UNIT I TRANSMISSION LINE PARAMETERS

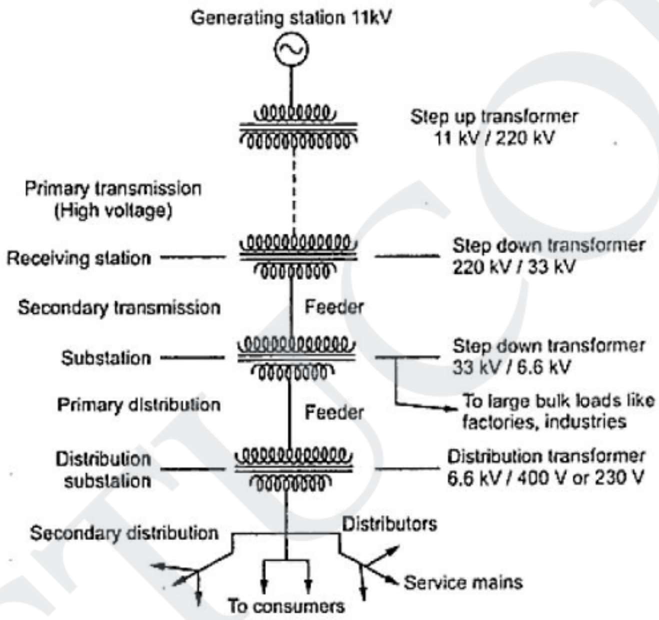
PART A

1. What are the components of a power system?(May 2014)

The components of power systems are,

1. Power plant: Generates electricity
2. Transformers: steps up or down the voltage level for transmission and distribution.
3. Transmission lines: carry the power from one place to another.
4. Substations: where the voltage is stepped up or down to meet the requirement.
5. Distribution lines: used for distribution of power where it's needed.
6. Distribution transformer: used to step down the voltage to the level suitable for household use.
7. Loads: Power requirements of small and large consumers.

2. Draw the structure of electric supply system.



3. What is meant by primary and secondary distributions?

The secondary transmission lines terminates at the substations where voltage is reduced from 33KV to 11KV lines which run along the road sides of the city forms the primary distribution. A primary distribution line terminates at the distributing substations where voltage is reduced from 11KV to 400 volts. Thus three phase 4 wire system which connect the distributing substation and the consumer point forms the secondary distribution.

4. What is meant by primary and secondary transmission?

Transmission of electric power at 110Kv, 132Kv, 400Kv, 765KV by three phase 3 wire overhead system is known as primary transmission. Transmission of electric power at 33KV by three phase 3 wire overhead system is known as secondary transmission.

5. What are the transmission level voltages we have in India?

Primary transmission level voltage is 132 KV, 220KV, 440KV, 750KV and secondary transmission level voltage is 33KV or 66KV.

6. Why all transmission and distribution systems are three phase systems?

A three phase A.C circuit using the same size conductors as the single phase circuit can carry three times the power which can be carried by a single phase circuit and uses three conductors for the three phases and one conductor for the neutral. Thus a three phase circuit is more economical than a single phase circuit in terms of initial cost as well as the losses. Therefore all transmission and distribution systems are three phase systems.

7. State the advantages of interconnected systems. (May 2018)

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.

8. Mention the limitations of using very high transmission voltage.

Limitations are (a) increased cost of insulation of conductors, (b) transformers switches gears and other terminal apparatus.

9. Why DC transmission is economical and preferable over AC transmission for large distances only?

Because with larger distances, the saving in cost of DC overhead lines become greater than the additional expenditure on terminal equipment.

10. Mention the problems associated with an EHV transmission?

The problems associated with EHV transmission are corona loss and radio interference, requirements of heavy supporting structures and their erection difficulties, and high insulation requirements.

11. What are the advantages of high voltage AC transmission? (Nov 2011)

(i) The power can be generated at high voltages. (ii)The maintenance of AC substations is easy and cheaper.(iii) The total line cost per MW per km decreases considerably with the increase in line voltage (iv) The line can be easily tapped and extended with simple control of power flow in the network.

12. What are the primary constants of transmission lines?

Resistance, inductance, capacitance and conductance distributed uniformly along the length of the line are called constants or parameters of transmission line.

13. Define resistance of transmission line?

Resistance of transmission line in a single phase is defined as the loop resistance per unit length of line. (Loop resistance is nothing but the sum of resistances of both the wires for unit line length).In a three phase, it is defined as the resistance per phase. (i.e) resistance of one conductor

14. Define inductance of transmission line. Give its unit.

When an alternating current flows through a conductor, a changing flux is setup which links the conductor. Due to these flux linkages, the conductor possesses inductance. Mathematically, Inductance of transmission line is defined as the ratio of flux linkage to unit current. Its unit is Henry.

$$L = \frac{\psi}{I}$$

Ψ = flux linkages in weber-turns

I = current in amperes

15. Define capacitance of transmission line.

Capacitance is defined as shunt capacitance between the two wires per unit line length (or) the capacitance between the conductors in a transmission line is the charge (q) per unit potential difference (v). Its unit is Farad per meter.

Capacitance $C = \frac{q}{v}$ farad

16. What is skin effect? Is it applicable to DC current also? (Nov 2012, May 2014).(Nov 2018)

An alternating current when flowing through the conductor, does not distribute uniformly, rather it has the tendency to concentrate near the surface of the conductor. This phenomenon is called skin effect. It is not applicable to DC current.

17. What is the effect of skin effect on the resistance of transmission line?

Due to skin effect the effective area of cross section of the conductor through which current flows is reduced. Consequently the resistance of line is increased when carrying an alternating current.

18. What is the cause of skin effect?

A solid conductor may consist of large number of strands, each carrying a small portion of the total current. The inductance of the individual strands will vary according to their positions. Thus the strands near the centre are surrounded by a greater magnetic flux and hence have a larger inductance than that near the surface. The presence of high reactance near the centre causes the alternating current to flow near the surface resulting in skin effect.

19. Give an expression for the loop inductance of a single phase, two wire system.

The expression for the loop inductance of a single phase, two wire system is given by,

$L = 10^{-7}\left[1 + 4\ln\frac{d}{r}\right]$;

d =Distance between two conductors; r =radius of the conductor.

20. How inductance and capacitance of a transmission line are affected by the spacing between the conductors?

$$L = 10^{-7}\left[\frac{1}{2} + 2\log_e\frac{d}{r}\right]$$

$$C = \frac{2\pi\varepsilon}{\log_e\frac{d}{r}}$$

Where d – spacing between the conductors, r- radius of the conductor.

If the spacing between the conductors is increased, inductance of the transmission line is increased and capacitance of the transmission line is decreased.

21. Write an expression for the inductance of each conductor for a 3 phase overhead transmission line in which the conductors are unsymmetrical spaced but transposed.

If the current carrying conductors A,B,C are spaced asymmetrically and are transposed to avoid the unbalancing effect then the inductance of each conductor for a 3 phase overhead transmission line is $= \left[0.5 + 2\ln\left(\frac{\sqrt[3]{d_1 d_2 d_3}}{r}\right)\right] X10^{-7}$ H/m. Where d_1, d_2, d_3 are the distances between the conductors ,r- radius of the conductors.

22. What is the effect of proximity effect? (May 2018)

Proximity effect results in,

i) the non-uniform distribution of current in the cross section.

ii) the increase of resistance.

23. Distinguish between GMD and GMR.(Dec 2015)

s.no	GMD(Dm)	GMR(Ds)
1)	GMD is also called as mutual GMD	GMR is also called as self GMD
2)	GMD is defined as the geometrical mean of the distances from one end of the conductor to the other end. (i.e. between the largest and smallest)	GMR is defined as the limit of geometric mean of distances between all the pairs of elements in that area as the number of elements increase without limit
3)	Mutual GMD depends only upon the spacing and is independent of the exact size, shape, orientation of the conductor.	Self GMD of a conductor depends upon the size and shape of the conductor and is independent of spacing between the conductors.

24. Write an expression for electric potential at a conductor in a group of charged conductors?

Let A, B, C etc be the group of conductors operating at potentials such that charges Q_A, Q_B, Q_c etc. coulomb per meter length. $V_A = \frac{1}{2\Pi\varepsilon_0}\left[Q_A \ln\frac{1}{r} + Q_B \ln\frac{1}{d_1} + Q_C \ln\frac{1}{d_2} + ...\right]$.

Where r-radius of the conductor A. d_1, d_2, … - distance between the conductor A and other conductor B, C etc., ε_0- permittivity of free space.

