of surge impedance for over head lines? (May/June 13)

- For Over head lines, surge impedance is 400 ohm.

25. What is the range of surge impedance for under ground lines? (May/June 13)

- For Underground lines, surge impedance is 40-50 ohm.

26. What is the importance of voltage control? (APR/MAY 2015)

The task of voltage control is closely associated with fluctuating load conditions and corresponding requirements of reactive power compensation. Therefore several voltage control methods are employed in power system to keep the voltage levels within the desirable limits.

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27. **Mention the significance of surge impedance loading(APR/MAY 2016) (APR/MAY 2017)**

Surge Impedance Loading is a very essential parameter when it comes to the study of power systems as it is used in the prediction of maximum loading capacity of transmission lines.

28. **States the condition for maximum power delivered and draw the power angle diagram. (Nov/Dec 16)**

. The power transfer across the line is therefore:

$$\boldsymbol{S} = \boldsymbol{V_r}\left[\frac{\boldsymbol{V_s} - \boldsymbol{V_r}}{jX}\right]^* = \frac{V_r e^{-j\phi_2}(V_s e^{j\phi_1} - V_r e^{j\phi_2})}{-jX}$$

$$= j\frac{V_s V_r}{X}e^{-j(\phi_2-\phi_1)} - j\frac{V_r^2}{X} = \frac{V_s V_r}{X}\sin\delta + j\frac{V_r}{X}(V_s\cos\delta - V_r)$$

Where

$$\delta = \phi_2 - \phi_1$$

is called the power angle, which is the phase difference between the voltages on bus 1 and bus 2.

29. **What is power circle diagram? (NOV/DEC 2018)**

From the basic equations developed for the operation of transmission line, relating the sending-end and the receiving-end variables, it is possible to construct circle diagrams giving the locus of the current, as well as kVA under different operating conditions. The locus of the current falls on a circle and if the voltage is constant, the same diagram can be used as power circle diagram with different scale. The diagrams can be constructed for the receiving-end conditions or the sending-end conditions. The diagrams so constructed are then known as receiving-end power circle diagram and sending-end power circle diagram, respectively.

30. **Why should the reactive power transfer in lines be minimized? (NOV/DEC 2018)**

- **Minimized reactive power flows**: The reactive power flows should be minimized such that the active and reactive power losses can be reduced. In addition, the by-product of the minimized reactive power flows can actually reduce the voltage drop across transmission lines and transformers.

31. Mention the various methods of voltage control in transmission lines.

(Nov/Dec 16)

- *Excitation control and voltage regulators at the generating stations:*
- *Use of tap changing transformers at sending end and receiving end of the transmission lines*
- *Switching in shunt reactors during low loads or while energizing long EHV lines*
- *Switching in shunt capacitors during high loads or low power factor loads*
- *use of series capacitors in long EHV transmission lines and distribution lines in case of load fluctuations*
- *Use of tap changing transformers in industries, substations, distribution substations*
- *use of static shunt compensation having shunt capacitors and thyristorized control for step-less control of reactive power*
- *Use of synchronous condensers in receiving end substations for reactive power compensation*

Unit 2- MODELLING AND PERFORMANCE OF TRANSMISSION LINES

Descriptive type Questions Q&A

22A 3 - phase, 50 Hz, 40 Km long overhead line has the following line constants: resistance per phase per Km = 0.153 ohm, inductance per phase per Km = 1.21 mH, capacitance per phase per Km = 0.00958 μ F. The line supplies a load of 20 MW at 0.9 power factor lagging at a line voltage of 110 KV at the receiving end. Use nominal π representation; calculate sending end voltage, sending end current, sending end power factor, regulation and efficiency.

(Nov/Dec 2013)

23A three phase 5 km long transmission line, having resistance of 0.5 Ω/ km and inductance of 1.76 mH/km is delivering power at 0.8 pf lagging. The receiving end voltage is 32 kV. If the supply end voltage is 33 kV, 50 Hz, find line current, regulation and efficiency of the transmission line

24The A, B, C, D constants of a 3 phase transmission line are A = D = 0.936 + j0.016, B = 33.5 + j138 ohm, C = (-0.9280 + j901.223)xl0-6 mho. The load at the receiving end is 40 MW at 220 kV with power factor of 0.86 lagging. Find the magnitude of the sending end voltage, current, power, line efficiency and the voltage regulation. Assume the magnitude of the sending end voltage remains constant.

25A 200 Km long three phase transmission line has a resistance of 48.7 ohms per phase, inductive reactance of 80.20 ohms per phase and capacitance (line to neutral) 8.42nF per Km. It supplies a load of 13.5 MW at a voltage of 88 KV and power factor 0.9 lagging. Using nominal T circuit, find the sending end voltage, current, regulation and power angle. **(Apr/May 2011)**

Derive expressions for regulation and efficiency of a short transmission line. Draw required circuit and phasor diagram**(NOV/DEC 2017)**

26A three phase transmission line having a series impedance (20+j30)Ω delivers 7MW at 33kV and 0.8 lagging power factor. Find the sending and voltage, regulation and power angle. Neglect shunt capacitance.(6) **(NOV/DEC 2017)**

27Draw the equivalent circuit and phasor diagram with relevant equation for the medium transmission line using **(May/June 2013)**

(i) End condenser method

(ii) Nominal π method and its ABCD constants. **(Nov/Dec 10)**

(iii) Nominal T method.

28 Explain the classification of transmission lines with their characteristics.

(Nov/Dec 14)

29 Define the following,**(Nov/Dec 14)**

- Surge Impedance,
- Attenuation Constant,
- Voltage Regulation,
- Transmission Efficiency.

30 A 3 phase transmission line has a series impedance of (10+j30)Ω per phase. For receiving and sending voltages of 132kV and 140 kV respectively. Draw the receiving end power circle diagram and determine the following,**(Nov/Dec 11)**

- The maximum real power delivered by the line and the load power factor under that condition.
- The capacity of shunt compensation equipment for supplying a load of 150MVA at 0.8 pf lagging and the power angle under that condition.
- The capacity of shunt compensation equipment to maintain the above voltage under no-load condition.
- The unity pf that the line can supply with voltages at above values.

Explain the method of drawing receiving end power circle diagrams. (16)

(May/June 2014)) (NOV/DEC 2017)

31 A 50 Hz, three-phase transmission line is 250 Km long. It has a total series impedance of ohms and a shunt admittance of914 x 10-6 ohms. It delivers 5(fMw at 220 KV with a power factor of 0.9 lag. Find the:

(i) Sending end voltage, (ii) Voltage regulation

(iii) Transmission efficiency by nominal —T method. (16)**(May/June 2014)**

32Write short notes on the following, **(Nov/Dec 2013)**

(i) Surge impedance loading,

(ii) Power angle curve,

(iii) Load ability limits based on thermal loading.

