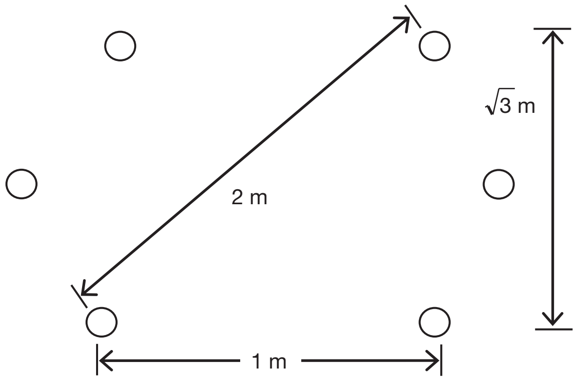
Power Systems Test 3

Number of Questions: 25 **Section Marks: 90**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. A sending end bus transfers power through the following transmission line to receiving end. The value of capacitance per ph per km in µF is ___________ (if radius = 2cm).



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2. The velocity of travelling wave through cable at relative permittivity 4 is

(A) 3×10^8m/sec (B) 1.5×10^8m/sec
(C) 0.75×10^8m/sec (D) 12×10^8m/sec

3. Which of the following methods are used for improving the string efficiency of suspension type insulators

(P) Grading of insulator discs
(Q) Longer cross arm
(R) Guard rings

(*A*) Only *P* (B) Only *Q*
(C) Both *P* and *Q* (D) *P*, *Q* and *R*

4. For transmiting power a solid conductor is replaced by bundle conductor consisting of five smaller conductors per phase. If the radius of each conductor in bundle conductor is 10mm, then the diameter of solid conductor is _____

(A) 22.36 mm (B) 67.08 mm
(C) 44.72 mm (D) 100 mm

5. If δ is the loss angle of the cable then the power factor of the cable is

(A) cos δ (B) sin δ
(C) tan δ (D) None of the above

6. Proximity effect is due to

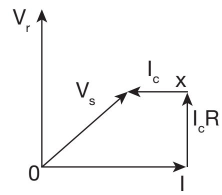
(A) The current flowing through its own conductor
(B) The field produced by the current flowing through the adjacent (nearest) conductor
(C) The load supplied by the conductor
(D) The atmosphere sourrounding the conductor

7. In Hydro power plant spill way is used as

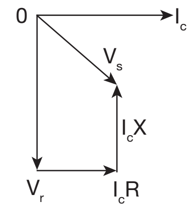
(A) to reduce pressure of water in penstock
(B) to discharge excess of water in reservoir
(C) to reduce water pressure at turbine valve
(D) to discharge excess of water in surge tank

8. The phasor diagram of Ferranti effect is

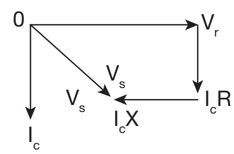
(A)



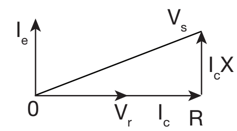
(B)



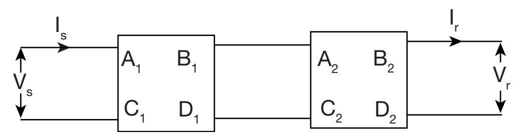
(C)



(D)



9. The resultant *A*, *B*, *C*, *D* parameters of the following network is



(A) $A = A_1 A_2 + B_1 B_2$; $B = A_1B_2 + A_2 B_1$;
$C = B_1 C_2 + B_2C_1$; $D = B_2C_1 + D_1D_2$
(B) $A = A_1 A_2 + B_1C_1$; $B = A_1 B_2 + B_1D_1$;
$C = A_2C_1 + C_1D_2$; $D = B_2C_1 + D_1D_2$
(C) $A = A_1 A_2 + B_1C_2$; $B = A_1B_2 + B_1 D_2$;
$C = A_2 C_1 + C_2 D_1$; $D = B_2 C_1 + D_1 D_2$
(D) $A = A_1 A_2 + B_2 C_1$; $B = A_2 B_1 + B_1 D_2$;
$C = A_2 C_1 + C_2 D_1$; $D = B_2 C_1 + D_1 D_2$

10. When multiplication factor (*K*) is greater than one in nuclear reactor means

(A) Number of neutrons in one generation is greater than the number of neutrons of immediately preceding generation.
(B) Number of neutrons in one generation is greater than the number of neutrons of next generations.
(C) The control rods of nuclear reactor is taken out
(D) None of the above