25. Define proximity effect on conductors.(May 2014/May 2015/Nov 2018)

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

26. Write an expression for electric potential at a charged single conductor?

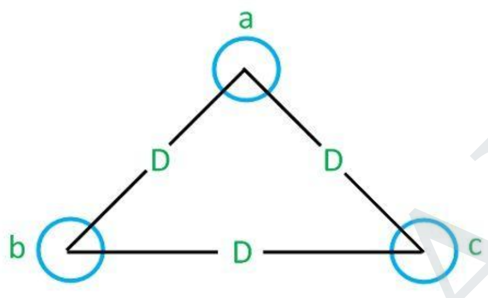
Electric potential at a charged single conductor "A" is $V_A = \frac{Q_A}{2\Pi\varepsilon_0}\int_r^{\infty}\frac{dx}{x}$ Where Q_A=charge per meter length; ε_o = permittivity of free space, r = radius of the conductor, x = distance at which potential is considered.

27. What is ACSR conductor?

ACSR conductor is an Aluminum Conductor Steel Reinforced. It consists of central core of galvanized steel strand surrounded by a number of aluminum strands. ACSR is a composite conductor which combines the lightness, electrical conductivity and rustleness of aluminum with the high tensile strength and has a larger diameter. So to minimize the corona losses they are now used as overhead conductors in the long distance transmission lines.

28. Define symmetrical spacing.

In three phase system when the line conductors are equidistant from each other then it is called symmetrical spacing. Such an arrangement of conductors is also referred to as equilateral spacing. It is shown in the diagram below,



Symmetrical three-phase line

29. What is a composite conductor?

A conductor which operates at high voltages and composes of two or more elements or strands, electrically in parallel is called as a composite conductor.

30. What is bundle conductor? State its advantages?(Dec 2014)

A bundle conductor is a conductor made up of two or more sub conductors and is used as one phase conductors. Its advantages are reduced reactance and reduced voltage gradient.

31. Define transposition of line. (Nov 2011,Dec 2015,May 2016)

When three phase line conductors have unsymmetrical spacing the flux linkages and inductances of each phase are not the same. This results in the unequal voltage drops in the three phases even if the currents in the conductors are balanced. Therefore the voltage at the receiving end will not be the same for all phases. To avoid the unbalancing effect the positions of the line conductors are interchanged at regular intervals along the line so that each conductor occupies the original position of every other conductor over an equal distance.

32. Write the expression for a capacitance of a single-phase transmission line. (Nov 2012)

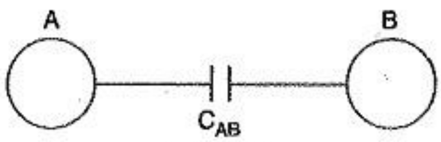


Fig. 9.22

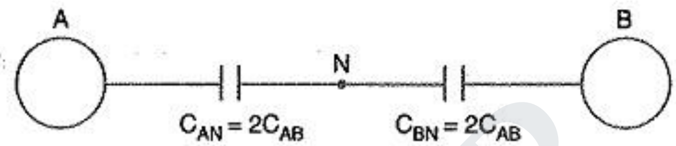


Fig. 9.23

∴ Capacitance to neutral, $C_N = C_{AN} = C_{BN} = 2C_{AB}$

$$\therefore \quad C_N = \frac{2\pi\varepsilon_0}{\log_e \frac{d}{r}} \text{ F/m} \qquad \ldots(ii)$$

Capacitance per unit length between the conductors $C_{AB} = \frac{\pi\varepsilon_0}{\ln(d/r)}$ F/m.

33. Define the term critical disruptive voltage?(Nov 2011, Nov 2013, Dec 2014)

The potential difference between conductors, at which the electric field intensity at the surface of the conductor exceeds the critical value and corona occurs is known as critical disruptive voltage.

34. A three phase transmission line has its conductor at the corners 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. (Nov 2013, May 2015)

$$L = 10^{-7}\left[\mu_r + 2\ln\frac{d}{r}\right] = 0.22\text{mH/Km}$$

35. What are the advantages of using bundled conductors? (APRIL 2019)

1. Bundling of conductors leads to reduction in line inductance.
2. The voltage regulation of the line is also increased as the reactance of the line is reduced.
3. Reduction in the formation of corona discharge leads to less power loss and hence improved transmission efficiency of the line.
4. Reduction in communication line interference due to reduction in corona.

36. List out the parameters affecting skin effect in transmission line. (APRIL 2019)

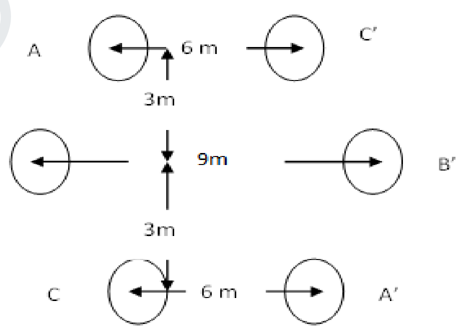
Factors affecting skin effect,

- **Frequency** – Skin effect increases with the increase in frequency.
- **Diameter** – It increases with the increase in diameter of the conductor.
- **The shape of the conductor** – Skin effect is more in the solid conductor and less in the stranded conductor because the surface area of the solid conductor is more.
- **Type of material** – Skin effect increase with the increase in the permeability of the material (Permeability is the ability of material to support the formation of the magnetic field).

PART B

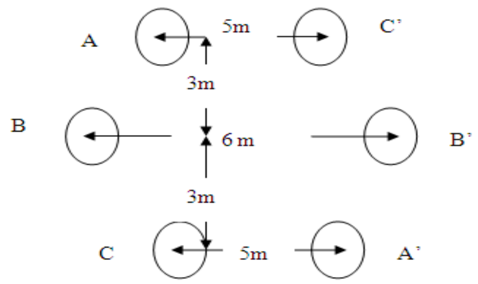
1. Explain the structure of electric power system in detail. **(APRIL 2017, May 2018)**
2. Explain the effects of high voltage on volume of copper and on efficiency. **(Nov 2016)**
3. Explain about skin effect and proximity effect.**(Nov 2013)**
4. (i) Derive an expression to find the loop inductance of single phase overhead transmission line.**(Dec 2015)**

   (ii) Derive the expression for the inductance of each line when the conductors are unsymmetrical placed.
5. (i) A three phase circuit line consists of 7/4.5 mm hard drawn copper conductors. The arrangement of the conductors is shown in figure. The line is completely transposed. Calculate inductive reactance per phase per km of the system. **. (May 2015)**

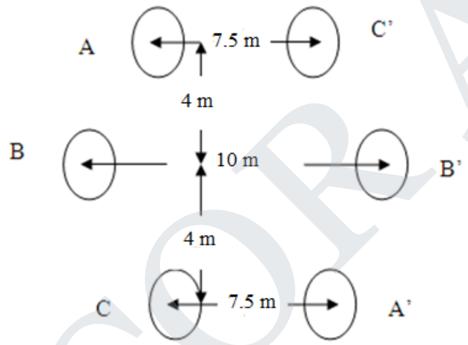


   (ii) Explain about interference between power and communication circuits **(Nov 2013/May 2015)**
6. Find the inductance per Km of a three phase three wire transmission systems consisting of 2 cm diameter conductors spaced 4m apart in horizontal plane. The conductors are regularly transposed. **(May 2012)**

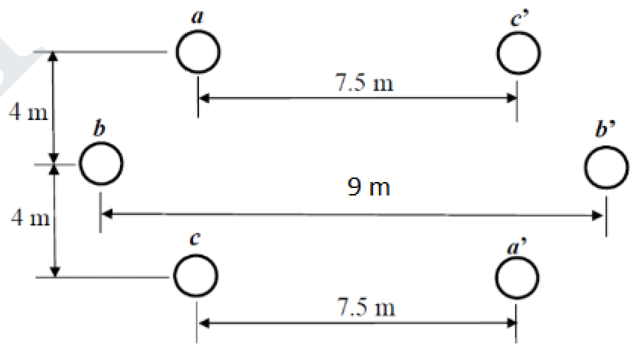
7. (i)Find the inductance per phase per km of double circuit three phase line shown in fig. The line is completely transposed and operated at a frequency of 50 Hz. r =6mm.**(Nov 2011)**



(ii)Determine the inductance per km of a double circuit 3 phase line as shown in Fig. The transmission line is transposed within each circuit and each circuit remains on its own side. The diameter of each conductor is 15mm.**(May 2016)**



8. Determine the inductance per km of a transposed double circuit 3-phase line shown in fig below. Each circuit of the line remains on its own side. The diameter of the conductor is 2.532 cm. **(April 2019)**



9. Find the capacitance between the conductors of a single phase 10 Km long line. The diameter of each conductor is 1.213cm. The spacing between the conductors is 1.25m. **(May 2012)**

10. Derive an expression for capacitance of three phase unsymmetrically spaced but completely transposed conductors. **(Nov 2012, Nov 2013, Dec 2014,Dec 2015,May 2016)**

11. Derive the capacitance of a three phase overhead line for symmetrical and unsymmetrical spacing.**(Nov 2018)**

12. Determine the capacitance and charging current per unit length of the line when the arrangement of the conductor is shown in below figure. The line is completely transposed and diameter is 15mm and operating voltage is 220 kV.