33Explain the factors affecting corona loss. **(May/June 2013)**

34Write short notes on corona power loss. **(May/June 2013)**

35Explain about Rigorous method for long lines. **(Nov/Dec 2012)**

36Assume a three-phase line has the impedance of 5+j20 ohm per phase delivers a load of 30MW at a power factor of 0.8 lag and voltage of 33kV. Determine the capacity of the phase modifier to be installed at the receiving end if the voltage at sending end is to be maintained at 33kV.**(Nov/Dec 11)**

37Deduce an expression for the sending end and receiving end power of a line in terms of voltages and ABCD constant. **(Apr/May 2011) (NOV/DEC 2017)**

38Write a short notes on: **(Nov/Dec 10)**

(i) Shunt Compensation

(ii) Series Compensation

39A balanced three phase load of 30MW is supplied at 132kv,50hz and0.85pf.lagging by means of a transmission line. The series impedance of a single conductor is(20+j52)Ω and the total phase neutral admittance 315x10-6Siemen.Using nominal T method, Determine (i)A,B,C and D constants of the (i) sending end voltage (iii)regulation of the line(16) **(APR/MAY 2015)**

40Explain the real and reactive power flow in lines. Also explain the methods of voltage control.(16) **(APR/MAY 2015)**

41Draw the nominal T circuit of a medium length transmission line and derive expressions for sending end voltage and current. Also draw the respective phasor diagram.(16) **(Nov/Dec 15)**

42Show that the real power transferred is dependent on the power angle and reactive power transferred is dependent on the voltage drop in the line**(Nov/Dec 15)**

43(a)A 3phase, 50Hz, 100km line has the following constants. Resistance / phase / km = 0.153 ohm, inductance/phase/km = 1.21mH, capacitance/phase/km =0.00958 µF. If the line supplies a load of 20MW at 0.9pf lagging at 110kV at the receiving end calculate sending end current, sending end power factor, regulation and transmission efficiency using nominal T method (16) **(APR/MAY 2016)**

(OR)

(b) The constants of a three phase line are A=0.9∠2° and B=140∠°ohms per phase. The line delivers 60 MVA at 132kV and 0.8pf lagging. Draw power circle diagrams and find (a) sending end voltage and power angle (b) the maximum power which the line can deliver with the above values of sending and receiving end voltages (c) the sending end power and power factor (d) line losses.(16) **(APR/MAY 2016)**

44(a)A 3ϕ, 50Hz, transmission 30km long has a total series impedance of (40+j125) Ω and shunt admittance of 10-3 mho. The load is 50MW at 220kV with 0.8pf lag. Find the sending end voltage, current, power factor, efficiency and regulation using nominal π-method.(16) **(Nov/Dec 2016)**

(OR)

(b) Derive the expression for the real and reactive power flow through transmission lines. (16) **(Nov/Dec 2016)**

45 What are the different methods available for voltage control and explain any one method. **(APR/MAY 2017)**

46(b)(i)Explain the meaning of performance of lines. (5)

47(ii) A single phase 50 Hz generator Supplies an inductive load of 6 MW at 0.8 pf lagging by means of an overhead line 15km long. The line resistance and inductance are 0.02 ohm/km and 0.85 mH/km. The voltage at the receiving end s 11kV.Determine the sending end voltage and voltage regulation. (8) . **(APR/MAY 2017)**

(OR)

(b)Explain the formation of corona, critical voltages, corona loss, advantages, disadvantages and methods to reduce the effect of corona. (16) **(Nov/Dec 16)**

48. Explain the following,**(Nov/Dec 12)**

(i) Corona Effect

(ii) Disruptive critical voltage

(iii) Visual critical voltage

(iv) Corona power loss

49. Explain the interference between power and communication circuits (**Nov/Dec 13)**

50. Discuss the factors which affecting corona loss **(Apr/May 2011)(Nov/Dec 11)** Explain the factors affecting corona loss and the methods of reducing corona loss. **(April/May 2017)**

51. Explain the following with respect to corona(i) corona(ii) effects of corona(iii)disruptive critical voltage(iv)visual critical voltage(v)corona power loss. Also explain the interference with neighboring communication circuits(16) (**AP/MY 2015**)

52. a) Determine the efficiency and regulation of a 3-phase, 100 km, 50 Hz transmission line delivering 20 MW at a.p.f. of0.8 lagging and 66 kV to a balanced load. The conductors are of copper, each having resistance 0.1 ohm per km, inductance 0.1117 H per km and capacitance 0.9954 μF per km. Neglect leakage and use nominal-π method. (APRIL/MAY 2018)

(OR)

b) Derive the expression for voltage and current at any point 'x' from the receiving end of a long transmission line. (APRIL/MAY 2018) **(NOV/DEC 2018)**

53. Derive the expression for the voltage induced in communication lines due to the current in power lines. **(Nov/Dec 11)**

54. Derive voltage regulation, power factor and transmission efficiency of short transmission line with diagrams. (NOV/DEC 2018)

Unit 3- MECHANICAL DESIGN OF LINES

Mechanical design of OH lines – Line Supports –Types of towers – Stress and Sag Calculation – Effects of Wind and Ice loading. Insulators: Types, voltage distribution in insulator string, improvement of string efficiency, testing of insulators.

Two marks Q&A

1. What is sag template? (May/June 2014) (Nov/Dec 2015) . (APRIL/MAY 2018)

A Sag Template is a very important tool with the help of which the position of towers on the Profile is decided so that they conform to the limitations of vertical and wind loads on any particular tower, and minimum clearances, required to be maintained between the line conductor to ground, telephone lines, buildings, streets, navigable canals, power lines, or any other object coming under or near the line.

2. What is meant by Sag? (Nov/Dec 13) (APR/MAY 2016) (NOV/DEC 2018)

The difference between points of supports and the lowest point on the conductor is called sag.

3. What is deviation tower? (May/June 2013)

It is the deviation from straight run and changes direction in a tower called deviation tower. It is depend upon the stress due to conductor weight and wind pressure.

4. Name any 2 factors affecting sag. (Nov/Dec 2012) (Nov/Dec 10) (Nov/Dec 2016) (April/May 2017)

The length of span

The working tensile stress.

