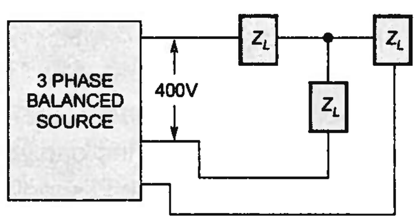
2 Transmission Line Design and Performance

2.1 - 3-Phase Systems

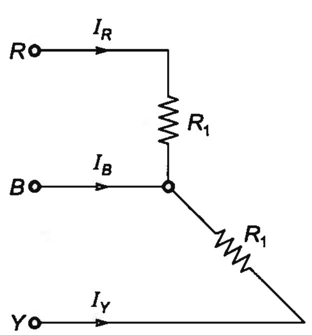
Q.1 If the 3-phase balanced source in the figure delivers 1500 W at a leading power factor 0.844, then the value of Z_L (in ohm) is approximately



(a) $90\angle 32.44°$ (b) $80\angle 32.44°$
(c) $80\angle -32.44°$ (d) $90\angle -32.44°$

[GATE-2002 : 2 Marks]

Q.2 For the three-phase circuit shown in the figure the ratio of the currents $I_R : I_Y : I_B$ is given by



(a) $1:1:\sqrt{3}$ (b) $1:1:2$
(c) $1:1:0$ (d) $1:1:\sqrt{3/2}$

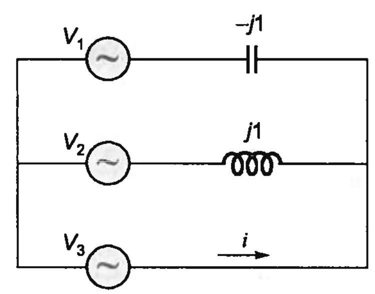
[EE-GATE-2005 : 2 Marks]

Q.3 The line A to neutral voltage is $10\angle 15°$ V for a balanced three-phase star connected load with phase sequence ABC. The voltage of line B with respect to line C is given by

(a) $10\sqrt{3}\angle 105°$ V (b) $10\angle 105°$ V
(c) $10\sqrt{3}\angle -75°$ V (d) $-10\sqrt{3}\angle 90°$ V

[EE-GATE-2014 : 1 Mark, Set-3]

Q.4 In the given network $V_1 = 100\angle 0°$ V, $V_2 = 100\angle -120°$ V, $V_3 = 100\angle +120°$ V. The phasor current i (in Ampere) is



(a) $173.2\angle -60°$ (b) $173.2\angle 120°$
(c) $100.0\angle -60°$ (d) $100.0\angle 120°$

[EE-GATE-2015 : 2 Marks, Set-2]

Q.5 Three equal impedance are first connected in delta across a 3-phase balanced supply. If the same impedances are connected in star across the same supply then,
(a) Phase current will be one-third
(b) Line current will be one-third
(c) Power consumed will be one-third
(d) Phase current will remain the same

[EE-ESE-2014]

Q.6 A balanced delta-connected load $(16 + j12)\ \Omega$/phase is connected to a 3-phase 230 V balanced supply. The line current and the real power drawn respectively are
(a) 19.9 A and 3.17 kW
(b) 11.5 A and 6.34 kW
(c) 19.9 A and 6.34 kW
(d) 11.5 A and 3.17 kW

[EE-ESE-2015]

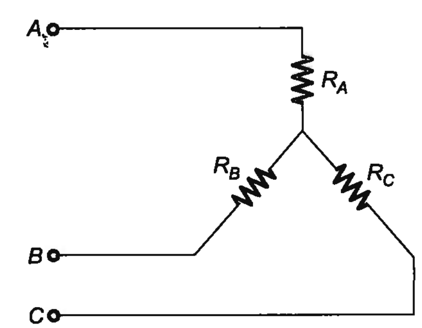
Q.7 A balanced load of $5 + j4$ is connected in delta. What is the impedance per phase of the equivalent star connection?
(a) $5 + j4$ (b) $1.66 + j1.33$
(c) $15 + j12$ (d) $2.5 + j2$

[EE-ESE-2015]

Q.8 A 3-phase star-connected balanced balanced load consumes P watts of power from a 400 V (line to line voltage) supply. If the same load is connected in delta across the same supply, what is the power consumption ?
(a) $P/3$ W (b) P W
(c) $\sqrt{3}P$ W (d) $3P$ W

[EE-ESE-2004]

Q.9 The following are the results of tests conducted on the below star-connected load:

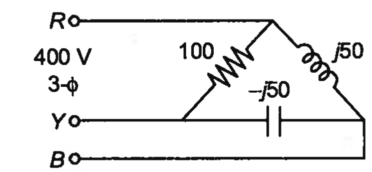


The resistance between B and C with A open : 22 Ω
The resistance between C and A with B open : 18 Ω
The individual resistance of R_A, R_B and R_C are respectively,
(a) 8 Ω, 14 Ω and 4 Ω
(b) 10 Ω, 2 Ω and 8 Ω
(c) 4 Ω, 8 Ω and 14 Ω
(d) 6 Ω, 6 Ω and 8 Ω

[EE-ESE-2011]

Numerical Data Type Questions

Q.10 A set of 3 equal resistors, each of value R_x, connected in star across RYB of given figure consumes the same power as the unbalanced delta connected load shown. The value of R_x is ______ Ω.