13. (i) 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 line consisting of m-strands in one conductors and n-strands in the other conductor.

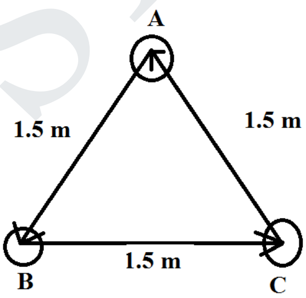
(ii) Explain the concept of self GMD and mutual GMD for evaluating inductance of transmission line.

14. Derive the expressions for inductance of a three phase transmission line with unsymmetrical spacing. **(Nov 2016)**

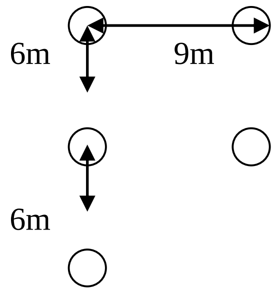
15. A 220kV, 50 Hz, 200 Km long transposed three phase line has its conductors on the corners of the triangle with sides 6m, 6m and 10m. The conductor radius is 1.81 cm. Find the capacitance per phase per km of the line. **(Nov 2016)**

16. Explain the advantages of bundled conductors when used for overhead lines.**(APRIL 2017)**

17. Determine the inductance of a three phase line operating at 50Hz and the conductors are arranged as shown below. The conductor diameter is 0.7 cm. **(APRIL 2017)**



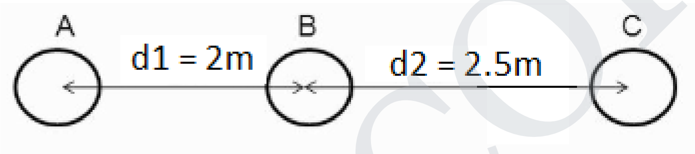
18. Determine the inductance of a single phase transmission line consisting of three conductors of 2.5 mm radii in the 'go' conductor and two conductors of 5 mm radii in the return conductor. The configuration of the line is as shown in figure below. **(May 2018)**



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

20. Derive the inductance of single phase two wire line and three phase overhead line. **(Nov 2018)**

21. A 3-phase. 50 Hz, 66 kV overhead line conductors are placed in a horizontal plane as shown in Fig. The conductor diameter is 1·25 cm. If the line length is 100 km, calculate (i) capacitance per phase, (ii) charging current per phase, assuming complete transposition of the line.**(April 2019)**



UNIT II MODELLING AND PERFORMANCE OF TRANSMISSION LINES

PART A

1. **Give the lengthwise classification of transmission lines.**

Transmission lines are classified as short transmission lines (length <80 km),medium transmission lines (80km<length < 250km), long transmission lines (length > 250 km)

2. **Define regulation of a transmission line. (Nov 2012,Nov 2013,May 2014)**

Regulation of a transmission line is defined as the change in voltage at the receiving end when full load is thrown off the sending end voltage remaining the same. It is usually expressed as a percentage of receiving end voltage. $\%\text{Regulation} = \frac{V_R^{'} - V_R}{V_R} X100.$

Where $V_R^{'}$ - no load voltage at the receiving end, V_R- receiving end voltage.

3. Define transmission efficiency.(Dec 2015)

Efficiency of a transmission line is defined as the ratio of power received to the power sent. $\eta = \frac{\text{Power delivered}}{\text{Power sent out}} X100 = \frac{V_R I_R \cos\varphi_R}{V_S I_S \cos\varphi_S} X100$. Where V_R, I_R, $\cos\Phi_R$ are the receiving end voltage, current and power factor respectively. V_s, I_s, $\cos\Phi_s$ are the sending end voltage, current and power factor respectively.

4. Explain the influence of power factor on the regulation of a transmission line.

(i) When the load power factor ($\cos\Phi_R$) is lagging or unity or leading that $IR\cos\Phi_R > IX_L \sin\Phi_R$ then voltage regulation is positive (receiving end voltage is lesser than the sending end voltage) and increases with the decrease in power factor for lagging loads (for a given V_R and I).

(ii) When the load PF is leading to this extent that $IR \cos\Phi_R < IX_L \sin\Phi_R$ the voltage regulation is negative and decreases with the decrease in power factor for leading loads (for a given V_R and I)

5. Under what circumstances, the receiving end voltage may be higher than that of the sending end?

When load power factor $\cos\Phi_R$ is leading, $IX_L \sin\Phi_R > IR \cos\Phi_R$ then regulation is negative (i.e.). The receiving end voltage may be higher than that of the sending end. Where I – load current,X_L -loop reactance, $\cos\Phi_R$ - receiving end power factor(leading)

6. Explain how capacitance effects are taken into account in medium transmission lines.

Medium transmission lines have sufficient length (80-250km) and operate at voltages greater than 20KV. In such lines the capacitive current is appreciable and hence cannot be neglected. So to obtain reasonable accuracy the effects of capacitance must be taken into account.

7. Mention the Significance of surge impedance loading.(May 2016)

The Significance of surge impedance loading is,

(i)To identify the maximum power transfer capability.

(ii) To analyse the system stability

8. What is surge impedance? Write the formula for finding surge impedance of transmission line. (Dec 2015)

The square root of the ration of line impedance (Z) and shunt admittance (Y) is called the surge impedance (Z_C) of the line.

Surge impedance $Z_C = \sqrt{\frac{Z}{Y}}$

9. What are the limitations of nominal T and Π methods in transmission lines problems?

Generally the capacitance is uniformly distributed over the entire length of the line. But for easy calculations in nominal T and Π the capacitance is concentrated at one or two points also in nominal Π method the capacitance connected in the load side has no effect on voltage drop. Due to all these there may be considerable error in calculation.

10. How the capacitance effects are taken into account in a long transmission line?

Long transmission lines have sufficient length and operate at voltage higher than 100KV the effects of capacitance cannot be neglected. Therefore in order to obtain reasonable accuracy in long transmission lines calculations, the capacitance effects must be taken into account.

11. Define surge impedance loading or natural power loading of the line?(Dec 2014)

Surge impedance loading of the line is the maximum power transmitted when a lossless line operating at its nominal voltage, is terminated with resistance equal to surge impedance of the line. $P_{SIL} = \frac{V_{RL}^2}{Z_o}$; where V_{RL}^2 -line voltage at the receiving end, Z_o-surge impedance in ohms, P_{SIL}-surge impedance loading.

12. What is the difference between nominal T and nominal Π configuration?(MAY 2014)

S.NO	**Nominal T**	**Nominal Π**
1.	In this the whole line capacitance is assumed to be concentrated at the middle point of the line and half the line resistance and reactance are lumped on its either side	In this the whole line capacitance is assumed to be divided into two halves, one half being connected at the receiving end and other half at the receiving end.
2.	Full charging current flows over half the line	Capacitance at the receiving end has no effect on the line drop. But the charging current of the second half capacitance is added to obtain the total sending current

13. What are the ABCD constants and give its units?

ABCD constants are generalized circuit constants of a transmission line. They are usually complex numbers. Input voltage and current are expressed in terms of output voltage and current. The constants A and D are dimensionless B and C are ohms and mhos respectively.

14. What is a power circle diagram?(Nov 2018)

A power circle diagram is a diagram drawn for the transmission line network involving the generalized circuit constants and the sending end voltage V_S and receiving end voltage V_R. It is used to determine the maximum power that can be transmitted over the line both at the receiving and the sending end.

15. Define attenuation in a transmission lines?

Attenuation is defined as the power loss in line. It is nothing but the transmission loss (i.e.). The difference between the sending end power and receiving end power.

16. Define visual critical voltage.

Visual critical voltage is defined as the min. phase neutral voltage at which corona glow appears all along the line conductors.

It has been seen that in case of parallel conductors, the corona glow does not begin at the disruptive voltage V_c but at a higher voltage V_v , called **visual critical voltage**.

17. Write an expression for the power loss due to corona.

$P = 242.2\left(\frac{f+25}{\delta}\right)\sqrt{\frac{r}{d}}(V - V_C)^2 X10^{-5}$ KW/km/ph. Where f - supply frequency Hz, V – phase to neutral r.m.s voltage in KV, V_c – critical disruptive voltage (r.m.s) per phase, δ – air density factor, r – radius of the conductor in meters d – spacing between conductors in meters.

18. What are the voltages regulating equipments used in transmission system?

Synchronous motors, tap changing transformers, series shut capacitors, booster transformers, compound generators, induction regulator.

19. Distinguish between attenuation and phase constant.(Nov 2011)

Characteristics impedance $Z_C = \sqrt{Z/Y}$, Propagation constant $\gamma = \sqrt{ZY} = \alpha + j\beta$.

α–attenuation constant, β – phase constant.

α = Attenuation constant, it causes the signal amplitude to decrease while propagating through a transmission line.