5. What is meant by tower spotting?(Nov/Dec 2015)

6. Define String efficiency (Nov/Dec 10) Nov/Dec 2015)

The ratio of voltage across the whole string to the product of number of discs and the voltage across the disc nearest to the conductor is known as string efficiency.

$$string\ efficiency = \frac{voltage\ across\ the\ insulator\ string}{number\ of\ discs \times voltage\ across\ the\ disc\ nearest\ to\ the\ conductor}$$

The greater the string efficiency, the more uniform is the voltage distribution.

7. What are the advantages of string insulators? (Nov/Dec 2011)

i. Cheaper than pin type insulators for voltage greater than 33 KV

ii. Number of disc can be inserted depending upon the voltage that flows.

iii. Failure in any one unit will not affect the entire string. Replacement can be done easily.

iv. More flexibility.

v. Conductor runs below the cross arm, so line conductors are less affected by lightening.

vi. Arrangements act as lightening arrestors.

8. What are the causes of failure of insulators? (April/May 2011)

Causes of failure of insulators are porosity, presence of impurities and cracks, puncture of insulator and flash over.

9. Give the importance of stay insulators.

i. In case of low voltage lines, it is necessary that the stays are to be insulated at a height of not less than 3 meters from ground.

ii. It is used to create insulation between pole and stay clamp.

iii. In case if the insulator breaks, then the stay wire will not fall on the ground.

10. A 1 km long single core cable has a core diameter of 2.5cm, insulation thickness of 1.25 cm and resistivity of the insulation is 4.5×10^4 ohms-cm. calculate the insulation resistance/km

$$R = \frac{\rho}{2\pi l} \ln \frac{D}{d}$$

$$t = \frac{D - d}{2}$$

$$1.25 = \frac{D - 2.5}{2}$$

$$D = 5\ cm$$

$$R = \frac{4.5\ \times 10^4}{2\pi \times 100000} \ln \frac{5}{2.5}$$

$$R = 496\ Mohm$$

11. What are the various methods of improving string efficiency? (May/June 13) (Nov/Dec 2016)

i. By using larger cross arm

ii. By grading the insulator

iii. By using guard ring

12. Write down the expression for insulation resistance of a single core cable (Nov/Dec 13)

$$R = \frac{\rho}{2\pi l} \ln \frac{R}{r} \text{ ohms}$$

13. What is shackle Insulator? (May/June 2014)

When the low voltage transmission line meets a dead end or a corner or a sharp curve it is subjected to a greater tension. The insulators, which are used to relieve the low voltage line of excessive tension, are called shackle insulators.

14. Why are insulators used with overhead lines? (Nov/Dec 14) (NOV/DEC 2018)

Insulators are used to support the conductors and withstand both the normal operating voltage and surges due to switching and lightning. It also provide necessary insulation between line conductors, tower and thus prevent any leakage from conductors to earth.

15. What are the test performed on the insulators? (APR/MAY 2016)

According to the British Standard, the electrical insulator must undergo the following tests

1. Flashover tests of insulator
2. Performance tests
3. Routine tests

16. Specify the different types of insulators. (April/May 2017)

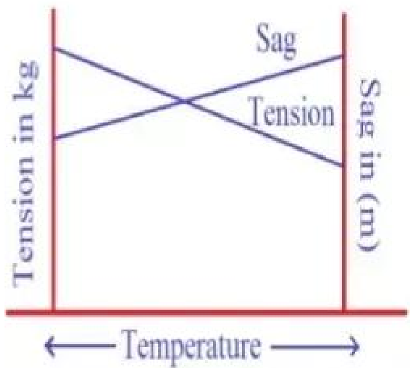
1. Pin Insulator 2. Suspension Insulator 3. Strain Insulator In addition to that there are other two types of electrical insulator available mainly for low voltage application, e.i. Stay Insulator and Shackle Insulator

17. How does grading improves string efficiency? (Nov/Dec 2013)

This method uniforms the potential distribution across each units in insulator strings. Thereby string efficiency improves.

18. What is meant by stringing chart(APR/MAY 2016)

Stringing chart is basically a graph between Sag, Tension with Temperature. As we want low Tension and minimum sag in our conductor but that is not possible as sag is inversely proportional to tension. It is because low sag means a tight wire and high tension whereas a low tension means a loose wire and increased sag. Therefore, we make compromise between two but if the case of temperature is considered and we draw graph then that graph is called

Stringing chart 

As Temperature increases then sag will increase but sag is inversely proportional to Tension so Tension will decrease.

19. Give the significance of a stringing chart. (NOV/DEC 2017)

a. For finding the sag in the conductor

b. In the design of insulator string

c. In the design of tower

d. To find the distance between the towers

20. State the advantages of suspension type insulators. (APRIL/MAY 2018)

(i) Suspension type insulators are cheaper than pin type insulators for voltages beyond 33 kV.

(ii) Each unit or disc of suspension type insulator is designed for low voltage, usually 11 kV. Depending upon the working voltage, the desired number of discs can be connected in series.

(iii) If any one disc is damaged, the whole string does not become useless because the damaged disc can be replaced by the sound one.

(iv)The suspension arrangement provides greater flexibility to the line. The connection at the cross arm is such that insulator string is free to swing in any direction and can take up the position where mechanical stresses are minimum.

(v) In case of increased demand on the transmission line, it is found more satisfactory to supply the greater demand by raising the line voltage than to provide another set of conductors. The additional insulation required for the raised voltage can be easily obtained in the suspension arrangement by adding the desired number of discs.

(vi)The suspension type insulators are generally used with steel towers. As the conductors run below the earthed cross-arm of the tower, therefore, this arrangement provides partial protection from lightning.

Unit 3- MECHANICAL DESIGN OF LINES

Descriptive type Questions Q&A

1. Explain briefly the different methods for improving string efficiency of an insulator. **(Nov/Dec 2012) (Apr/May 2011)**

2. Discuss briefly on the following types **(Nov/Dec 2010)**

(i) Pin type insulator**(NOV/DEC 2017)**

(ii) Suspension type insulator.

3. An insulator string for 66 kV line has 4 discs. The shunt capacitance between each joint and metal work is 10% of the capacitance of each disc. Find the voltage across the different discs and string efficiency.