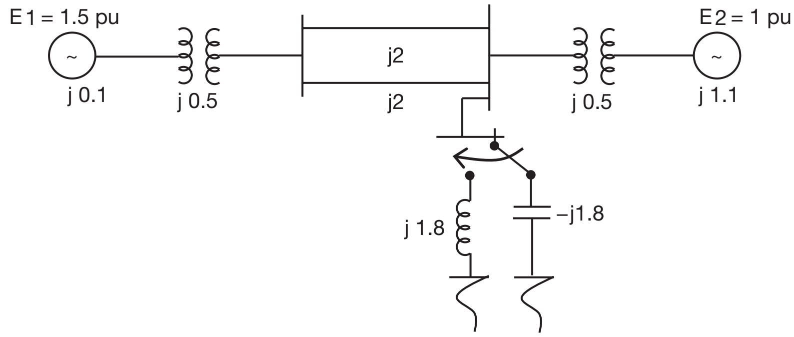
11. A 3-phase, 50Hz, transmission line has its conductors at the corners of an equilateral triangle with side 4m. The diameter of each conductor is 1.8 cm. The inductive reactance of the circuit per phase is

(A) 0.398 mΩ/m (B) 1.27 mH/ph/m
(C) 0.398 Ω/km (D) 3.98 mΩ/m

12. A two disc insulator string has each disc capacitance *C* and shunt capacitance between metal link and ground is 0.4C, the top most unit voltage is 11kV. The voltage across the unit near to the conductor is _____

(A) 11 kV (B) 15.4 kV
(C) 26.41 kV (D) 19.05 kV

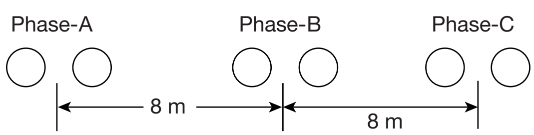
13. For the system shown in figure below the value of change in the steady state stability limit in pu is ____________ if change in switch is occurred



14. Calculate the capacitance between any two conductors in a 3 - phase, 3 - core metal sheathed cable. The capacitance between two conductors bunched with the sheath and the third conductor is 0.5μF per km, the capacitance between bunched conductors and sheath is 0.65μF/km

(A) 0.214μF/km (B) 0.642μF/km
(C) 0.963μF/km (D) 0.321μF/km

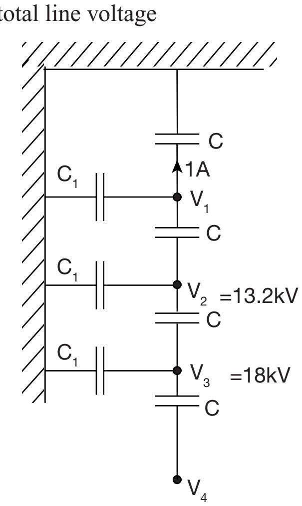
15. A three-phase, 60Hz, conductors as shown in the figure with each sub conductor of the bundle has a diameter of 30mm and spacing between sub conductors is 0.4m



Calculate the line inductance per kilometer of the circuit.

(A) 9.98×10^{-4}mH (B) 0.998mH
(C) 99.86×10^{-2}mH (D) 0.99×10^{-3}mH

16. Each conductor of a 3 phase *HV* line is suspended by four disc type insulators as shown in figure and the currents and voltages are also given. When $X_C = 1\Omega$.
Calculate the total line voltage



(A) 119 kV (B) 238 kV
(C) 68 kV (D) 136 kV

17. Match the following

	List - I		List II
P	Coolant Rods	1	A fissile fuel of a reactor
Q	Thorium - 232	2	Boron
R	Heavy water	3	Graphite
		4	A fertile fuel of nuclear reactor
		5	Used as a moderator

	P	Q	R
(A)	2	1	5
(B)	2	1	3
(C)	4	1	3
(D)	4	1	5

18. A three phase, 765 kV, 60 Hz, 300 km, fully transposed line has the following positive sequence impedance and admittance:
$Z = 0.0165 + j0.3306\ \Omega$/km
$Y = j4.674 \times 10^{-6}$ S/km
Neglecting line losses, find the theoretical steady state stability limit for this line, given that surge impedance is 266.1Ω and wavelength is 5000 km

(A) 2200 MW (B) 5974 MW
(C) 2987 MW (D) 8985 MW

19. A short transmission line having its line impedance angle as 30°. For getting zero regulation the receiving end lagging power factor angle should be