[EE-GATE-1994 : 2 Marks]

Q.11 A 3-phase, 4-wire system supplies power to a balanced star-connected load. The current in each phase is 15 A. The current in the neutral wire will be _____ A.

2.2 - Transmission Line Parameters

Multiple Choice Questions

Q.12 Consider a long, two-wire line composed of solid round conductors. The radius of both conductors is 0.25 cm and the distance between their centres is 1 m. If this distance is doubled, then the inductance per unit length:
(a) Doubles
(b) Halves
(c) Increases but does not double
(d) Decrease but does not halve

[GATE-2002]

Q.13 For a single-phase overhead line having solid copper conductors of diameter 1 cm, spaced 60 cm between centres, the inductances in mH/km is
(a) $0.05 + 0.2\ ln\ 60$
(b) $0.2\ ln\ 60$
(c) $0.05 + 0.2\ ln\ (60/0.5)$
(d) $0.2\ ln\ (60/0.5)$

[GATE-1999]

Q.14 For an extra-high voltage overhead transmission line, four conductors are used per phase (in a bundle) at the corners of a square of side s meter. The GMR (Geometric Mean Radius) of each conductor is (r_m = radius of conductor)

(a) $(r'_m s^2 \times \sqrt{2}\, s)^{1/4}$ (b) $(r'_m s^3)^{1/4}$

(c) $(r'_m 3 s^3)^{1/4}$ (d) $[r'_m \times (\sqrt{2}\, s)^3]^{1/4}$

[ESE-2008]

Q.15 A 3-phase transmission line conductors were arranged in horizontal spacing with '*d*' as the distance between adjacent conductors. If these conductors are rearranged to form an equilateral triangle with sides equal to '*d*', then the

(a) capacitance and the inductance will increase.

(b) capacitance will increase and the inductance will decrease.

(c) capacitance and the inductance will remain the same.

(d) capacitance will decrease and the inductance will increase.

[GATE-2000]

Q.16 A long wire composed of a smooth round conductor runs above and parallel to the ground (assumed to be a large conducting plane). A high voltage exists between the conductor and the ground. The maximum electric stress occurs at

(a) the upper surface of the conductor

(b) the lower surface of the conductor

(c) the ground surface

(d) midway between the conductor and ground

[GATE-2002]

Q.17 The component inductance due to the internal flux linkage of a non-magnetic straight solid circular conductor per meter length has a constant value, and is independent of the conductor-diameter, because

(a) All the internal flux due to a current remains concentrated on the peripheral region of the conductor

(b) The internal magnetic flux-density along the radial distance from the centre of the conductor increases proportionately to the current enclosed

(c) The entire current is assumed to flow along the conductor-axis and the internal flux is distributed uniformly and concentrically

(d) The current in the conductor is assumed to be uniformly distributed throughout the conductor cross-section

[ESE-2003]

Q.18 When there is interference in an overhead communication line running parallel and in close proximity to an overhead power line, the voltage induced in the communication line in the longitudinal and lateral directions by the earth and power line are due to

(a) magnetic induction and electric induction respectively

(b) electric induction and magnetic induction respectively

(c) both magnetic induction and electric induction

(d) magnetic induction only

[ESE-2000]

Q.19 Consider the following statements:

1. By using bundle conductors in an overhead line, the corona loss is reduced.
2. By using bundle conductors, the inductance of transmission line increases and capacitance reduces.
3. Corona loss causes interference in adjoining communication lines.

Which of these statements are correct?

(a) 1 and 2 (b) 2 and 3

(c) 1 and 3 (d) 1, 2 and 3

[ESE-1999]

Q.20 The horizontally placed conductors of a single-phase line operating at 50 Hz are having outside diameter of 1.6 cm, and the spacing between centers of the conductors is 6 m. The permittivity of free space is 8.854×10^{-12} F/m. The capacitance to ground per kilometer of each line is

(a) 4.2×10^{-9} F (b) 8.4×10^{-9} F

(c) 4.2×10^{-12} F (d) 8.4×10^{-12} F

[GATE-2014]

Numerical Data Type Questions

Q.21 The conductors of a 10 km long, single phase two wire line are separated by a distance of 1.5 m. The diameter of each conductor is 1 cm. If the conductors are of copper, the inductance of the circuit is _____ mH.