4. In a 33 kV overhead line, there are three units in the string of insulators. If the capacitance between each insulator pin and earth is 11% of self capacitance of each insulator, find the distribution of voltage over 3 insulators

and string efficiency. Draw the equivalent circuit. **(NOV/DEC 2017)**

5. Draw with neat sketches and explanation of pin and suspension type insulators. Compare their merits and dements. **(May/June 2014)**

6. Explain with neat sketch the constructional features of pin type and suspension type insulators.

7. Each line of a 3 phase system is suspended by a string of 3 identical insulators of self capacitance C farad. The shunt capacitance of connecting metal work of each insulator is 0.2 C to earth and 0.1 C to line. Calculate the string efficiency of the system, if a guard ring increases the capacitance to the line of metal work of the lowest insulator to 0.3C. **(Nov/Dec 2014)**

8. In a 3-unit insulator the joint to tower capacitance is 20% of the capacitance of each unit.By how much should the capacitance of the lowest unit be increased to get a string efficiency of 90%?The remaining two units are left unchanged(**16**) **(APR/MAY 2015)**

9. What are the various properties of insulators?Also briefly explain about suspension type and pin type insulator.Draw the schematic diagram(16) **(APR/MAY 2015)**

10. Explain the role of static shielding in insulators(6). (**Nov/Dec 2015**)

11. A string of eight suspension insulators is to be graded to obtain uniform distribution of voltage across the string.If the capacitance of the top unit is 10 times the capacitance to ground of each unit,determine the capacitance of the remaining seven units.(10) **Nov/Dec 2015)**

12. (a)(i)Briefly explain the different methods to improve string efficiency of suspension type insulators.(8) **(APR/MAY 2016)**

(ii)A three unit insulators string is fitted with a guard ring. The capacitances of the link pins to metal work and guard ring. The capacitances of the link pins to metal work and guard ring can be assumed to be a 15% and 5% of the capacitance of each unit. Determine voltage distribution string efficiency.(8) **(APR/MAY 2016)**

13. (a)(i)Explain the different types of insulators.(8) (**Nov/Dec 2016)**

(ii)A string of five insulator units has mutual capacitance equal to 10 times the pin to earth capacitance, find voltage distribution across various units as the percent of the total voltage across the string and string efficiency.

14. A transmission line has a span of 275m between level supports. The conductor has an effective diameter of 1.96 cm and weighs 0.865 kg/m. its ultimate strength is 8060 kg. if the conductor has ice coating of radial thickness 1.27 cm and is subjected to a wind pressure of $39 kg/m^2$ of projected area. Calculate the maximum sag. Assume that the safety factor is 2 and ice weighs $910 kg/m^3$. **(Nov/Dec2014)**

15. What is a Sag-Template? Explain how this is useful for location of towers and stringing of power conductors? **(Nov/Dec2014)**

16. Assuming that the shape of an overhead line can be approximated by a parabola deduce expression for calculating sag,and conductor length.How can the effect of wind and ice loadings be taken into account(16) **(Nov/Dec 2015)**

17. An overhead line has a span of 336m. The line is supported at a water crossing from two towers whose heights are 33.6 m and 29 m above water level. The weight of the conductor is 8.33 N/m and tension in the conductor is not to exceed $3.34 x 10^4$ N. Find (i) clearance between the lowest point on the conductor and water (ii) horizontal distance of this point from the lower support. **(Nov/Dec 2010)**

18. An overhead line has a span of 160m of stranded copper conductor between level supports. The sag is 3.96 m at —5.50 C with 9.53 mm thick in ice coating and wind pressure of 40 Kgf/m2 of projected area. Calculate the temperature at which the sag will remain the same under conditions of no ice and no wind. The particulars of the conductor are as follows:

Size of conductor 7/3.45 mm, Area of cross section 64.5 mm2 weight of conductor 0.594 Kgf/m, Modulus of elasticity 12700 Kgf/mm2, Coeficient Qf linear expansion 1.7 x 10-510 C, Assume 1 ms of ice to weight 913.5 Kgf. **(May/June2014)**

19. Derive the expression for sag of a line supported between two supports of the same height **(Nov/Dec 2012)**

20. Derive an expression for sag calculation in a line. **(Apr/May 2011)**

21. (a) A transmission line has a span of 275m between level supports. The conductor has an effective diameter of 1.96cm and weighs 0.865kg/m.If the conductor has ice coating of radial thickness 1.27 cm and is subjected to a wind pressure of 3.9gm/sq.cm of projected area.The ultimate strength of the conductor is 8060 kg.Calculate the sag if the factor safety is 2 and weight of 1 c.c of ice is 0.91gm. **(APR/MAY 2016)**

22. (a) An OHL at a river crossing is supported from two towers of heights 30m and 90m above water level with the span of 300m. The weight of the conductor is 1 kg/m and the working tension is 2000kg.Determine the clearance between the conductor and the water level midway between the

towers. (16) **(Nov/Dec 2016)**

23. i) Prove that a transmission line conductor between two supports at equal heights takes the form of a catenary.(7) (NOV/DEC 2017)

24. ii) What is a sag-template? Explain how this is useful for location of towers and stringing of power conductors.(6) (NOV/DEC 2017)

25. Explain the key points to be considered for tower spotting. Also list the basic types of tower based on circuits used. **(APR/MAY 2017)**

26. a) In a 33 kV overhead line, three are there units in the string of insulators. If the capacitance between each insulator pin and earth is 11% of self-capacitance of each insulator, find the distribution of voltage over 3 insulators and string efficiency. **(APRIL/MAY 2018)**

27. a) A transmission line conductor having a dia of 19.5 mm weights 0.85 kg/m. The span is 275 metres. The wind pressure is 39 kg/m2 of projected area with ice coating of 13 mm. The ultimate strength of the conductor is 8000 kg. Calculate the maximum sag if the factor of safety is 2 and ice weighs 910 kg/m3. (APRIL/MAY 2018)

28. (a) Calculate sag and tension of a conductor when
    i. supports are at equal levels (7) (NOV/DEC 2018)
    ii. supports are at unequal levels. (6) (NOV/DEC 2018)
    Analyze with, without the effect of ice loading and wind.

29.

Unit 4- UNDER GROUND CABILITYS

Underground cabilitys - Types of cabilitys – Construction of single core and 3 core Cabilitys - Insulation Resistance – Potential Gradient - Capacitance of Single-core and 3 core cabilitys - Grading of cabilitys - Power factor and heating of cabilitys– DC cabilitys.

Two marks Q&A

1. What is the necessity of grading of an underground cable? (Nov/Dec 10)

Grading of the underground cable is done to achieve uniform electrostatic stress in the dielectric of cable.

The following are the two main methods of grading of cables:

i. Capacitance grading

ii. Intersheath grading

2. List the four main insulating materials used in cables?(May/June 13) (Nov/Dec 2016)

i. PVC

ii. Rubber

iii. Impregnated paper

iv. Polythene

3. What are the effects of grading of cables? List out methods of grading also.(Nov/Dec 2011) (April/May 2017)

Uniform electrostatic stress in the dielectric of cable is achieved by grading of cables.