(A) 30° (B) 60°
(C) 120° (D) 45°

20. A 3-phase, 132kV, 50Hz, system has 200 km long transmission line of diameter 1.05 cm, 2.5 delta spacing, air temperature 25° and approximate barometric pressure of 70 cm. calculate the corona power loss (Assume surface irregularity factor of 0.85)

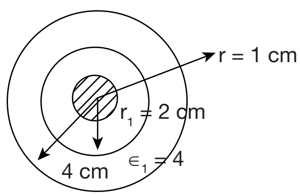
(A) 8kW / Phase / km
(B) 14.03kW / Phase / km
(C) 2.69kW / Phase / km
(D) 4.67kW / Phase / km

21. A 10 km transmission line is operating at a frequency of 1000 Hz. The transmission line is a

(A) electrically short
(B) electrically long transmission
(C) any of the above
(D) both (a) and (b)

22. A string insulator has 5 units, the voltage across the bottom most unit is 35%. Its string efficiency is
(A) 57.14% (B) 30.76%
(C) 69.24% (D) 42.86%

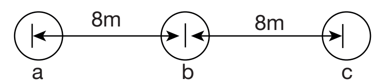
23. Calculate the maximum safe working voltage of the cable as shown in the figure (Assume the peak voltage gradient in the air 35kV/cm)



(A) 42.87 kV peak (B) 30.32 kV peak
(C) 21.43 kV peak (D) 37.13 kV peak

24. Determine the reactance of a 130 kV overhead line where the conductors are located in a plane and the distance between two adjacent conductors is 4m. Conductor diameter is 20 mm
(A) 0.82 Ω/km/phase (B) 0.205 Ω/km/phase
(C) 0.41 Ω/km/phase (D) 0.615 Ω/km/phase

25. Three phase transposed line is as shown:



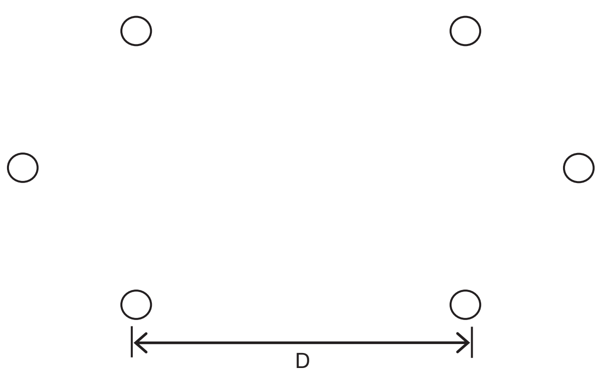
GMR of each conductor is 1.515 cm. Determine the inductance per phase per kilometer of the line.
(A) 0.85 mH/km
(B) 2.6 mH/km
(C) 2.6 H/km
(D) 1.3 mH/km

Answer Keys

2. B	**3.** D	**4.** C	**5.** B	**6.** B	**7.** B	**8.** B	**9.** C	**10.** A	**11.** A
12. B	**14.** D	**15.** B	**16.** A	**17.** D	**18.** B	**19.** B	**20.** D	**21.** B	**22.** A
23. B	**24.** C	**25.** D							

Hints and Explanations

1. If we find the GMD and GMR for the given.
Configuration we will get as



$\text{GMD} = 3^{1/4}\ D = 3^{1/4}$

$\text{GMR} = \sqrt{r \times 2\text{D}} = \sqrt{2 \times 10^{-2} \times 1}$

$$\text{C/ph/m} = \frac{2\pi \in}{\text{lu}\dfrac{\text{GMD}}{\text{GMR}}}$$

$$= \frac{2\pi \times 8.854 \times 10^{-12}}{\text{lu}\dfrac{3^{1/4}}{\sqrt{0.02}}}$$

$C_n = 0.0249$ μF/ph/km.

2. Surge impedance loading α (Voltage)^2

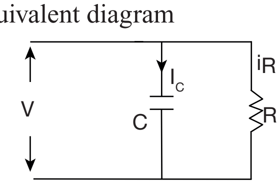
$$\frac{SIL_1}{SIL_2} = \frac{V_1^2}{4V_1^2}$$

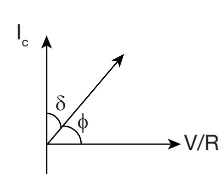
$\Rightarrow\ SIL_2 = 4SIL_1$ Choice (B)

3. Choice (D)

4. Solid conductor Radius = R_1
One conductor Radius in Bundle conductor = r
$\pi R^2 = n\ \pi r^2$
$R = \sqrt{n}\ r = \sqrt{5} \times 10$
= 22.36mm
Diameter of solid conductor = $2R$
= 44.72mm Choice (C)