[GATE-2001]

Q.22 A 3-phase transmission line has its conductors at the corners of an equilateral triangle with side 3 m. The diameter of each conductor is 1.63 cm. The inductance of the line per phase per km is _____ mH.

[ESE-2002]

Q.23 The total reactance and total susceptance of a lossless overhead EHV line, operating at 50 Hz, are given by 0.045 pu and 1.2 pu respectively. If the velocity of wave propagation is 3×10^5 km/s, then the approximate length of the line is ___ km.

[GATE-2007]

Q.24 A single phase transmission line and a telephone line are both symmetrically strung one below the other, in horizontal configurations, on a common tower. The shortest and longest distances between the phase and telephone conductors are 2.5 m and 3 m. The voltage (V/Km) induced in the telephone circuit, due to 50 Hz current of 100 A in the power circuit is _____.

[GATE-2006]

Q.25 A single-phase transmission line has two conductors each of 10 mm radius. These are fixed at a center-to-center distance of 1 m in a horizontal plane. This is now converted to a three-phase transmission line by introducing a third conductor of the same radius. This conductor is fixed at an equal distance *D* from the two single-phase conductors. The three-phase line is fully transposed. The positive sequence inductance per phase of the three-phase system is to be 5% more than that of the inductance per conductor of the single-phase system. The distance *D*, in meters, is __________.

2.3 - Transmission Line Performance

Multiple Choice Questions

Q.26 If *X* is the inductive reactance/phase and *R* is the resistance/phase of a short transmission line, what is the power factor angle of the load for maximum voltage regulation?

(a) $\cos^{-1} X/R$ (b) $\tan^{-1} X/R$

(c) $\cos^{-1} R/X$ (d) $\tan^{-1} R/X$

[ESE-2006]

Q.27 Consider the following statements:

1. Equivalent-*T* circuit of a long line is preferred to equivalent-π circuit.
2. The nature of reactive power compensation is different for peak load and off-peak load conditions.
3. Ferranti effect is significant only on medium and long lines.

Which of the statements given above are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2008]

Q.28 **Assertion (A):** In the modelling of medium and long transmission lines the nominal-π and T circuits are not equivalent to each other.

Reason (R): A star-delta transformation can be used to derive the one circuit from the other.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not a correct explanation of A

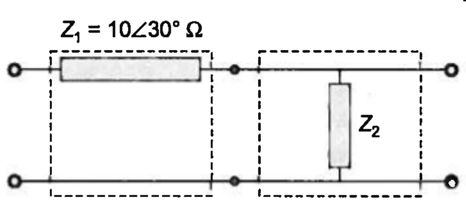
(c) A is true but R is false

(d) A is false but R is true **[ESE-2002]**

Q.29 In which one of the following models of transmission lines, is the full charging current assumed to flow over half the length of the line only?
(a) Equivalent-π (b) Short line
(c) Nominal-π (d) Nominal-T
[IAS-1998]

Q.30 Consider the following statements:
The calculations performed using short-line approximate model instead of nominal-π model for a medium length transmission line delivering lagging load at a given receiving-end voltage always results in higher
1. sending-end current 2. sending-end power
3. regulation 4. efficiency
Which of these statements are correct?
(a) 1 and 2 (b) 3 and 4
(c) 1, 2 and 3 (d) 1, 2 and 4
[IAS-2001]

Q.31 Two networks are connected in cascade as shown in the figure . With the usual notations the equivalent A, B, C and D constants are obtained. Given that $C = 0.025\angle 45°$ S, the value Z_2 is



(a) $10\angle 30°\ \Omega$ (b) $40\angle -45°\ \Omega$
(c) $1\ \Omega$ (d) $0\ \Omega$
[GATE- 2005]

Q.32 A transmission line has an impedance of $(3 + j4)\ \Omega$/phase. The P.F. of the load required for maximum and zero voltage regulation are respectively?
(a) 0.6 lead, 0.6 lag (b) 0.6 lag, 0.6 lead
(c) 0.6 lag, 0.8 lead (d) 0.8 lag, 0.6 lead

Q.33 A short transmission line having zero resistance and total series reactance of 0.4 pu is provided with reactive power compensation at the mid-point of the line such that the mid-point voltage is held at 0.96 pu when the voltage at both ends are 1.0 pu. What is the steady state power transmission limit of such a system?
(a) 4.8 pu (b) 0.0 pu
(c) 2.4 pu (d) 9.6 pu
[ESE-2009]