Methods of grading

i. Capacitance grading

ii. Intersheath grading

4. List out the four main properties of insulating materials for cables.What are the desirable properties of insulator? (NOV/DEC 2017) . (APRIL/MAY 2018)

i. High insulation resistance to avoid leakage current

ii. High dielectric strength to avoid electrical breakdown of the cable

iii. High mechanical strength to withstand the mechanical handling of cables

iv. Non-hygroscopic i.e) it should mot absorb moisture from air or soil.

v. Non inflammable

vi. Unaffected by acids and alkalies

5. Show that the insulation resistance of cable is inversely proportional to its length.

Derivation:

Let,

r be the radius of the conductor

R be the radius of metallic sheath

x be the radius of annulus

l be the length of cable

ρ be the resistivity of insulation

Insulation resistance $dR_{ins} = \frac{\rho\, dx}{2\pi x}$ ohms/m

Insulation resistance per meter length is,

$$R_{ins} = \int_r^R \frac{\rho\, dx}{2\pi x} = \frac{\rho}{2\pi}\int_r^R \frac{dx}{x}$$

$$= \frac{\rho}{2\pi}[\ln R - \ln r]$$

$$= \frac{\rho}{2\pi} \ln \frac{R}{r} \quad \text{ohms / m}$$

If the cable has length of l meters, then

$$R = \frac{\rho}{2\pi l} \ln \frac{R}{r} \quad \text{ohms}$$

6. Give the classification of cable for 1ϕ and 3ϕ Service with operating voltages.

i. Low tension cables – upto 1000 V

ii. High tension cables – upto 11000 V

iii. Super tension cables – from 22 KV– 33 KV

iv. Extra High tension cables – from 33 KV– 66 KV

v. Extra super tension cables – beyond 132 KV

7. What is the function of sheath in a cables?

The sheath does not allow the moisture to enter and protects the cable from all external influences like chemical or electrochemical attack fire etc.

8. What is meant by serving of a cable?

A layer of fibrous material permitted with waterproof compound applied to the exterior of the cable is called serving of a cable.

9. What is meant by dielectric stress in a cable? (May/June 2014)

Under Operating Conditions, the insulation of a cable is subjected to electrostatic force known as dielectric stress.

10. What are the factors to be considered while selecting a cable for a particular service? Nov/Dec 14)

- Materials,
- Working Voltage,
- Load Current,
- Short circuit current,
- Load factor,
- Frequency,
- Acceptable Voltage Drop,
- Economics

11. What is the main purpose of armouring? (APR/MAY 2015)

The main purpose of armour is to provide mechanical protection, although it can also provide part of the earth fault path. For multi-core cables steel wire armour is most often used.

12. What are the materials mainly used in bus bars? (APR/MAY 2015)

- Alluminium busar,
- Copper busbar
- Alluminium coated copper busbar or tinned busbar.

13. A single core cable,1.7km long has a conductor radius of 13mm and an insulation thickness of 5.8mm.The dieclectric has a relative permittivity of 2.8.Find the capacitance per meter length of cable. (Nov/Dec 15)

14. Define Grading of Cables. (Nov/Dec 12)

The process of achieving uniform electrostatic stress in the dielectric of cables is known as grading of cables.

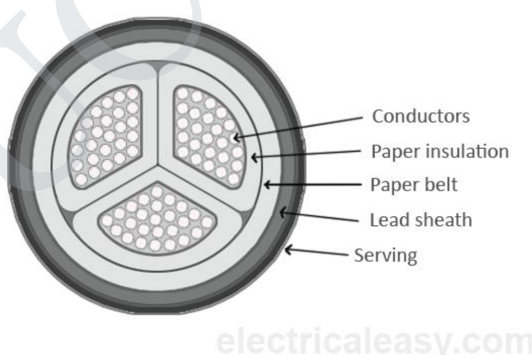
15. Classify the cables used for three phase service(APR/MAY 2016)

The following types of cables are generally used for 3-phase service :

1. Belted cables — upto 11 kV
2. Screened cables — from 22 kV to 66 kV
3. Pressure cables — beyond 66 kV.

16. What is a belted-Cable? (NOV/DEC 2017)

The conductors (usually three) are bunched together and then bounded with an insulating paper 'belt'. In such cables, each conductor is insulated using paper impregnated with a suitable dielectric. The gaps between the conductors and the insulating paper belt are filled with a fibrous dielectric material such as Jute or Hessian. This provides flexibility as well as a circular shape. As we discussed earlier (in Construction of Cables), the jute layer is then covered by a metallic sheath and armouring for protection. One particular speciality of this cable is that its shape may not be perfectly circular. It is kept non-circular to use the available space more effectively.



There are some limitations of such construction. Since the electric field is tangential, the insulation provided is stressed. As a result, the dielectric strength falls over time. Hence, such construction isn't preferred for voltage levels above 11 kV.

17. List the advantages of polythene insulators? (NOV/DEC 2018)

They possess very good strength and toughness. They possess good shock absorption capacity. Advantages of plastic are corrosion resistant and chemically inert. They have low thermal expansion of co-efficient and possess good thermal and electrical insulating property

Unit 4- UNDER GROUND CABILITYS

Descriptive type Questions Q&A

30. What is grading of cable. Discuss the two methods of grading of cable in detail. **(Apr/May 2011) (NOV/DEC 2017)**

31. Derive the expression for insulation resistance, capacitance, electric stress and dielectric loss of a single core cable. **(Nov/Dec 2010)**

32. Discuss the capacitance grading of underground cables. **(May/June 2013) (May/June 2014)**

33. Derive an expression for the insulation resistance, capacitance and the electrostatic stress of a single core cable. **(Nov/Dec 2014)**

34. With neat diagram explain the constructional features of various cables. **(Nov/Dec 2012)(Nov/Dec 2011)**

35. Derive an expression to determine the capacitance of a belted cable. **(Nov/Dec 2013)**

36. Explain any four insulating materials used in manufacturing of cables (6) **Nov/Dec 2015)**

37. Write short notes on:

(i) Properties of Insulation material used for cables. (5)

(ii) The Capacitance per kilometer of a 3 phase belted core cable is 0.2micro farad/km between two cores with third core connected to sheath. Calculate the kVA. The supply voltage is 6.6kV and 30km long. **(APR/MAY 2017)**

38. Find the economic size of a single core cable working on a 132kv three phase system,if a dielectric stress of 60kV/cm can be allowed(10). (**Nov/Dec 2015)**

39. Explain the methods of grading of cables with neat diagrams and equations.(16) **(APR/MAY 2016)**

40. i) Derive the expression for the capacitance of a single-core cable. (8) (APRIL/MAY 2018)

ii) A single core cable has a conductor diameter of 1cm and internal sheath diameter of 1.8 cm. If impregnated paper of relative permittivity 4 is used as the insulation, calculate the capacitance for 1km length of the cable. (5)

