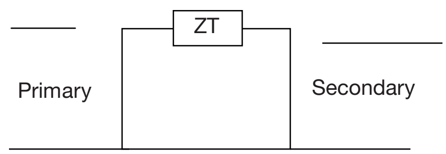
Power Systems Test 4

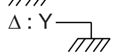
Number of Questions: 25 **Section Marks: 90**

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

1. A zero sequence network of a 3 - phase transformer as shown in the below figure
The corresponding transformer connection is



(A) $Y : Y$
(B) 

(C) $\Delta : \Delta$
(D) 

2. By increasing the voltage level two times, the surge impedance loading of a transmission line is
(A) Increased by two times
(B) Increased by four times
(C) Remains same
(D None of the above

3. The Bundle conductor
(A) reduces corona loss
(B) increases corona loss
(C) increases surge impedance
(D) reduces power loss

4. The daily energy produced in a thermal power station is 800Mwh and maximum demand on the station is 100MW. Then the load factor of the station is ———
(A) 0.80
(B) 0.34
(C) 0.12
(D) 0.22

5. Characteristic Impedance of a loss less transmission line is
(A) $\sqrt{\dfrac{r - j\omega C}{g + j\omega L}}$
(B) $\sqrt{\dfrac{r + j\omega L}{g + j\omega C}}$
(C) $\sqrt{(r + j\omega L)(g + j\omega C)}$
(D) $\sqrt{(r - j\omega C)(g + j\omega L)}$

6. Given equation
$x_1 + x_1 x_2 = 10$
$x_1 + x_2 = 6$
and initial estimates $x_1^{(0)} = 1; x_2^{(0)} = 1$, what are the x_1, x_2 values after third iteration of Gauss – seidel method?
(A) 1, 5
(B) 1, 1
(C) 5, 5
(D) 5, 1

7. Calculate the surge impedance loading of a loss less 400kV, 3 - phase, 60Hz over head line if the average value of surge impedance is 500ohms.
(A) 500MW
(B) 400MW
(C) 320MW
(D) 300MW

8. Which of the following distribution system is more reliable
(A) Radial system
(B) Ring main system
(C) Inter connected system
(D) 2 - Wire system

9. Given system of equations
$x_1^2 - 2x_1 - x_2 = 3$
$x_1^2 + x_2^2 = 41$
What is the last element of the jacobian matrix for this system?
(A) $3x_2$
(B) -1
(C) $2x_1$
(D) $2x_2$

10. In power system load flow studies bus admittance matrix is
(A) Null matrix
(B) Full matrix
(C) Sparse matrix
(D) Diagonal matrix

11. Let the voltages in three phases be $V_a = 8\angle 0^o$, $V_b = 6\angle{-90^o}$ and $V_C = 16\angle 143.1^o$, the positive, negative and zero sequence voltages are

(A) $\begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 9.8\angle 18\cdot 4^\circ \\ 2\angle 143\cdot 1^\circ \\ 4.3\angle -86\cdot 2^\circ \end{bmatrix}$

(B) $\begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 2\angle 143\cdot 1^\circ \\ 9\cdot 8\angle 18\cdot 4^\circ \\ 4.3\angle -86\cdot 2^\circ \end{bmatrix}$

(C) $\begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 2\angle 143\cdot 1^\circ \\ 4.3\angle -86\cdot 2^\circ \\ 9\cdot 8\angle 18\cdot 4^\circ \end{bmatrix}$

(D) $\begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 4.3\angle -86\cdot 2^\circ \\ 9\cdot 8\angle 18\cdot 4^\circ \\ 2\angle 143\cdot 1^\circ \end{bmatrix}$

12. The surge impedance for the overhead line and cable are 450 ohms and 50 ohms respectively. If the 30kV surge is transmitted in to the cable calculate the surge travels along an overhead line
(A) 3kV
(B) 150kV
(C) 24kV
(D) 37.5kV

13. Z_{bus} for a given system is

$$Z_{bus} = j\begin{bmatrix} 0.24 & 0.14 & 0.2 & 0.2 \\ 0.14 & 0.2275 & 0.175 & 0.175 \\ 0.2 & 0.175 & 0.310 & 0.310 \\ 0.2 & 0.175 & 0.310 & 0.5 \end{bmatrix}$$

A belted three phase fault occurs at bus 4. What is the bus voltage during fault?