β = Phase constant, it is the imaginary component of the propagation constant. It gives us the phase of the signal along a transmission line, at a constant time.

20. What is Ferranti effect?(Nov 2011,Nov 2013,May 2015,May 2016) (May 2018)

The effect in which the voltage at the receiving end of the transmission line is more than the sending voltage is known as the Ferranti effect. Such type of effect mainly occurs because of light load or open circuit at the receiving end.

21. What are the factors limiting power transfer capability?

a) Thermal loading unit b) stability limit c) voltage drop limit.

22. What is sending end power circle diagram and receiving end power circle diagram?

The circle drawn with sending end true and reactive power as the horizontal and vertical co-ordinates are called sending end power circle diagram. The circle drawn with receiving end values are called receiving end power circle diagram.

23. What is the range of surge impedance in a underground cable?(Nov 2012)

Surge impedance can be defined as the input impedance of a transmission line when its length is infinite. The range of surge impedance in a underground cable is 40 to 60Ω.

24. What is the importance of voltage control?(May 2015)

When the load on the supply system changes, the voltage at the consumer's terminals also changes. The variation of voltage at consumer's terminals are undesirable and must be kept within prescribed limits.

25. Define critical disruptive voltage.

Critical Disruptive Voltage is defined as the minimum phase to neutral voltage required for the Corona discharge to start. Basically corona discharge is the current discharge in the air. Therefore it is quite obvious that surrounding air shall breakdown for corona to start.

26. Why the control of reactive power is essential for maintaining a desired voltage profile?(Dec 2014)

$$\Delta V = \sqrt{(Q_C - Q_L) \times X_L}$$

Voltage drop in the system is directly proportional to the difference in capacitive and inductive reactive power. Hence reactive power should be controlled to improve the system stability and efficiency.

27. What is corona?(May 2016/Nov 2018)

Corona discharge can cause an audible hissing or cracking noise as it ionizes the air around the conductors. This is common in high voltage electric power transmission lines. The phenomenon of violet glow, hissing noise and production of ozone gas around the conductor, radio interference, and electrical power loss in an overhead transmission line is known as corona.

28. Why should the reactive power transfer in transmission lines be minimized? (Nov 2018)

Reactive power consumes transmission and generation resources. To maximize the amount of real power that can be transferred across a congested transmission interface, reactive-power flows must be minimized. Similarly, reactive-power production can limit a generator's real-power capability.

29. What is the effect of leading load power factor on voltage regulation of a short transmission line? (APRIL 2019)

Percentage voltage regulation = $\frac{IR\cos\phi_R - IX_L\sin\phi_R}{V_R} * 100$ (for leading pf)

- When the load PF is leading to this extent that IR $\cos\Phi_R < IX_L \sin\Phi_R$ the voltage regulation is negative and decreases with the decrease in power factor for leading loads (for a given V_R and I).
- For a given V_R and I, the voltage regulation of the line decreases with the decrease in p.f. for leading loads.

30. What are disadvantages of corona? (APRIL 2019)

- Corona is accompanied by a loss of energy. Due to this power loss, the transmission efficiency reduces.
- There is a non-sinusoidal voltage drop due to non-sinusoidal corona current and these may cause some interference with neighbouring communication circuits due to electromagnetic and electrostatic induction effects.
- Owing to the formation of corona, ozone gas is produced which chemically reacts with the conductor and causes corrosion.

PART B

1. Deduce the expression for (a) %regulation (b) ABCD parameters of a medium transmission line represented in nominal π and nominal T configuration. **(Dec 2015)**

2. A balanced three phase load of 30MW is supplied at 132KV, 50Hz and 0.85p.f. lagging by means of a transmission line. The series impedance of a single conductor is (20+j52)Ω and the total phase-neutral admittance is 315×10^{-6}Siemen. Using nominal T method, Determine i) A, B, C and D constants of the line (ii) sending end voltage (iii) regulation of the line.**(Nov 2011, May 2015)**
3. A 3phase, 50 Hz, 100km line has the following constants. Resistance/ph/km = 0.153 ohm, inductance/ph/km = 1.21 m, Capacitance/ph/km = 0.00958µF. If the line supplies a load of 20 MW at 0.9 pf lagging at 100Kv at the receiving end calculate the sending end current, sending end power factor, regulation and transmission efficiency using nominal T method.**(May 2016)**
4. (i)Explain the real and reactive power flow in transmission line.

   (ii) Show that real power transferred is dependent on the power angle and the reactive power transferred is dependent on the voltage drop in the line **(Dec 2015)**
5. (i) Perform the analysis of long transmission lines using RIGOROUS method.(OR) Derive the sending end current and voltage for a long transmission line with necessary diagram.**(Nov 2018)**

   (ii) Explain the concept of surge impedance loading. **(Nov 2012, Nov 2013, May 2018)**
6. Explain the various factors affecting the corona loss and state its advantages and disadvantages. **(Nov 2011)**
7. Explain the method of drawing receiving end power circle diagrams.**(May 2014)**
8. The constants of a 3 phase line are $A=0.9\angle 2^0$ and $B=140\angle 70^0$ ohms per phase. The line delivers 60 MVA at 132Kv and 0.8 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.**(May 2016)**
9. A three phase, 50 Hz transmission line, 40 Km long delivers 36 MW at 0.8 power factor lagging at 60KV (phase). The line constants per conductor are, R = 2.5Ω, L = 0.1H, C = 0.25µF. Shunt leakage may be neglected. Determine the voltage, current, power factor, active power and reactive volt-amperes at the sending end. Also determine the efficiency and regulation of the line using nominal π method. **(Nov 2013)**
10. A 3 phase overhead transmission line has a series impedance of (10+j30)Ω per phase. For receiving and sending end voltages of 132 kV and 140 kV respectively. Draw the receiving and power circle diagram and determine the following:

(i) The maximum real power delivered by the line and load power factor under that condition.

(ii) The capacity of shunt compensation equipment for supplying a load of 150MVA at 0.8 power factor lagging and the power angle under that condition.

(iii) The capacity of shunt compensation equipment to maintain the above voltage under no- load condition.

(iv) The unity power factor load that the line can supply with voltages at above values.**(Dec 2014)**

11. (i) Explain the classification of transmission lines with their characteristics **(Dec 2014)**

(ii) Define the following (a)Surge impedance. (b) Attenuation constant. (c) Voltage regulation. (d)Transmission efficiency.

12. A 50 Hz,3 phase transmission 30 Km long has a total series impedance of (40+j125)Ω and shunt admittances of 10^{-3} mho. The load is 50 Mw at 220Kv with 0.8 Pf lag. Find the sending end voltage, current, power factor, efficiency and regulation using nominal π-method. **(Nov 2016)**

13. Derive the expressions for the real and reactive power flow through transmission lines.**(Nov 2016)**

14. Explain the meaning of performance of lines. **(APRIL 2017)**

15. A single phase 50 Hz generator supplies an inductive load of 6 MW at 0.8 Pf lagging by means of an overhead line 15 km long. The line resistance and inductance are 0.02 ohm/km and 0.85 mH/km. The voltage at the receiving end is 11 kV. Determine the sending end voltage and voltage regulation. **(APRIL 2017)**

16. Estimate the corona loss for a three-phase, 110KV,50Hz and 150Km long transmission line consisting of three conductors each of 10mm diameter and spaced 2.5m apart in a equilateral triangle formation. The temperature of air is 30°C and the atmospheric pressure is 750mm of mercury. Assume the irregularity factor as 0.85. Ionization of air may be assumed to take place at a maximum voltage gradient of 30KV/cm**. (May 2014)**

17. Explain the flowing with respect to corona (i) corona (ii) effects (iii) disruptive critical voltage (iv) visual critical voltage (v) corona power loss. **(Nov 2012, Nov 2011, Nov 2012 May 2015)**

18. Explain the formation of corona, critical voltages, corona loss, advantage, disadvantages and methods to reduce the effect of corona. **(Nov 2016)**

19. Explain the factors affecting corona loss and methods of reducing corona loss. **(APRIL 2017) (May 2018)**

20. Determine the efficiency and regulation of a 3-phase, 100km, 50Hz transmission line delivering 20 MW at a p.f of 0.8 lagging and 66kV 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 micro farad per km. Neglect leakage and use nominal pi method. **(May 2018)**

21. Derive voltage regulation, power factor and transmission efficiency of short transmission line with necessary diagram. **(Nov 2018)**

22. A 3-phase, 50 Hz transmission line 100 km long delivers 20 MW at 0·9 p.f. lagging and at 110 kV. The resistance and reactance of the line per phase per km are 0·2 Ω and 0·4 Ω respectively, while capacitance admittance is $2{\cdot}5 \times 10^{-6}$ siemen/km/phase. Calculate : (i) the current and voltage at the sending end (ii) efficiency of transmission. Use nominal T method. **(April 2019)**

23. (i) A 275 kV transmission line has the following line constants: A = 0.85∟5° and B = ∟75°. Determine the power at unity power factor that can be received if the voltage profile at each end is to be maintained at 275 kV.
(ii)Determine the factors affecting corona. **(April 2019)**

UNIT III MECHANICAL DESIGN OF LINES

PART A

1. What is the reason for the sag in the transmission line?

While erecting the line, if the conductors are stretched too much between supports then there prevails an excessive tension on the line which may break the conductor. In order to have safe tension in the conductor a sag in the line is allowed.