(APRIL/MAY 2018)

41. Explain the different cables used for three-Phase system. **(NOV/DEC 2018)**

42. A 2km long 3 core, 3ϕ cable has capacitance 0.5 μF/km between two conductors bunched with sheath and the third conductor. The capacitance between the conductor is also measured when bunched together and the sheath and found to be 0.75μF/km. Determine

(i) Capacitance between phases

(ii) Capacitance between the conductor and the sheath

(iii)Effective per phase capacitance

(iv)Capacitance between two conductors connecting a third conductor to the sheath

(v) Charging current if the supply voltage is 11kV,50Hz. (16) (**Nov/Dec 2016)**

PART C -(1 x 15 = 15 marks)

16.(a) A 33 kV, 50 Hz , 3-phase underground cable, 4 km long uses three single core cables. Each of the conductor has a diameter of 2.5 cm and the radial thickness of insulation is 0.5 cm. Determine (i) Capacitance of the cable/phase (ii) charging current/phase (iii) total charging kVAR. The relative permittivity of insulation is 3. **(NOV/DEC 2018)**

Or

(b) The insulation resistance of a single-core cable is 495 MΩ per km. If the core diameter is 2.5 cm and resistivity of insulation is 4.5 x ·1014 Ω - cm, find the insulation thickness. **(NOV/DEC 2018)**

Unit 5- DISTRIBUTION SYSTEMS

Distribution Systems – General Aspects – Kelvin's Law – AC and DC distributions - Techniques of Voltage Control and Power factor improvement – Distribution Loss –Types of Substations -Methods of Grounding – Trends in Transmission and Distribution: EHVAC, HVDC and FACTS (Qualitative treatment only).

Two marks Q&A

1. List the various substation equipments.

i. Transformer

ii. Bus bars

iii. Insulators

iv. Isolators and fuses

v. Circuit breaker

vi. Relays

vii. Lightening arresters.

2. What are the various methods of earthling in substations?(Nov/Dec 2011) (April/May 2017)

i. Solid grounding

ii. Resistance grounding

iii. Reactance grounding

iv. Resonant grounding

3. Mention the advantages of outdoor substation over indoor substation. (April/May 2011)

i. Time required for erection is less

ii. Future extension is easy

iii. Fault location is easy

iv. Capital cost is low

4. What are the objectives of earthling? (Nov/Dec 2013) (April/May 2011) (Nov/Dec 2016)

Due to defective electrical apparatus and some other reasons, electricity causes electric shock hazards for human being and animals. Grounding is of major concern to increase the reliability of supply service, as it provides stability of voltage conditions, prevents excessive voltage peaks during the disturbances. Grounding is also a measure of protection against lightening.

5. Why are transmission lines 3 phase 3 wire circuits while distribution lines are 3 phase 4 wire circuits? (Nov/Dec 10)

Transmission lines 3 phase 3 wire circuits while distribution lines are 3 phase 4 wire circuits because transmission line consists of three conductors which represents the phases R, Y, and B whereas distribution line requires neutral in addition with three phases to supply the 1 phase loads of domestic and commercial consumers.

6. Classify the types of substation depending upon its physical features.

i. Indoor substation

ii. Outdoor substation

iii. Underground substation

iv. Pole mounted substation.

7. What is substation?

The assembly of apparatus used to change some characteristic (eg: voltage , A.C to D.C frequency power factor etc) of electric supply is called a substation.

8. What is bus bar? What are the materials mainly used for Busbar? (APR/MAY 2015)

Busbar is a conductor to which a number of circuits are connected.

The materials used in bus bars are,

Copper and aluminium

9. What are the major equipments of a substation?(May/June 2014) (Nov/Dec 10) (NOV/DEC 2017)

- Transformers, Circuit Breakers,
- Isolators, Current and Potential transformers,
- Bus bars, Protective relays,
- Lightning arresters,Earthing Switch,
- Shunt Capacitors, Station Battery and Charging Equipment.

10. Enumerate the various methods of neutral grounding. (May/June 2014)

- solid grounding, resistance grounding
- reactance grounding, resonant grounding

11. What is the purpose of terminal and through sub-stations in the power system? (Nov/Dec 14)

A terminal sub-station is one in which the line supplying to the substation terminates or ends. It may be located at the end of the main line or it may be situated at a point away from main line route.

A through sub-station is one in which the incoming line passes 'through' at the same voltage. A tapping is generally taken from the line to feed to the transformer to reduce the voltage to the desired level.

12. What is the function of isolators? (Nov/Dec 13)

It is used to disconnect a part of the system for general maintenance and repairs.

13. Mention any 4 bus bar schemes used in substation. (May/June 13)

- Single bus bar arrangements
- Single bus bar arrangements with sectionalism
- Double bus bar arrangements
- Double bus bar arrangements with sectionalism

14. List type of Substations. (Nov/Dec 12) (APR/MAY 2015)

- Transformer Substations, Switching Substations
- Industrial Substations, Indoor Substations
- Outdoor Substations, Underground Substations
- Pole-mounted Substations

15. List out the basic types of FACTS controllers. (April/May 2011)

i. Series controller
ii. Shunt controller
iii. Combined series series controller
iv. Combined series shunt controller

16. What are the various types of HVDC systems? (May/June 2013)

i. Monopolar
ii. Bipolar
iii. Homopolar
iv. Back to back coup[ling
v. Multi terminal HVDC system

17. Differentiate a primary distribution and secondary distribution with the help of a diagram.

S.NO	PRIMARY DISTRIBUTION	SECONDARY DISTRIBUTION

1	Also called high voltage distribution	Also called low voltage distribution
2	Uses 3ϕ 3 wire system	Uses 3ϕ 4 wire system
3	Voltage level is 6.6 KV	Voltage level is 230 V for 1ϕ and 415 V for 3ϕ

18. What are the applications of HVDC transmission system? (Nov/Dec2016)

i. Long distance bulk power transmission

ii. Underground or under water cables

iii. Asynchronous interconnection of AC system operating at different frequencies or where independent control of system is desired

iv. Control and stabilization of power flows in AC ties in an integrated power system.