Numerical Data Type Questions

Q.34 The generalized circuit constants of a 3-phase, 220 kV rated voltage, medium length transmission line are
$A = D = 0.936 + j0.016 = 0.936\angle 0.98°$
$B = 33.5 + j138 = 142.0\angle 74.4°\ \Omega$
$C = (-5.18 + j914) \times 10^{-6}$ ℧
If the load at the receiving end is 50 MW at 220 kV with a power factor of 0.9 lagging, the magnitude of line to line sending end voltage is ______ kV. **[GATE-2004]**

Q.35 For a 400 km long tran smission line, the series impedance is $(0.0 + j0.5)\ \Omega$/km and the shunt admittance is $(0.0 + j5.0)\ \mu$mho/km. The magnitude of the series impedance (in Ω) of the equivalent π circuit of the transmission line is ____.
[GATE-2014]

Conventional Questions

Q.36 Assume that the equations between the sending end voltage and current with the corresponding receiving end voltage and current in terms of A, B, C, D constants of a long transmission line are known, derive equations for sending end and receiving end power.
[ESE-2005]

Q.37 A 400 kV transmission line has $A = 0.8\angle 0° = D$, $B = 100\angle 90°\ \Omega$, $C = 0.5 \times 10^{-6}$ ℧/phase, $V_S = 400$ kV. Find
(i) V_R,
(ii) I_C and X_{LSH} under no load condition.

Q.38 A 300 km long transmission line operating at $V_S = 1$ p.u. Find V_R under no load.

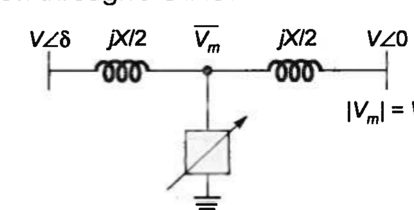
Q.39 A 400 kV transmission line has $B = 200\angle 90°\Omega$, $\beta = 0.5$ rad, $C = 0.5 \times 10^{-6}$℧. At no load condition. Find
(i) Charging current
(ii) V_R
(iii) Shunt reactor reactance requirement for maintaining $V_R = V_S$.
(Assume line is loss less.)

2.4 - Power Flow and Surge Impedance Loading

Multiple Choice Questions

Q.40 Consider the following statements:
Surge impedance loading of a transmission line can be increased by
1. increasing its voltage level
2. addition of lumped inductance in parallel
3. addition of lumped capacitance in series
4. reducing the length of the line
Of these statements:
(a) 1 and 3 are correct
(b) 1 and 4 are correct
(c) 2 and 4 are correct
(d) 3 and 4 are correct
[ESE-2001]

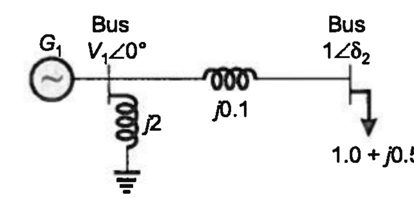
Q.41 In a transmission line, the mid-point voltage is maintained to V by a compensating device as shown in the circuit below. What is the real power flow through the line?



(a) $\frac{V^2}{X}\sin\frac{\delta}{2}$ (b) $\frac{2V^2}{X}\sin\delta$
(c) $\frac{V^2}{X}\sin\delta$ (d) $\frac{2V^2}{X}\sin\frac{\delta}{2}$
[ESE-2009]

Q.42 The combined effect of series and shunt compensation on transmission lines in terms of degree of series compensation (K_{se}), degree of shunt compensation (K_{sh}), and surge impedance of uncompensated line (Z_0) is given by which one of the following equations?
(a) $Z'_0 = Z_0\sqrt{1-K_{se}}\cdot\sqrt{1-K_{sh}}$
(b) $Z'_0 = \left[\sqrt{1-K_{se}}\cdot\sqrt{1-K_{sh}}\right]/Z_0$
(c) $Z'_0 = Z_0\sqrt{(1-K_{se})/(1-K_{sh})}$
(d) $Z'_0 = Z_0\sqrt{(1-K_{sh})/(1-K_{se})}$
[ESE-2004]

Q.43 A two bus power system shown in the figure supplies load of 1.0 + j0.5 pu.