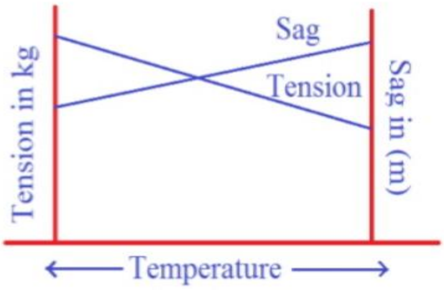
2. What are the factors on which conductor spacing and ground clearance depend? (OR) Give any two factors that affect sag in an overhead line. (Dec 2014) (Nov 2012)

The factors on which conductor spacing and ground clearance depend are,

- Factors are Conductor weight,
- Temperature variations,
- Effect of wind and Ice loading

3. **What is meant by string chart? (Nov 2011,May 2016)**

For use in the field work of stringing the conductors, temperature-sag and temperature tension charts are plotted for the given conductor and loading conditions. Such curves are called stringing charts The curves of tension and sag vs. temperature is called string chart.



4. **What are the materials mainly used in bus bars? (May 2015)**

The materials mainly used in bus bars are,

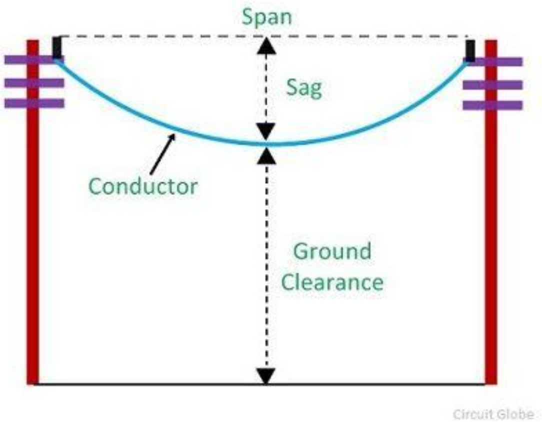
(i) Aluminum (ii) copper (iii) tin (iv) silver

5. **Explain the term "sag of a line".(Nov 2018)**

While erecting an overhead line, it is very important that conductors are under safe tension. If the conductors are too much stretched between supports in a bid to save conductor material, the stress in the conductor may reach unsafe value and in certain cases the conductor may break due to excessive tension. In order to permit safe tension in the conductors, they are not fully stretched but are allowed to have a dip or sag. The difference in level between points of supports and the lowest point on the conductor is called sag.

6. **What is meant by sag? (Nov 2013,May 2016)**

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



7. What is sag template?(May 2014,Dec 2015, May 2018)

There are two types of supports being used. They are straight and angle tower. While the straight run towers are used for straight runs and normal conditions, the angle towers are used at angles, terminals and other points where a considerable amount of unbalanced pull may be thrown on the supports. The angle towers are therefore designed to withstand heavy loadings as compared to standard towers. Sag template is used to locate and design the angle tower in compare with straight run tower.

8. What is meant by tower spotting? (Dec 2015)

The efficient location of structures on the profile is an important component of line design. Structures of appropriate height and strength must be located to provide adequate conductor ground clearance and minimum cost. In the past, most tower spotting has been done manually, using templates, but several computer programs have been available for a number of years for the same purpose.

9. What are the advantages of string insulators?(Nov 2011)

(i) Number of units can be increased. (ii) Replacement of fault insulator unit is possible. (iii) Low tension due to its swinging

10. Give the relation for the insulation resistance of a cable. (Nov 2013)

The relation for the insulation resistance of a cable is given by,

$R = \frac{\rho}{2\pi l} \log_e \frac{r2}{r1};$ where,

ρ= resistivity, l= length of the cable, a= area. r1 - conductor radius $r1$ and r2 - internal sheath radius

11. What is shackle insulator?(May 2014)

Shackle Insulators are frequently used for low voltage distribution line. It can be used either in a horizontal or in a vertical position. They can be directly fixed to the pole with a bolt or to the cross arm. The conductor in the groove is fixed with a soft binding wire.

12. Define creepage distance.

Creepage distance is the shortest distance on the contour of the external surface of the insulator unit or between two metal fittings on the insulator.

13. Define disruptive discharge voltage.

This is defined as the voltage which produces the loss of dielectric strength of insulation. It is that voltage at which the electrical stress in the insulation causes a failure which includes the collapse of voltage and passage of current.

14. How does the grading improve the string efficiency?(Nov 2013)

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 ths string in such a way that the top unit has minimum capacitance, increasing progressively as the bottom unit is reached. Since voltage is inversely proportional to capacitance, this method tends to equalize the potential distribution across the units in the string.

15. What is the purpose of insulator?(May 2015, May 2018)

Insulators are used in electrical equipment to support and separate electrical conductors without allowing current through themselves.

Insulators provide necessary insulation between line conductors and supports and thus prevent any leakage current from conductors to earth.

16. What are the factors to be considered while selecting a cable for a particular service?(Dec 2014)

The factors to be considered while selecting a cable for a particular service are,

(i) Type of insulating material (ii) voltage (iii) Current Carrying Capacity

(iv) Derating Factor (v) Short circuit Withstand (vi) Bending Radius.

17. What are the causes for the failure of insulators?

The causes for the failure of insulators are,

(a) Cracking of insulators (b) Short circuit (c) Porosity of materials (d) Improper glaze

(e) Flash over (f) Mechanical stress

18. Define string efficiency. (Dec 2015)

The string efficiency is defined as the ratio of total voltage across the string to the product of number of units and the voltage across the unit adjacent to the line conductor

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

19. What are the tests performed on insulators ?(May 2016)

a) Flashover tests
   - Power frequency dry flashover test
   - Power frequency wet flashover test
   - Impulse frequency flashover test

b) Performance tests
   - Temperature cycle test
   - Puncture voltage test
   - Mechanical strength test
   - Electro-mechanical test
   - Porosity test

c) Routine tests
   - High voltage test
   - Proof load test
   - Corrosion test

20. What is the purpose of insulation in a cable?(May 2015)

The insulation or dielectric withstands the service voltage and isolates the conductor with other objects. Cable and wire insulation prevents the insulated wire's current from coming into contact with other conductors. It preserves the wire material against environmental threats and resists electrical leakage.

21. List the advantages of polythene insulators?(Nov 2018)

- Polyethylene has many useful properties which make it suitable for several applications. It has low strength and hardness, but is very ductile and has good impact strength; it will stretch rather than break.
- Polyethylene is water resistant and durable, so it is longer lasting when exposed to the elements compared to other polymers.

22. Why are insulators used with overhead lines?(Nov 2018)

The overhead line conductors should be supported on the poles or towers in such a way that currents from conductors do not flow to earth through supports i.e., line conductors must be properly insulated from supports. This is achieved by securing line conductors to supports with the help of insulators. The insulators provide necessary insulation between line conductors and supports and thus prevent any leakage current from conductors to earth.

Thus the over head line insulators play an important part in the successful operation of power system.

23. What are types of line supports used in transmission and distribution systems?(APRIL 2019)

The line support used for transmission and distribution of electric power are of various types including wooden poles, steel poles, R.C.C. poles and lattice steel towers. The choice of supporting structure for a particular case depends upon the line span, X-sectional area, line voltage, cost and local conditions.

24. What are the factors affecting the sag in the transmission line? (APRIL 2019)

The factors affecting the sag in the transmission line are,

- **Conductor weight** – Sag of the conductor is directly proportional to its weight. The weight of the conductors is increased due to ice loading.
- **Span** – Sag is directly proportional to the square of the span length. Longer span gives more sag.
- **Tension** -The sag is inversely proportional to the tension in the conductor. Higher tension increases the stress in the insulators and supporting structures.
- **Wind** – It increases sag in the inclined direction.
- **Temperature** – The sag is reduced at low temperatures and is increases at higher temperatures.

PART B

1. (i) Explain the testing methods for insulators.

(ii) Find the economic size of a single core cable working on a 132 kV three phase systems, if a dielectric stress of 60 kV /cm can be allowed **(Dec 2015)**

2. (i) Explain the different methods of improving the string efficiency. **(Nov 2012,May 2016)**

(ii) A three unit insulator string is fitted with a guard ring. The capacitance 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 the voltage distribution and string efficiency.**(May 2016)**

3. (i) Why are insulators used with overhead lines? Discuss the desirable properties of insulators.