19. State the various devices used in FACTS.

i. Static synchronous compensator(STATCOM)

ii. Static synchronous generator

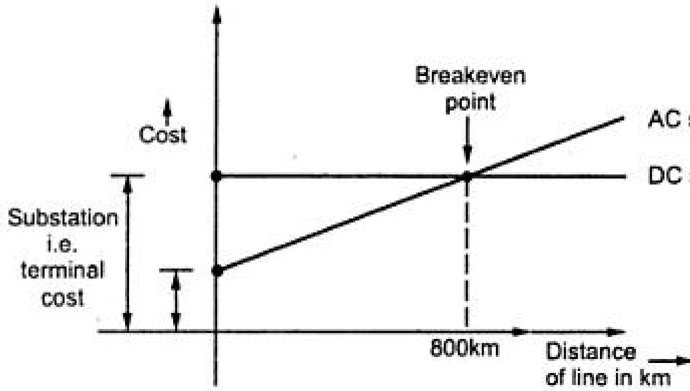
iii. Static VAR compensator

iv. Thyristor switched capacitor

20. Define breakeven distance in HVDC transmission

A graph is plotted between the cost and distance of line in Km by taking cost along y axis and line in Km along x axis.

The curves for AC and DC transmission intersect each other at a point called breakeven point. Distance measured till breakeven point is called breakeven distance.



21. **What is meant by STATCOM?**

It is shunt connected static VAR compensator whose capacitive or inductive output current can be controlled independently of the AC system voltage.

22. **Explain the term regional grid.**

In order to achieve economy, reliability and continuity in the supply individual power systems that are generating electrical power are arranged in the form of electrically connected areas called regional grid.

23. **State the advantages of EHVAC transmission system**

i. With the increase in transmission voltage, the transmission efficiency increases for a given amount of power to be transmitted over a given

ii. distance

iii. Voltage regulation is improved, because of reduction in line losses

iv. The volume of conductor material decreases, being inversely proportional to the square of transmission voltage

24. **Mention the terminal equipments in HVDC system.**

i. DC line inductors.

ii. Harmonic filter on DC side

iii. Converter transformers

iv. Reactive power source

v. Harmonic filter on AC side

vi. Ground electrodes

25. What is the necessity of FACTS? What are the objectives of FACTS? (APR/MAY 2016) (NOV/DEC 2017)

The FACTS technology makes use of power electronic promotes the control of transmission line. It also increase load on the line upto the thermal limits without having compromise with the reliability.

26. How does a.c. distribution differ from the d.c distribution? (Nov/Dec 14)

In case of ac distribution, The power generated is always in AC. It is then stepped up and down appropriately Then distributed at around 11kV and finally 440V (3 phase) for household usage. The frequency is maintained at around 50 Hertz. Not much of power conversion is required here.

In case of DC, the generated voltage 11kV is stepped up and converted to high voltage DC. Load in this dc distribution act at a particular point and also the same load may act at both the end of the lines. This is done using power electronic converters. At the receiving end, the voltage is converted back to AC. This is done by inverters. This is then distributed. The main advantage is that the power factor can be maintained at unity.

27. What is a feeder/Distributor? (May/June 13) (Nov/Dec2015) **(Nov/Dec2016)**

Feeder is a conductor which connects the substation or localized generating station to the area where power is to be distributed.

28. What is ring main distribution? (Nov/Dec 2012) (April/May 2017)

A ring distributor is a distributor which is arranged to form a closed circuit and is fed at one or more than one point.

Advantages are,

i. Less voltage fluctuations at consumer's terminals. Less copper is required

ii. Each part of the ring carries less current than in radial system.

29. Distinguish between radial and ring main distribution.

S.NO	RADIAL DISTRIBUTION	RING MAIN DISTRIBUTION
1	Fed at one end only	Fed at one or more points
2	More voltage fluctuation at far end	Less voltage fluctuation at consumers terminals
3	Less reliable	More reliable
4	Straight line distributor with both ends	Forms a closed loop.

30. What are the advantages of a 3 wire dc distribution system over a 2 wire dc distribution system?

If 3 wire system is used to transmit the same amount of power over the same distance with same efficiency with same consumer voltage we require 0.3125 times copper as required in 2 wire system.

31. List out the advantages of high voltage AC transmission. (Nov/Dec 2012) (APR/MAY 2016)

i. Reduced line losses

ii. Reduced in current

iii. Reduction in volume of conductor material required

iv. Decrease in voltage drop and increase in transmission efficiency

v. Improvement of voltage regulation

vi. Increased power handling capacity

32. Mention the demerits of HVDC transmission. (Nov/Dec 10)

i. The dc voltages cannot be stepped up for transmission of power at high voltages.

ii. The dc switches and circuit breakers have their own limitations.

iii. Power transmission with HVDC is not economical if the length of transmission line is less than 500km

iv. Considerable reactive power is required by converter station.

v. Maintenance of insulator is more.

33. State Kelvin's Law for size of transmission conductor.(Nov/Dec 14)

The annual expenditure on the variable part of the transmission system should be equal to the annual cost of energy wasted in the conductor used in that system.

34. What is gas insulated substation? (APRIL/MAY 2018)

A gas-insulated substation (GIS) uses a superior dielectric gas, SF6, at moderate pressure for phase-tophase and phase-to-ground insulation. The high voltage conductors, circuit breaker interrupters, switches, current transformers, and voltage transformers are in SF6 gas inside grounded metal enclosures.

35. What,are the advantages of adopting EHV/UHV for transmission of AC

electric power? (NOV/DEC 2018)

The reasons for adopting of EHV/UHV range for transmission purposes are given below:

- Reduction of Electrical Losses, Increase in Transmission Efficiency, Improvement of Voltage Regulation and Reduction in Conductor Material Requirement:
- Economic considerations have led to the construction of power stations of large capacity and so need of transfer of bulk power over long distances arose.

Transmission of bulk power from generating stations to the load centres is technically and economically feasible only at voltages in the EHV/UHV range.

- Generating stations (Steam-, hydro- and nuclear-power stations) are located in remote areas (far away from load centres) because of the reasons of economy, feasibility and from the point of view of safety and environmental conditions. EHV transmission is, therefore, inevitable for transmission of huge blocks of power over long distances from these power plants to load centres.
- Flexibility for Future System Growth:
- Increase in Transmission Capacity of the Line:
- Possibility of Interconnections of Power Systems:
- Increase of Surge Impedance Loading:
- Reduction in Right-Of-Way:

36. Why galvanized steel wire is not suitable for EHT lines for the purpose of transmitting large amounts of power over long distance? (NOV/DEC 2018)

because of Poor conductivity

--High internal reactance & eddy current & hysterisis

Unit 5- DISTRIBUTION SYSTEMS

Descriptive type Questions Q&A

1. Explain briefly the various types of bus bar arrangements in a substation.

   Nov/Dec 2014, Nov/Dec 2010)