The values of V_1 in pu and δ_2 respectively are
(a) 0.95 and 6.00° (b) 1.05 and –5.44°
(c) 1.1 and –6.00° (d) 1.1 and –27.12°
[GATE-2014]

Q.44 A lossless radial transmission line with surge impedance loading
(a) takes negative VAR at sending end and zero VAR at receiving end.
(b) takes positive VAR at sending end and zero VAR at receiving end.
(c) has flat voltage profile and unity power factor at all points along it.
(d) has sending end voltage higher than receiving end voltage and unity power factor at sending end.
[GATE-2001]

Q.45 For a fixed receiving end and sending end voltages in a transmission system, what is the locus of the constant power?
(a) A straight line (b) An ellipse
(c) A parabola (d) A circle
[ESE-2004]

Q.46 For a loss-free long transmission line, the conventional line equations become,

$$V_s = (\cos \beta l)\ V_R + (j \sin \beta l) Z_c\ I_R$$

and $$I_s = \left(\frac{j \sin \beta l}{Z_c}\right) V_R + (\cos \beta l)\ I_R$$

Which one of the following statements is correct? If the line is terminated at the receiving end by its natural load impedance Z_c, then

(a) the voltage is constant in magnitude at all points along the line and, V_S and V_R always remain in the phase.

(b) the voltage is constant in magnitude at all points along the line but V_S advances in phase relative to V_R by an angle β radians per km.

(c) the magnitude of the voltage along the line changes in proportion to the line-length, and the V_S and V_R always remain in phase.

(d) the magnitude of the voltage along the line changes in proportion to the line-length, V_S advances in phase relative to V_R by β radians per km.

[ESE-2006]

Q.47 The active and the reactive power delivered at the receiving end of a short transmission line of impedance $Z\angle\Psi$ are respectively given by

$$P_R = \frac{V_S V_R}{Z}\cos(\Psi - \delta) - \frac{V_R^2}{Z}\cos\Psi, \text{ and}$$

$$Q_R = \frac{V_S V_R}{Z}\sin(\Psi - \delta) - \frac{V_R^2}{Z}\sin\Psi, \text{ with}$$

V_S and V_R being the magnitudes of voltages at the sending and receiving ends, δ the power-angle. At the power-limit condition *i.e.* for maximum P_R

(a) leading VARs (Q_R) goes to the load for any values of V_S

(b) lagging VARs (Q_R) goes to the load ONLY for $V_S = V_R$

(c) lagging VARs (Q_R) goes to the load for any values of V_S and V_R

(d) leading VARs (Q_R) goes to the load ONLY for $V_S = V_R$

[ESE-2001]

Q.48 In a long transmission line with *r*, *l*, *g* and *c* are the resistance, inductance, shunt conductance and capacitance per unit length, respectively, the condition for distortionless transmission is

(a) $rc = lg$ (b) $r = \sqrt{l/c}$

(c) $rg = lc$ (d) $g = \sqrt{c/l}$

[GATE-2014]

Numerical Data Type Questions

Q.49 An 800 kV transmission line is having per phase line inductance of 1.1 mH/km and per phase line capacitance of 11.68 nF/km. Ignoring the length of the line, its ideal power transfer capability in MW is _____

[GATE-2004]

Q.50 A lossless transmission line having Surge Impedance Loading (SIL) of 2280 MW is provided with a uniformly distributed series capacitive compensation of 30%. Then, SIL of the compensated transmission line will be _____ MW.

[GATE-2008]

Q.51 The surge Impedance of a 400 Km long overhead transmission line is 400 ohms. For a 200 Km length of the same line, the surge impedance will be _____ Ω.

[GATE-1995]

Conventional Questions

Q.52 Explain: Surge impedance loading of transmission line.

[ESE-2005]

2.5 - Travelling Waves

Multiple Choice Questions

Q.53 A short length of cable is connected between dead-end tower and sub-station at the end of a transmission line. Which of the following will decrease, when voltage wave is entering from overhead line to cable?

1. Velocity of propagation of voltage wave.
2. Steepness of voltage wave.
3. Magnitude of voltage wave.

Select the correct answer using the codes given below:

(a) 1 and 2 (b) 2 and 3

(c) 3 and 1 (d) 1, 2 and 3

[IAS-2001]

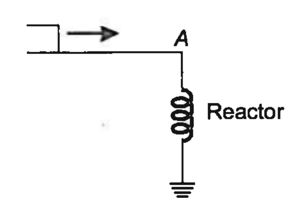
Q.54 If a line of surge impedance Z_0 is terminated in an impedance Z then the reflection for current and voltage surges at the termination are given respectively by

(a) $\frac{Z_0 - Z}{Z_0 + Z}, \frac{2Z}{Z_0 + Z}$ (b) $\frac{Z_0 - Z}{Z_0 + Z}, \frac{Z - Z_0}{Z_0 + Z}$

(c) $\frac{2Z_0}{Z_0 + Z}, \frac{2Z}{Z_0 + Z}$ (d) $\frac{2Z_0}{Z_0 + Z}, \frac{Z - Z_0}{Z_0 + Z}$

[ESE-2010]

Q.55 Consider a step voltage wave of magnitude 1 pu travelling along a lossless transmission line that terminates in a reactor. The voltage magnitude across the reactor at the instant the travelling wave reaches the reactor is



(a) –1 pu (b) 1 pu

(c) 2 pu (d) 3 pu

[GATE-2010]

Numerical Data Type Questions

Q.56 A lightning stroke discharges impulse current of 10 kA (peak) on a 400 kV transmission line having surge impedance of 250 Ω. The magnitude of transient over-voltage travelling waves in either direction assuming equal distribution from the point of lightning strike will be _____ kV.