(ii) An insulator string for 66KV lines 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 disc and string efficiency.**(Nov 2013)**

4. (i)What are the properties of insulators? Also briefly explain about pin and suspension type insulators. Draw the schematic diagram **(May 2015, Dec 2014, May 2018)**

(ii)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.**(Dec 2015)**

5. Each line of 3 phase system is suspended by a string of three 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 guard ring increases the capacitance to the line if metal work of the lowest insulators to 0.3 C. **(Dec 2014)**

6. (i) 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

   (ii) Explain the role of static shielding in insulators **(Dec 2015)**
7. Explain the different types of insulators.**(Nov 2016)**
8. 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. **(Nov 2016)**
9. What are the different types of testing of insulators? Explain any one method.**(APRIL 2017)**
10. Write short notes on:

    (i) Properties of insulation material used for cable.

    (ii) The capacitance per km of a three phase belted core cable is 0.2 μF/km between two cores with the third core connected to sheath. Calculate the KVA. The supply voltage is 6.6 kV and 30 km long. **(APRIL 2017)**
11. Deduce an approximate expression for sag in overhead lines when (i) supports are at equal levels. (ii) Supports are at unequal levels. Analyze with and without the effect of ice loading and wind. **(Nov 2012, Nov 2013, Nov 2018)**
12. An overhead line has a span of 160m of stranded copper conductor between level supports. The sag is 3.96m at -5.5°C with 9.53mm thick in ice coating and wind pressure of 40Kgf/m^2 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 the conductor=7/3.45mm, Area of cross section= 64.5 mm^2, weight of conductor =0.594 Kgf/m, Modulus of elasticity = 12700 Kgf/mm^2, Coefficient of linear expansion = $1.7x10^{-5}$/°C, Assume 1m^3 of ice to weight of 913.5 Kgf.**(May 2014)**
13. Assume that the shape of an overhead line can be approximated by a parabola, deduce expressions for calculating sag and conductor length. How can the effect of wind and ice loading be taken into account?**(Dec 2015)**
14. The towers of height 30 m and 90 m respectively support a transmission line conductor at water crossing. The horizontal distance between the towers is 500 m.

If the tension in the conductor is 1600 kg, find the minimum clearance of the conductor and water and clearance mid-way between the supports. Weight of conductor is 1·5 kg/m. Bases of the towers can be considered to be at water level. **(April 2019).**

15. Each line of a 3-phase system is suspended by a string of 3 similar insulators. If the voltage across the line unit is 17·5 kV, calculate the line to neutral voltage. Assume that the shunt capacitance between each insulator and earth is 1/8th of the capacitance of the insulator itself. Also find the string efficiency. **(April 2019)**

UNIT IV UNDER GROUND CABLES

PART A

1. **Why and where corrugated seamless aluminum sheath is used in cables?**

   It is used because it is very flexible and easily by repeated bending the sheath is not distorted and it is not damaged. It has lesser weight and reduced thickness. It is used in high voltage oil filled cables and telephone lines.

2. **What is meant by serving of a cable?**

   Layers of fibrous material permitted with water proof compound applied to the exterior of the cable is called serving of a cable.

3. **Why armoring is done in the cables? and why it is not done in single core cable(May 2015)**

   (i) To protect the sheath from mechanical damage armouring is done.

   (ii) The presence of magnetic material within the alternating magnetic field of a single core cable produces excessive losses. Hence single core cables are left unarmored with non-magnetic materials like tin-bronze or silicon-bronze tapes or wires.

4. **What is meant by grading of cables? (Nov 2012)**

   Grading of cable is the process of achieving uniform distribution of dielectric stress or voltage gradient in a dielectric of cable. Voltage gradient or dielectric stress is maximum at the surface of the conductor and minimum at the inner surface of a sheath.The method of equalizing the stress in the dielectric of the cable is called the grading of cables.

5. **Why the capacitance of the cable is very high than the capacitance of the overheadlines?**

   The distances between the conductors are small. The distance between the cores and the earthed sheath is also small. The permittivity of the cable insulation is 3 to 5 times greater than that of air insulation.

6. **Why the working voltage level of belted cables is limited to 22 KV?**

   It is limited because beyond 22 KV tangential stresses acting along the layers of paper insulation set up large current. These current causes local heating resulting in the risk of breakdown insulation at any moment.

7. **What is the function of sheath in a cable?**

   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. **Define the segmental conductors.**

   The stranded wires which are compacted by the rollers to minimize the air spaces between the individual wires are called segmented conductors .Here the conductor size is reduced for a given conductance.

9. **Mention the commonly used power cables.**

   Commonly used power cables are belted cables, screened cables, pressure cables, oil filled cables, gas pressure cables.

10. **What are the methods of grading of cables? (Nov 2011)**

    The process of achieving uniform electrostatic stress in dielectric of the cable is called grading of cable. Various types of grading are,

    - Capacitance grading
    - Inter sheath grading.

11. **What is meant by dielectric stress in a cable? (May 2014)**

    Under operating conditions, the insulation of a cable is subjected to electrostatic forces. This is known as dielectric stress. The dielectric stress at any point in a cable is in fact the potential gradient (or Electric field intensity) at that point.

12. **Classify the cables used for three phase service.(May 2016)**

    (i) Belted cables – upto 11kV (ii) Screened cables – from 22 kV to 66 kV (iii) Pressure cables – beyond 66 kV.

13. **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**

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

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

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

$$D = 5\ cm$$

$$R = \frac{4.5 \times 10^4}{2\pi \times 100000} \ln \frac{5}{2.5}, R = 496\ Mohm$$

14. 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

15. 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

16. A single core cable, 1.7km long has a conductor radius of 13mm and an insulation thickness of 5.8mm. The dielectric has a relative permittivity of 2.8. Find the capacitance per meter length of cable. (Dec 2015)

$C = \frac{2\pi\varepsilon_0\varepsilon_r}{\ln(R/r)}$. F/m ; R =(13+5.8)*$10^{-3}$ = 18.8*10^{-3} ; r = 13*10^{-3} m

C = 4.5*10^{-10} F/m ; For 1.7 km long C = 4.5*10^{-10}*1.7*1000 =7.65*10^{-7} F/phase.

17. What are the desirable characteristics of insulating materials used in cables? (Nov 2017, APRIL 2019)

The desirable characteristics of insulating materials used in cables are,

(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-inflammable.

(v) Low cost so as to make the underground system a viable proposition.

(vi) Unaffected by acids and alkalies to avoid any chemical action.

18. What are sources of heat generation in an underground cable? (APRIL 2019)

The sources of heat generation in an underground cable are,

- Copper loss in conductor
- Dielectric losses in cable insulation
- Losses in metallic sheathings and armoring

PART B

1. Derive the expression for the insulation resistance , capacitance and electrostatic stress of a single core cable.**(Dec 2014, May 2018)**

2. Explain the methods grading of cables with neat diagrams and equations.(OR) What is grading of cables Explain the following methods of grading of cables.(i) Capacitance grading (ii)Intersheath grading. **(May 2014,May 2016, Nov 2018, April 2019)**

3. (i) A single core cable has a conductor diameter of 1 cm and insulation thickness of 0.4 cm. If the specific resistance of insulation is $5x10^{14}$ ohm-cm. Calculate the insulation resistance for a 2 Km length of the cable.**(April 2019)**

(ii) The insulation resistance of the single core cable is 495 Mega-ohms per Km. If the core diameter is 2.5 cm and the resistivity of insulation is 4.5 x 10^{14} ohm-cm. Find the insulation thickness.**(Nov 2018)**

4. With neat diagrams explain constructional features of various types of cables.**(Nov 2011, Nov 2012)**

5. (i) Describe on experiment to determine capacitance of belted cable

(ii)A 33KV single core cable has a conductor diameter of 1cm and a sheath of inside diameter 4 cm. Find the min and max stress in the insulator.**(Nov 2013)**.

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

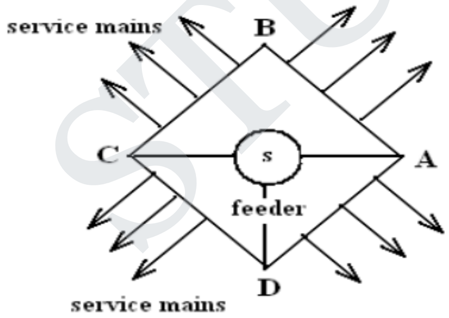
- **i.** Capacitance between phases
- **ii.** Capacitance between the conductor and the sheath
- **iii.** Effective per phase capacitance
- **iv.** Capacitance between two conductors connecting a third conductor to the sheath
- **v.** Charging current if the supply voltage is 11kV, 50Hz. **(Nov 2016)**

7. In a 33kV 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 **(May 2018)**
8. A single core cable has a conductor diameter of 1 cm 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. **(May 2018)**
9. Explain the different cables used for three phase system. **(Nov 2018).**
10. A 33kV, 50Hz, 3phase underground cable, 4km 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 2018).**
11. A conductor of 1 cm diameter passes centrally through a porcelain cylinder of internal diameter 2 cm and external diameter 7 cm. The cylinder is surrounded by a tightly fitting metal sheath. The permittivity of porcelain is 5 and the peak voltage gradient in air must not exceed 34 kV/cm. Determine the safe working voltage. **(April 2019)**

UNIT V - DISTRIBUTION SYSTEMS

PART A

1. **Draw the structure of distribution system.**



2. **What is a feeder? (Nov 2012,Dec 2015)**

   Feeder is a conductor or transmission line which transmits current from the generating stations to different distributing substations.