2. Explain with the help of phasor diagram, the voltage control by synchronous condenser. **(NOV/DEC 2018)**

3. Explain the following substation bus schemes.

i. main and transfer bus

ii. Double bus bar with bypass isolators. **(May/June2013)**

4. Explain the following:

i. Solid grounding

ii. Reactance grounding

iii. Indoor Substations

iv. Outdoor Substations

5. Explain about the various types of substations equipments. **(Nov/Dec 2013)**

6. Explain in detail the various types of bus bar arrangements. **(May/June 2014)**

7. Explain the various types of d.c. distributors. **(May/June 2014)**

8. What are the different types of bus bar arrangements used in substations? Illustrate your answer with suitable diagrams**(Nov/Dec 2014)**

9. Discuss the design of primary distribution system with respect to following: **(April/May 2011)**

   i. Selection of voltage
   ii. Choice of scheme
   iii. Size of feeders

10. Write short note on: **(APR/MAY 2015)**

    (i)Sub mains

    (ii) Stepped and tapered mains

    (iii)Grounding grids(16)

11. Explain the following: **(APR/MAY 2015)**

    (i) Neutral grounding

    (ii) Resistance grounding(16)

12. Describe any four methods of power system grounding(16) **(Nov/Dec 2015)**

13. Explain the principle of operation of compensators used for voltage control. **(Nov/Dec 2011)**

(OR)

b) (b) Explain the methods of neutral grounding.(16) **(APR/MAY 2016)** **(APRIL/MAY 2018)**

(OR)

(b) Explain the methods of neutral grounding.(16) **(Nov/Dec 2016)**

14. Describe about the various methods of neutral grounding in detail.(13) (NOV/DEC 2017)

15. Describe the different types of substation layouts and list few advantages of GIS. **(APR/MAY 2017)**

16. List out the advantages of higher operating voltage. And then compare EHVAC system with HVDC system (May/June2013)**(Nov/Dec 2013)**

17. Discuss in detail the problem associated with EHV AC transmission. Also state how these problems are being solved? **(Nov/Dec2014)**

18. What are the basic types of FACTS controllers? And explain. **(Nov/Dec2014)**

19. List out the objectives of FACTS. **(Nov/Dec 2013)**

20. Explain the advantages of HVDC lines. **(Nov/Dec 2012)**

21. Describe the types of HVDC links in detail.**(Nov/Dec 2011)(Nov/Dec 2012)**

22. Discuss in detail the various equipments used in HVDC converter station. **(Nov/Dec 2010)**

23. Explain in detail the advantages,disadvantages and application of HVDC transmission (16) **(APR/MAY 2015) (Apr/May 2018)**

24. A uniform two wire DC distributor 250m long is loaded with 0.4A/m and is fed at one end. If the maximum permissible voltage drop is not exceed 10V,find the cross sectional area of the distributor conductor. Take ρ=1.78x10-8 Ωm. **(Nov/Dec2015)**

25. Derive suitable expressions, draw current loading diagram and voltage drop diagram for uniformly loaded distributor of length 'l' fed at one end. How is power loss in the whole distributor computed? (**Nov/Dec2015**)

26. Discuss briefly each of the following (Nov/Dec 2010)

i. Interconnected System

ii. Radial distribution

iii. Ring main distribution

iv. Design consideration in distribution system. **(Nov/Dec 2013)**

27. An electric train taking a constant current of 600 A moves on a section of line between two substations 8 km and maintained at 575 and 590 volts respectively. The track resistance is 0.04 ohm per km both go and return. Find the point of minimum potential along the track and currents supplied by two substations at that instant.

28. Write Short notes on the following, **(Nov/Dec 2014)**

- Ring Main Distributor
- Current Distribution in a 3 wire d.c system
- Balancers
- 3 Phase 4 wire a.c distribution. (4+4+4+4=16)

29. Find the ratio of volume of copper required to transmit the power over a given distance by overhead system using. **(May/June 2013)**

i. Dc 2wire and 3 wire system,

ii. 3phase, 3 wire AC system.

30. Explain the following,

(i) Stepped or tapered distributor

(ii) Ring main distributor

(iii) DC distributor fed at one end

(iv) DC distributor fed at both ends **(Nov/Dec2012)**

31. Explain the following,**(Nov/Dec2012, Nov/Dec 2011, Apr/May 2011)**

(i) Main transfer bus

(ii) Ring bus

(iii) Double bus bar with single breaker

(iv) Double bus bar with by pass isolators

32. (a)(i)Explain the structure of electric power system (8) **(Apr/May 2016)**

(ii)A two-wire dc ring main distributor ABCDEA is fed at point A with 230V supply. The resistance of go and return conductors of each section AB, BC, CD, DE, AE are 0.1 ohm. The main supplies the loads of 10A at B, 20A at C,1 0A at D,30A at E. Find the voltage at each load point.(8)

(OR)

(b)(i)Explain the different types of FACTS controllers.(8)

(ii) Explain the different HVDC links.(8)

33. (a)(i)Explain the effect of high voltage on volume of copper and on efficiency. (8) **(Nov/Dec2016)**

(ii)Derive suitable expression to determine the voltage drop and power loss in an uniformly loaded distributor of length 'l' fed at both ends with equal voltage (8)

34. (i)Make comparison between EHVAC and HVDC system based on economics. 8)

ii.Explain the different HVDC links.(8) **(Nov/Dec2016)**

35. (i) Compare the overhead and underground distribution system (8)

(ii) State the advantages of Interconnected system.(5) **(April/May 2017)**

36. ii) Draw and explain a simple model of UPFC.(5) **(NOV/DEC 2017)**

37. i) Briefly discuss the technical advantageous of HVDC over HVAC transmission system.(8) **(NOV/DEC 2017)**

ii) Explain the application of HVDC transmission system.5) **(NOV/DEC 2017)**

PART - C (1x15=15 Marks)

1. a) A 2-wire D.C street mains AB, 600 m long is fed from both ends at 220 V. Loads of 20 A, 40 A. 50 A and 30 A are tapped at distances of 100 m,. 250 m. 400 m and 500 m from the end A respectively. If the area. of X-section of distributor conductor is 1square centimeter, find the minimum consumer voltage. Take ρ= 1.7 x l0-6 ohm-cm. **(APRIL/MAY 2018)**

(OR)

b) A single phase distributor 'AB' 300 m long supplies a load of 200 A at 0.8 pf lagging at its far end 'B' and a load of 100A at 0.0707 pf lagging at 200 m from sending end point A. Both pf are referred to the voltage at the far end. The total resistance and reactance per km (go and return) of the distributor is 0.2 ohm and 0.1 ohm. Calculate the total voltage drop in the distributor. **(APRIL/MAY 2018)**