[GATE-2004]

Q.57 A surge of 20 kV magnitude travels along a lossless cable towards its junction with two identical lossless overhead transmission lines. The inductance and the capacitance of the cable are 0.4 mH and 0.5 μF per km. The inductance and capacitance of the overhead transmission lines are 1.5 mH and 0.015 μF per km. The magnitude of the voltage at the junction due to surge is _____ kV.

[GATE-2003]

Q.58 At no load condition, a 3-phase, 50 Hz, lossless power transmission line has sending-end and receiving-end voltages of 400 kV and 420 kV respectively. Assuming the velocity of traveling wave to be the velocity of light, the length of the line, in km, is __________.

Conventional Questions

Q.59 Using the distributed parameter form of transmission line model, obtain the equations for V_s and I_s, in terms of V_R, I_R, line resistance/km, *r*, line inductance per km, *L*, conductance per km, *g*, capacitance per km, *C*, propagation constant, gamma γ and characteristic impedance, Z_C.

[ESE-2007]

Q.60 A transmission line has a surge impedance of 400 Ω is terminated with a cable having surge impedance of 50 Ω. If a lightening surge of 100 kV is travelling from the transmission line towards the cable. Find

(*i*) All the coefficients
(*ii*) Transmitted voltage & current
(*iii*) Reflected voltage & current
(*iv*) incident voltage & current.

Q.61 Two transmission line *A* & *B* connected through a cable *C*. The surge impedances are 400 Ω, 50 Ω and 300 Ω for *A, C, B* respectively. If the surge of 100 kV is travelling from transmission line A towards the cable *C* then find
(*i*) Transmitted Voltage into the cable.
(*ii*) Transmitted Voltage in line *B*
(*iii*) Transmitted voltage in cable C due to first reflected voltage from junction *BC* reaching the junction *A* and *C*.
(*iv*) Voltage towards cable just before 5T where T is the time taken by the voltage wave to travel along the length of the cable.
[ESE-2010]

Q.62 (*i*) A surge of 100 kV is incident on a line having a surge impedance of 400 ohms. It meets a cable having a surge impedance of 40 ohms. Derive expression for the transmitted voltage and reflected voltage and compute their values.
(*ii*) Explain the practical importance of this situation.
[ESE-2011]

2.6 - Corona

Multiple Choice Questions

Q.63 Which one of the following statements is correct?
Corona loss increases with
(a) decrease in conductor size and increase in supply frequency
(b) increase in both conductor size and supply frequency
(c) decrease in both conductor size and supply frequency
(d) increase in conductor size and decrease in supply frequency
[ESE-2004]

Q.64 The corona loss on a particular system at 50 Hz is 1kW/km per phase. What is the corona loss at 60 Hz in kW/km per phase?
(a) 0.83 (b) 1.0
(c) 1.13 (d) 1.2 [ESE-2005]

Q.65 The good effect of corona on overhead lines is to
(a) increase the line carrying capacity due to conducting ionised air envelop around the conductor
(b) increase the power factor due to corona loss
(c) reduce the radio interference from the conductor
(d) reduce the steepness of surge fronts
[ESE-2001]

Numerical Data Type Questions

Q.66 A 3-phase 220 kV, 50 Hz transmission line consists of 2 cm radius conductor spaced 2.5 m apart in equilateral triangular formulation. If the temperature is 20°C, atmospheric pressure 75 cm and irregularity factor (m_0) = 0.80, then the corona loss per km of line is _____kW. (Assume dielectric strength of air = 21.1 kV/cm(rms))

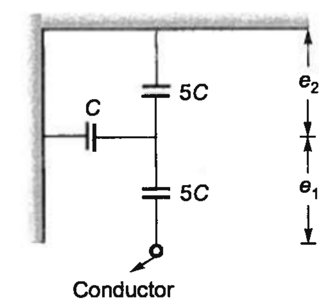
Q.67 A 3-phase, 220 KV, 50 Hz transmission line consists of 1.2 cm radius conductors spaced 2 m at the corners of an equilateral triangle. The disruptive critical voltage between the lines if irregularity factor = 0.96, temperature 20°C, Barometric pressure 72.2 cm of mercury and dielectric strength of air = 21.1 KV (rms)/cm is ______ kV (rms).