3. Distinguish between a feeder and a distributor.(May 2015)

S.NO	Feeder	Distributor
1.	Feeders are conductors or transmission lines which carry current from the stations to the feeding points.	Feeders terminate into distributors
2.	No tapping is taken from the feeders.	Distributor is also a conductor from which current is tapped off for the supply to the consumer.
3.	Current carrying capacity plays a major role in designing a feeder.	Whereas voltage drop plays a major role in designing a distributor.
4.	Current loading remains the same along its length.	Current loading factor varies along its length.

4. What are the demerits of HVDC transmission?

(i)Electric power cannot be generated at high DC voltages (ii) The DC voltages cannot be stepped up for transmission of power at high voltages. (iii) The converters produce a lot of harmonics which may cause interference with communication lines requiring filters which increases the cost (iv) Circuit breaking for multi-terminal line is difficult

5. What are the disadvantages high voltage AC transmissions?

(i) An AC line requires more copper than a dc line (ii) The construction of an AC line is more complicated than a DC transmission line. (iii) The cost of transformers, switchgear equipments and protective equipments increases with increase in transmission line voltage. (iv) It generates electrostatic effects which are harmful to human beings and animals.

6. What are terminal equipments necessary in HVDC system?

The terminal equipments necessary in HVDC system are converters, inverters mercury arc valves, thyristors etc.

7. What is ring main distributor?(Nov 2012)

In this system, primaries of distribution transformer form a loop. The loop starts from the substation bus bars, makes a loop through the area to be served, and returns to the substation

8. Give the reason why transmission line are three phase three wire circuits and distribution lines are three phase four wire circuits?(Nov 2013)

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

9. How does a.c. distribution differ from d.c. distribution?(Dec 2014)

AC distribution system does not need any conversion equipment before distribution and it requires three wire system for 3 phase and 2 wire system for single phase whereas d.c distribution requires only two wire system

10. What are the advantages of high voltage power transmission?(May 2015,Dec 2015,May 2016)

Electrical power is transmitted at high voltage because (i) It reduces the volume of conductor material used. (ii) It increases transmission efficiency. (iii) It improves power transfer capability. (iv) Economical for bulk transmission of power.

11. Name the different types of dc distributor.

(a)Distributor fed at one end (b) Distributor fed at both ends (c) Distributor fed at the centre (d) Ring distributor.

12. State the disadvantages of radial system.

(a)The end of distributor nearest to the feeding point will be heavily loaded. (b) The customer at the farthest end of the distributor would be subjected to serious voltage fluctuation with the variation in load. (c) The customers are dependent on a single feeder and single distributor.

13. What is a substation?

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

14. State the various types of substation according to its service requirements.(May 2015)

The various types of substation according to its service requirements are, (i)Transformer substation, (ii) Switching substation.(iii) Power factor correction sub-stations (iv) Frequency changer sub-stations (v) Converting sub-stations (vi) Industrial sub-stations.

15. List the types of substations classified according to its construction.

The types of substations classified according to its construction are, (i)Indoor substation, (ii) Outdoor substation, (iii) Pole mounted substation (iv) Underground sub-station.

16. Mention any two comparisons between indoor and outdoor substations.

Indoor**:** Space required and clearances between the conductors are less. Time required for erection and possibility of faults are more.

Outdoor**:** Space required and clearances between conductors are more. Time required for erection and possibility of faults are less.

17. What are the major equipments of a substation?(May 2014)

- Instrument Transformers
- Current Transformer
- Potential Transformer
- Conductors
- Insulators
- Isolators
- Busbars
- Lightning Arrestors
- Circuit Breakers
- Relays
- Capacitor Banks
- Batteries
- Wave Trapper
- Switch Yard
- Metering and Indication Instruments
- Equipment for Carrier Current
- Prevention from Surge Voltage
- The Outgoing Feeders

18. Define step potential.

It is the voltage between the feet of a person standing on the floor of the substation with 0.5m spacing between two feet during the flow of earth fault current through the earthing system.

19. Define touch potential.

It is the voltage between the fingers of raised hand touching the faulted structure and the feet of the person standing on the substation floor. The person should not get shocked even if the earth structure is carrying faulted current .i.e touch potential should be very low.

20. What is neutral grounding?

Neutral grounding is connecting the neutral or star point of any electrical equipment (generator, transformer etc) to earth.

21. Define coefficient of earthing.

Coefficient of earthing (C_e)is the ratio which is measured during single phase to ground fault:

C_e = Highest phase to ground voltage of healthy phase / Phase to phase voltage

22. Define resonant frequency.

Resonant frequency is defined as a reactance earthing with selected value of reactance to match with the line to ground capacitance.

23. Mention the disadvantages of ungrounded neutral.

Occurrence of insulation breakdown leading to the heavy phase to phase fault condition. Voltages due to lightning surges do not find path to earth.

24. Enumerate the various methods of neutral grounding.(May 2014).

The methods commonly used for grounding the neutral point of a 3-phase system are :

(*i*) Solid or effective grounding (*ii*) Resistance grounding

(*iii*) Reactance grounding (*iv*) Peterson-coil grounding

25. Give the response of resistance for earth driven rods.

R= $\rho /2\pi l * \ln (2l/d)$, where,l = length of the rod, d = diameter of the rod, ρ =resistivity of the rod.

26. Define the terms feeders and service mains? (Nov 2011)

Feeder is a conductor or transmission line which transmits current from the generating stations to different distributing substations. Conductors which connect consumer's premises with the distributor are called service mains.

27. Mention two significance of neutral grounding.(Nov 2013)

The system voltage during the earth fault depends on neutral earthing. Protection against arcing grounds, unbalanced voltages with respect to earth, protection from lightning.

28. What is the need of an earthing system?(Nov 2013)

(i)To save human life from danger of electrical shock or death by blowing a fuse. (ii) To provide alternative path for the fault current to flow so that it will not endanger the user. (iii) To protect buildings, machinery & appliances under fault conditions i.e. to ensure that all exposed conductive parts do not reach a dangerous potential (iv) To provide safe path to dissipate lightning and short circuit currents. (v) To provide stable platform for operation of sensitive electronic equipment i.e. to maintain the voltage at any part of an electrical system at a known value so as to prevent over current or excessive voltage on the appliances or equipment. (vi) to provide protection against static electricity from friction.

29. What are the objectives of FACTS?(May 2016)

The objectives of FACTS are,

(i)To increase the power transfer capability of the transmission system.

(ii) To keep power flow over designated routes.

30. What are the types of series controller?

(a)Static Synchronous Series Compensators(SSSC)

(b) Thyristor controlled series capacitor (TCSC)

(c) Thyristor switched series capacitor (TSSC)

(d) Thyristor controlled series reactor (TCSR)

(e) Thyristor switched series capacitor (TSSC)

31. What is STATCOM?

Static Synchronous Compensator: It is operated as a shunt connected static VAr compensator whose capacitive or inductive output current can be controlled independent of the AC system voltage.

32. What are the advantages of FACTs controller? (May 2018, APRIL 2019)

FACTS controllers can be utilized to increase the transmission capacity, improve the stability and dynamic behavior or ensure better quality in modern power systems. Their main capabilities are reactive power compensation, voltage control and power flow control.

33. What are the limitations of Kelvin's law? (APRIL 2019)

The limitations of Kelvin's law are,

- It is not easy to estimate the energy loss in the line without actual load curves, which are not available at the time of estimation.
- This law does not take into account several physical factors like safe current density, mechanical strength, corona loss etc.
- The conductor size determined by this law may not always be practicable one because it may be too small for the safe carrying of necessary current.
- Interest and depreciation on the capital outlay cannot be determined accurately.

34. What are the advantages of adopting EHV/UHV for transmission of AC electric power? (Nov 2018)

- As current gets reduced, size and volume of conductor required also reduces for transmitting the same amount of power.
- Voltage drop in line (3IR) reduces and hence voltage regulation of the line is improved.
- Line losses ($3I^2R$) gets reduced which results in the increase in transmission line efficiency.
- The total line cost of per MW per km decreases considerably.

- The operation of EHV AC system is simple, reliable and can be adopted easily.
- The lines can be easily tapped and extended.