5. The cable equivalent diagram





The phasor diagram
Power factor cosϕ = cos(90 – δ) = sinδ Choice (B)

6. Choice (B)

7. Spill way acts as safety valve for down and it can be used to discharge excess of water in reservoir. Choice (B)

8. During Ferranti effect the sending voltage less than the receiving end voltage and capacitor current leading the voltage. Choice (B)

9. Choice (C)

10. $K = \dfrac{\text{Number of neutrons of any one generation}}{\text{Number of neutrons of immediately preceding generation}}$

$\therefore$ $K > 1$ means number of neutrons of any one generation is greater than the number of neutrons of immediately preceding generation. Choice (A)

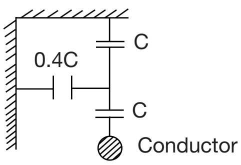
11. $L_{ph} = 0.2\,\ell n\left(\dfrac{4\times 100}{0.7788\times 0.9}\right)$

$= 1.27 \times 10^{-6}$H/ph/m

$X_L = 1.27 \times 10^{-6} \times 2\pi \times 50$

$= 0.398$mΩ/m Choice (A)

12. $K = \dfrac{\text{Shunt capcitance}}{\text{self capacitance}} = 0.4$



The voltage across the unit near to the conductor

= (1 + K) voltage across top most unit

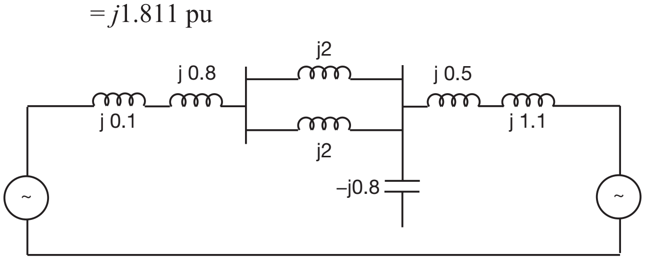
= (1 + 0.4) × 11 = 15.4kV Choice (B)

13. With capacitor SSSL = $\dfrac{E_1E_2}{X_{eq}b/nE_1\ \&\ E_2}$

$X_{eq} = j1.9 + j1.6 + \dfrac{j1.9\times j1.6}{-j1.8}$

$= j3.5 - j1.688$

$= j1.811$ pu



$P_{\max_1} = \dfrac{1.5\times 1}{1.81} = 0.828$ pu

With inductor connection

$P_{\max_2} = \dfrac{E_1E_2}{X_{eq}}$

$X_{eq} = j1.9 + j1.6 + \dfrac{j1.9\times j1.6}{j1.8}$

$= j5.188$

$P_{\max_2} = \dfrac{1.5}{5.18} = 0.289$ pu

Change in SSSL $= P_{\max_1} - P_{\max_2} = 0.539$.

14. Given $C_x = 3C_1 = 0.65$

$C_y = C_1 + 2C_2 = 0.5$

Capacitance between any two conductors = $\dfrac{C_0}{2}$

$C_0 = \dfrac{3}{2}C_y - \dfrac{C_x}{6} = \dfrac{3}{2}\times 0.5 - \dfrac{0.65}{6}$

$= 0.642\mu$F/km

Capacitance between any two conductors

$= 0.321\mu$F/km Choice (D)

15. $D = 8$m

$S = 0.4$m

$R = 15$mm

Self GMR of each group $D_{SR} = (r^1 s)^{1/2}$

$= \sqrt{0.7788\times 15\times 10^{-3}\times 0.4} = 0.0683$m

GMD between bundle conductors

$= D_M^R = \sqrt[3]{(D_{AB}\,D_{BC}\,.D_{CA})} = \sqrt[3]{8\times 8\times 16} = 10.07$m

Inductance of the bundle conductor line

$L_R = 2\times 10^{-7}\ln\left(\dfrac{D_M^R}{D_{SR}^R}\right)$

$= 2\times 10^{-7}\ln\left(\dfrac{10.07}{0.0683}\right)$

$= 0.998$mH/Km Choice (B)

16. Let $X_{C_1} = \dfrac{1}{k}\Omega$

$V_2/V_1 = \dfrac{k+1}{1} \Rightarrow V_2 = V_1(k+1)$

$V_3/V_1 = k^2 + 3k + 1$

$\Rightarrow \dfrac{V_3}{V_2} = \dfrac{1+3k+k^2}{k+1} \Rightarrow \dfrac{18}{13.2} = \dfrac{1+3k+k^2}{k+1}$