2.7 - Insulators

Multiple Choice Questions

Q.68 The insulation strength of EHV AC transmission line is mainly governed by
(a) Load Power factor
(b) Switching over-voltages
(c) Harmonics
(d) Corona
[GATE-2005]

Q.69 Consider a three-phase, 50 Hz, 11 kV distribution system. Each of the conductors is suspended by an insulator string having two identical porcelain insulators. The self capacitance of the insulator is 5 times the shunt capacitance between the link and the ground, as shown in the figure. The voltage across the two insulators is



(a) e_1 = 3.74 kV, e_2 = 2.61 kV
(b) e_1 = 3.46 kV, e_2 = 2.89 kV
(c) e_1 = 6.0 kV, e_2 = 4.23 kV
(d) e_1 = 5.5 kV, e_2 = 5.5 kV
[GATE-2010]

Q.70 Match **List-I** (Design parameters) with **List-II** (Factor(s) on which they depend) and select the correct answer using the codes given below the lists:
List-I
A. Number of suspension insulator discs
B. Permissible sag of transmission
C. Corona discharge
D. Inductance of transmission line conductor
List-II
1. Voltage and tower footing resistance
2. Voltage line conductor for a given tower
3. Voltage and conductor configuration
4. Conductor configuration and towei configuration

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	2	1
(c)	1	3	2	4
(d)	4	2	3	1

[ESE-2002]

Numerical Data Type Questions

Q.71 A string insulator has 4 units. The voltage across the bottom-most unit is 33.33% of the total voltage. Its string efficiency is _____ %.
[IAS-1995]

Q.72 A suspension type insulator has three units with self-capacitance *C* and ground capacitance of 0.2 *C* having a string efficiency of _____ %
[IAS-1998]

Q.73 In a transmission line each conductor is at 20 kV and is supported by a string of 3 suspension insulators. The air capacitance between each cap pin junction and tower is one fifth of the capacitance of each insulator unit. A guard ring, effective only over the line end insulator unit is fitted so that the voltages on the two units nearest the line end are equal. The voltage on the line end unit is _____ kV.

Conventional Questions

Q.74 Show how a string of insulators be protected against damage when a flash over occurs. Each line of a 3-phase system is suspended by a string of three similar insulators. If the voltage across the line unit is 10 kV, determine the line voltage of the system. Assume that the shunt capacitance between each insulator and the earthed metalwork of the tower is one-tenth of the capacitance of the insulation itself.
[ESE-2014]

Try Yourself

T1. The three conductors of a 3-phase line are arranged at the corners of a triangle of sides 2 m, 2.5 m and 4.5 m. The inductance per phase per meter, if the diameter of each conductor is 1.24 cm and conductors are regularly transposed is

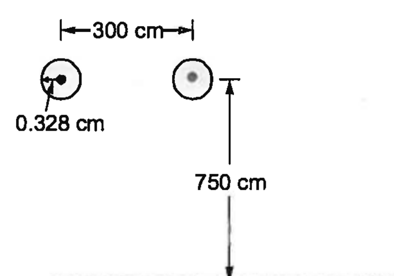
(a) 1.04 μH (b) 2.1 μH
(c) 1.27 μH (d) 2.8 μH

[Ans: (c)]

T2. There are 6 conductors in a Double circuit transmission line. Each conductor has a radius of 12 mm. The 6 conductors are arranged horizontally. The centre to centre distance between all the conductors is 2 m. The sequence of conductors are from left to right as follows: *a*, *b*, *c*, *a'*, *b'*, *c'*. Calculate the inductance per km per phase of this system.

[ESE-2007]

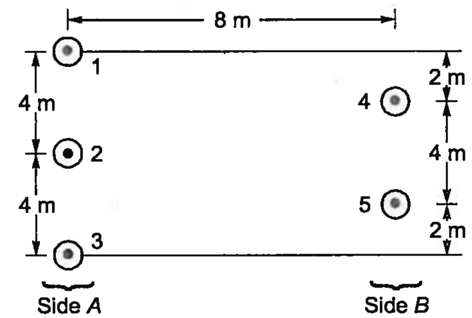
T3. A single phase line composed of 2 single strand conductors whose radius is 0.328 cm, spaced 3 m apart and 7.5 m above the ground as shown in figure below. The capacitance to neutral/km, if the effect of earth is considered and non-uniformity of charge is neglected is



(a) 0.21 μF/km (b) 21 μF/km
(c) 0.0082 μF/km (d) 0.012 μF/km

T4. The arrangement of conductors of a single phase transmission line is shown below, where the forward circuit is composed of three solid wires 2.5 mm in radius and the return circuit of two wires of radius 5 mm placed symmetrically with respect to the forward circuit.