35. Why galvanized steel wire is not suitable for EHT lines for the purpose of transmitting large amount of power over long distance? (Nov 2018)

The galvanized steel conductors can be used for extremely long spans or for short line sections exposed to abnormally high stresses due to climatic conditions. They have been found very suitable in rural areas where cheapness is the main consideration. Due to poor conductivity and high resistance of steel, such conductors are not suitable for transmitting large power over a long distance.

PART B

1. (i)Give the advantages, disadvantages and applications of HVDC and HVAC transmission.**(Nov 2012, May 2015, May 2018)**

(ii)What are the various types of HVDC links? Explain them in detail.**(Nov 2011,Nov 2012,May 2016)**

2. (i)Derive suitable expression, draw line current loading diagrams and voltage drop diagrams for uniformly loaded distributor of length '*l*' fed at one end. How is power loss in the whole distributor computed?

(ii)A uniform two wire DC distributor 250m long is loaded with 0.4 A/m and is fed at one end. If the maximum permissible voltage drop is not to exceed 10V, find the cross sectional area of the distributor conductor. Take $\rho = 1.78 \times 10^{-8}$ Ωm **(Dec 2015)**

3. Define FACTS and list and explain its objectives. (ii) explain the basic types of FACTS controllers.**(Nov 2013, Dec 2014,May 2016)**

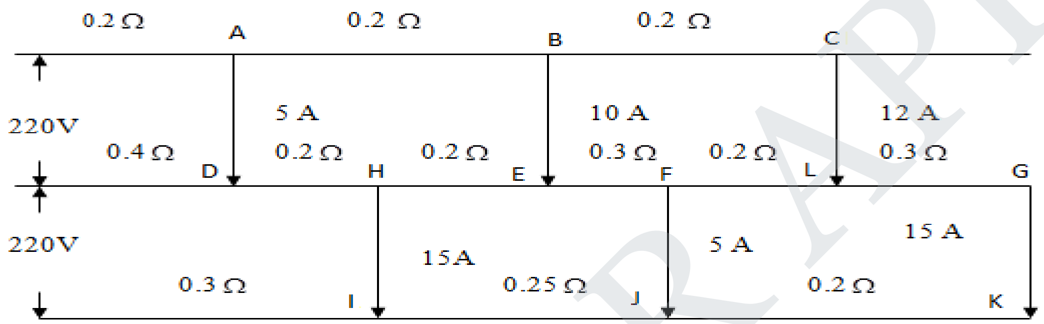
4. (i) Consider a distributor loaded with uniform loading of *i* amperes per meter run and are fed from two end feeding points at different voltages. Find the point of minimum potential occurrence in the distributor.

(ii) A 800m long, two wire DC distributor fed from both ends, is loaded uniformly at the rate of 1.2 A/m run. If the resistance of the distributor is 0.1 Ω/km (go and return) and feed points are maintained at 245V and 240V respectively, calculate the minimum voltage, its point of occurrence and current supplied from two feeding points. **(Dec 2015)**

5. A two wire dc ring main distributor ABCDEA is fed at point A with 230V supply. The resistances of go and return conductors of each section AB, BC, CD, DE, EA are 0.1

ohm. The main supplies the loads of 10A at B, 20A at C, 10A at D, 30A at E. Find the voltage at each loadpoint.(**May 2016)**

6. 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 2012)**
7. Explain the following system of distribution i) radial system ii) ring main system iii) interconnected system iv) design consideration in distribution system.**(Nov 2013)**
8. A 3 wire DC distributor is fed at one end at 220 V between wires and middle wire as shown in fig. The numbers between sections indicate the resistance of the respective section. Calculate the voltage between middle wire and outer at each load point. **(Nov 2011)**



9. An electric train taking a constant current of 600A moves on a section of line between two substations 8 km and maintained at 575 and 590 volts respectively. The track resistance is 0.04Ωper Km both go and return. Find the point of minimum potential along the track and currents supplied by two substations at the instant**.(May 2014)**
10. Derive suitable expressions to determine the voltage drop and power loss in an uniformly loaded distributor of length “l” fed at both ends with equal voltages. **(Nov 2016)**
11. Make a comparison between EHVAC and HVDC system based on economics. **(Nov 2016)**
12. Explain the different HVDC links. **(Nov 2016)**
13. Draw the layout of modern system and explain. What is the highest voltage level available in India for EHV transmission? **(Nov 2013,May 2014, May 2015,May 2016)**
14. Explain in detail the methods of neutral grounding and resistance grounding systems. **(May 2015,Dec 2015, May 2016, May 201)**
15. Explain the classification of substation based on service requirement and constructional feature and Write short notes on substation equipments. **(Nov 2013)**

16. Draw the circuit arrangement and explain the various elements of the following bus-bar arrangements. (i) Single bus scheme. (ii) Double bus bar with bypass insulator scheme.**(Nov 2011, Nov 2013)**

17. A transmission line conductor at a river crossing is supported from two towers at a height of 50 and 80m above water level. The horizontal distance between the towers is 300m. If the tension in the conductor is 2000 kg, find the clearance between the conductor and water at a point midway between the towers. Weight of conductor per metre=0.844 kg. Derive the formula. **(Nov 2011)**

18. Explain the following (i) Ring bus (ii) main and transfer bus (iii) double bus with single breaker (iv) double bus with bypass isolators. **(Nov 2012, Nov 2013, Dec 2014)**

19. Explain the methods of voltage control **(May 2015)**

20. Explain with the help of phasor diagram , voltage control by synchronous condenser. **(Nov 2018)**

21. Write short notes on (i) Sub mains (ii) Stepped and tapered mains (iii) Grounding grids. **(May2015)**

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

23. 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 working tension is 2000 Kg. Determine the clearance between the conductor and the water level midway between the towers. **(Nov 2016)**

24. Explain the methods of neutral grounding. **(Nov 2016)**

25. Describe the different types of substation layouts and list few advantages of GIS. **(April 2017)**

26. What are the different methods available for voltage control and explain any one method. **(APRIL 2017)**

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

28. Explain about the various methods of cable grading. **(Nov 2017)**

29. The self-capacitance of each unit in a string of three suspension insulator is C. The shunting capacitance of the connecting metal work of each insulator to earth is 0.15 C while for line it is 0.1 C. calculate the voltage across each insulator as a percentage of the line voltage to earth and string efficiency. **(Nov 2017)**

30. Compare the overhead and underground distribution system. **(APRIL 2017)**

31. State the advantages of interconnected system. **(APRIL 2017)**

32. A 400 V, 3 phase 4 wire service main supplies a star connected load. The resistance of each line is 0.1Ω and that of the neutral 0.2 Ω. The load impedances are Z_R=(6+j9),Z_Y= 8 Ω and Z_B=(6-j8). Calculate the voltage across each load impedance and current in the neutral. Phase sequence RYB. **(APRIL 2017)**

33. Explain your understanding about transmission of power and distribution of power. **(APRIL 2017)**

34. A transmission line conductor having a dia of 19.5 mm weights 0.85 kg/m. The span is 275m. The wind pressure is 39kg/m^2 of projected area with the 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/m^2 . **(May 2018)**

35. A 2-wire d.c. street mains AB, 600 m long is fed from both ends at 220 V. Loads of 20A, 40A, 50A and 30A are tapped at distances of 100m, 250 m, 400 m and 500m from the end A respectively. If the area of X-section of distributor conductor is 1 square centimeter, find the minimum consumer voltage. Take ρ=1.7X10-6 ohm-cm. **(May 2018)**

36. 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 200m from send 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. **(May 2018).**

37. Explain the following of DC distributor **(Nov 2018)**

I. Distributor fed at one end
II. Distributor fed at both ends
III. Distributor fed at the centre.

38. Find the voltage drop on a DC distributor having concentrated loads supplied to both ends with (i) equal voltage (ii) unequal voltage. **(Nov 2018)**

39. What is transformer substation? Discuss the role of major components in a transformer substation. **(April 2019)**

40. (i) What is neutral grounding? What are the advantages of neutral grounding?

(ii)Explain the resistance grounding of the neutral point of a 3-phase system. **(April 2019)**

41. A single phase distributor one km long has resistance and reactance per conductor of 0·1 Ω and 0·15 Ω respectively. At the far end, the voltage V_B = 200 V and the current is 100 A at a p.f. of 0·8 lagging. At the mid-point M of the distributor, a current of 100 A is tapped at a p.f. of 0·6 lagging with reference to the voltage V_M at the mid-point. Calculate :

(i) voltage at mid-point

(ii) sending end voltage V_A

(iii) phase angle between V_A and V_B. **(April 2019)**

42. A 2-wire d.c. ring distributor is 300 m long and is fed at 240 V at point A. At point B, 150 m from A, a load of 120 A is taken and at C, 100 m in the opposite direction, a load of 80 A is taken. If the resistance per 100 m of single conductor is 0·03 Ω, find :

(i) current in each section of distributor (ii) voltage at points B and C.**(April 2019)**

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