$\Rightarrow$ $k = 0.2$

$V_1 = V_2/k + 1 = 13.2/1.2 = 11$ kV

$V_4 = V_1(1 + k^3 + 5k^2 + 6k) = 26.49$ kV

$V_{\text{Total}} = (26.49 + 18 + 13.2 + 11)$ kV = 68.69 kV per phase

$\therefore$ $V_{\text{line}} = \sqrt{3} \times 68.69$ kV = 119 kV Choice (A)

17. Thorium - 232 is a fertile fuel and Heavy water is used as a moderator in nuclear reactor. Choice (D)

18. SIL $= \dfrac{(765)^2}{266.1} = 2199\,\text{MW}$

$l = 300$, $\lambda = 5000$

$$P_{\max} = \frac{1\times1\times2199}{\sin\left(\dfrac{2\pi\times300}{5000}\right)} = 5974\,\text{MW}$$ Choice (B)

19. For zero regulation power factor angle
$\phi = \pi/2$ – impedance angle
$\phi = 90° - 30°$
$= 60°$ Choice (B)

20. Radius of conductor $= \dfrac{1.05}{2} = 0.525\text{cm}$

The ratio $\dfrac{d}{r} = \dfrac{2.5}{0.525}\times100 = 476.19$

$$\sqrt{\frac{r}{d}} = \sqrt{\frac{1}{476.19}} = 0.0458$$

$$\delta = \frac{3.92b}{273+t} = \frac{3.92\times70}{273+25} = 0.92$$

Critical disruptive voltage $V_d = 21.1 \times 0.85\ \delta\ r\ \ell_n\left(\dfrac{d}{r}\right)$

$= 21.1 \times 0.85 \times 0.92 \times 0.525\ \ell n\,(476.19)$
$= 53.41$kV line to neutral

Power loss $= 241\times10^{-5}\left(\dfrac{f+25}{\delta}\right)\sqrt{\dfrac{r}{d}}\,(V-V_d)^2$

$= 241\times10^{-5}\left(\dfrac{75}{0.92}\right)(0.0458)(76.21-53.41)^2$

$= 4.67$kw/phase/km Choice (D)

21. The transmission line may be electrically long or short. For a electrically short line indicates that Bl is shorter angle in degree generally below 10 electrical degree.

$\text{Bl} = \dfrac{2\pi f}{} |$ radians

$= \dfrac{2\pi\times1000}{3\times10^5}\times10\times\dfrac{180}{\pi}$ (elect degree)
$= 12°$.

$\text{Bl} > 10° \Rightarrow$ So electrically long line. Choice (B)

22. Voltage across bottom unit = 0.35 × Voltage across the string

String efficiency $= \dfrac{\text{Voltage across string}}{n\times0.35\times\text{Voltage across the string}}$

$= \dfrac{1}{5\times0.35}\times100 = 57.14\%$ Choice (A)

23. The maximum working voltage

$$V = r\,g_{1\max}\ \ell n\left(\frac{r_1}{r_2}\right) + r_1 g_2 \max\ \ell n\left(\frac{R}{r_1}\right)1$$

$$g_{1\max} = \frac{q}{2\pi\varepsilon_0 r}$$

$$g_{2\max} = \frac{q}{2\pi\varepsilon_0\varepsilon_r r_1}$$

$r\,g_{1\max} = g_{2\max}\ \varepsilon_1\ r_1$

$$\Rightarrow\ g_{2\max} = \frac{r\,g_{1\max}}{\varepsilon_r\ r_1}$$

$$G_{2\max} = \frac{1\times34}{4\times2} = 4.375\text{kV/cm}$$

$$V = 1\times35\ \ell n\left(\frac{2}{1}\right) + 2\times4.375\ \ell n\left(\frac{4}{2}\right)$$

$= 30.32$kV peak Choice (B)

24. $a_{12} = a_{23} = 4$; $a_{13} = 8$; $d/2 = 0.01$m

$a = \sqrt[3]{4\times4\times8} = 5.04$

$$x = 2\pi\ 50 \times 2 \times 10^{-4}\ \ell n\left(\frac{5.04}{0.01}+\frac{1}{4}\right)$$

$= 0.0628\ \ell n(504 + 0.25) = 0.41\ \Omega$/km/phase Choice (C)

25. GMD $= \sqrt[3]{8\times8\times16} = 10.0794$ m

$$L = \frac{0.2\times10.0794}{1.515\times10^{-2}} = 1.3\,\text{mH/km}$$ Choice (D)