The mutual GMD between sides *A* and *B* is



(a) 8.8 m (b) 6.4 m
(c) 7.6 m (d) 6.8 m

T5. The three conductors of a 3-phase line are arrange at the corners of a triangle of sides 2 m, 2.5 m and 4.5 m. The inductance per phase per meter, if the diameter of each conductor is 1.24 cm and conductors are regularly transposed is

(a) 1.04 μH (b) 2.1 μH
(c) 1.27 μH (d) 2.8 μH

T6. A typical line has the following parameters;
A = D = 0.96∠1.0° and B = 100 ∠80° Ω.
If the line suupplies a load of 30 MW at 0.8 pf lag, 110 kV, the voltage regulation of the line is

(a) 15.5% (b) 18.24%
(c) 19.61% (d) 20.78%

T7. A 275 kV transmission line has the following line constants:
A = 0.85∠5° ; *B* = 200∠75° Ω
Thepower at unity power factor that can be received if the voltage profile at each end is to be maintained at 275 kV is

(a) 112.63 MW (b) 175.75 MW
(c) 192.00 MW (d) 160.00 MW

T8. A typical line has the following parameters;
A = *D* = 0.96∠1.0° and *B* = 100∠80 Ω
The maximum power that can be transmitted if the sending and receiving end line voltages are 120 kV and 110 kV respectively is _____ MW.

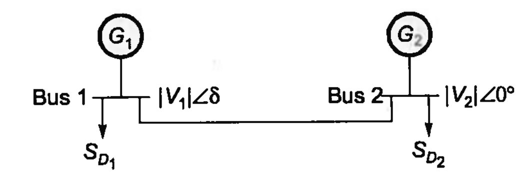
[Ans: 109.83]

T9. In a two bus ac system, the sending end voltage $|V_s|$ and the receiving end voltage $|V_r|$ for the line is 1 pu. The line reactance is *j*0.05 pu and resistance is neglected. If the real power flow through the line is 10 pu then the reactive power flow through the line is _____ p.u.

[Ans: 5.36]

T10. An interconnector cable having a reactance of *j*0.05 pu links two generating stations G_1 and G_2 as shown below, where $|V_1| = |V_2| = 1$ pu. The load demand at two buses are $S_{D_1} = 15 + j5$ pu and $S_{D_2} = 25 + j15$ pu.

The total active power at the generating station G_1 when δ = 15° is _____ p.u.



[Ans: 5.68]

T11. A surge of 15 kV magnitude travels along a cable towards its junction with an overhead line. The inductance and capacitance of the cable and overhead line are respectively 0.3 μH, 0.4 μF and 1.5 μH, 0.012 μF per km. The voltage rise at the junction due to the surge is

(a) 24.22 kV (b) 31.26 kV
(c) 27.87 kV (d) 40.20 kV

T12. A shunt inductor at receivng end of a transmission line is operated at 96% of its rated voltage and 104% of its rated frequency. The reactive power consumed by it (as compared to rated capacity) is

(a) 11.4% low (b) 12.07% high
(c) 4.2% low (d) 4.2% high

T13. A 220 kV lossless transmission line has total series inductance of 4/π H and total shunt capacitance of 1/π μF. If the sending end voltage is maintained at 230 kV. The voltage regulation is

(a) 4.55% (b) 6.8%
(c) 2.27% (d) 2%

T14. At an industrial substation with a 8 MW load, a capacitor of 4 MVAR is installed to maintain load pf at 0.9 leading, if a compensating element is also connected so that the pf changes to 0.9 lagging. The compensating elemnet is

(a) Capacitor of 4.5 MVAR
(b) Reactor of 4.5 MVAR
(a) Capacitor of 7.75 MVAR
(a) Reactor of 7.75 MVAR

T15. A transmission line with reactance of 0.3 pu is supplied at constant voltage of 1.25 pu, it is supplying reactive power 0.4 pu and is operating at half of hte steady-state stability limit. The receiving end voltage in feeder is

(a) 1 pu (b) 1.32 pu
(c) 1.11 pu (d) 1.18 pu

T16. In a string of three identical suspension insulator units supporting a transmission line conductor, if the self capacitance of each unit is denoted as C farads, the capacitance of each connector pin to ground can be taken as 0.1 C farads. If the maximum permissible voltage per unit is given as 20 KV then the string efficiency is

(a) 80.12 % (b) 86.67 %
(c) 91.01 % (d) 89.12 %

[Ans: (b)]

T17. Determine the voltage across the bottom unit of a string of suspension insulators consisting of 3 similar units. The voltage between line and earth is 60 kV and the ratio of the capacitance of each unit and the capacitance between pin to earth is 10 : 1.

(a) 19.4 kV (b) 21.3 kV
(c) 22.2 kV (d) 23.1 kV

■■■■