(A) 0.84 p.u (B) 1.24 p.u
(C) 0 p.u (D) 0.5 p.u

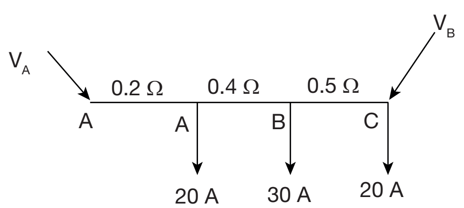
14. The incremental cost characteristics of the two units in a plant are given by

$I_{C1} = 0.2P_1 + 6.0$Rs/Mwh
$I_{C2} = 0.4P_2 + 5.0$Rs/Wh

Calculate the total load 500MW supplied by each plant

(A) $P_1 = 168.34$MW, $P_2 = 331.66$MW
(B) $P_1 = 250$MW, $P_2 = 250$MW
(C) $P_1 = 331.66$MW, $P_2 = 168.34$MW
(D) $P_1 = 300$MW , $P_2 = 200$MW

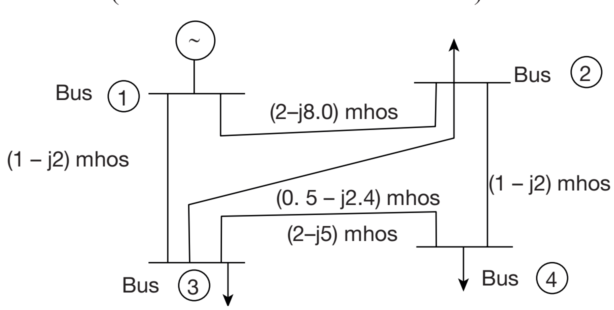
15. A d. c distribution system as shown in figure



The two ends of the feeder are fed by voltage sources such that $V_A - V_B = 5$V. Calculate the value of the voltage V_A for a minimum voltage of 300V at any point along the feeder

(A) 298.90V (B) 287.27V
(C) 312.72V (D) 301.09V

16. For the following single line diagram, power flows as given in the below table then calculate the second bus voltage at the end of first iteration using Gauss – seidal method. (Assume acceleration factor is 1.5)

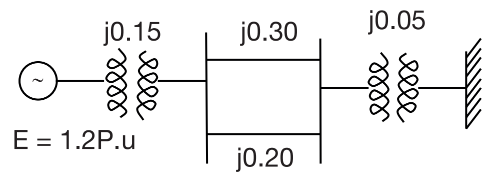


Bus code	P	Q	V
1	–	–	1.05
2	0.4	0.2	1.0
3	0.3	0.1	1.0
4	0.2	0.1	1.0

(A) 1.0∠–1.65° (B) 1.0∠–4.12°
(C) 1.0∠–1.85° (D) 1.0∠1.65°

17. The 20 MVA generator supplying rated power at 0.8 pf (tag) when a fault reduces the electric power output by 50%. The power input to the generator may be assumed constant. Losses may be neglected. The accelerating torque at the time of the fault is ____________ N–m.

18. When the following system is operating under normal condition, the maximum power transmitted from generating station to infinite bus is _____
Infinite bus $V = 1.0\angle 0°$

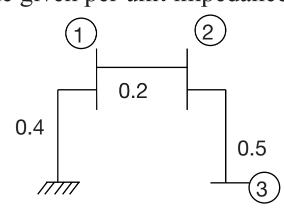


(A) 1.71P.u (B) 1.2P.u
(C) 2.67P.u (D) 3.0P.u

19. An overhead line with surge impedance of 500Ω is terminated through a resistance of Z. A surge travelling over the line has a reflection coefficient of 0.8 then the value of Z is

(A) 500Ω (B) 900Ω
(C) 4500Ω (D) 1250Ω

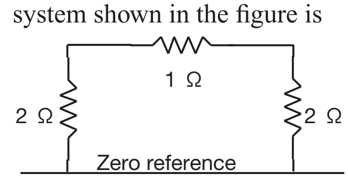
20. The bus admittance matrix of the following network is _____ [For the given per unit impedance values]



(A) $\begin{bmatrix} -5.25 & 5 & 0 \\ 5 & -7 & 2 \\ 0 & 2 & -2 \end{bmatrix}$ (B) $\begin{bmatrix} 5.25 & -5 & 0 \\ -5 & 7 & -2 \\ 0 & -2 & 2 \end{bmatrix}$

(C) $\begin{bmatrix} -7.25 & 5 & 2 \\ 5 & -7 & 2 \\ 2 & 2 & -4 \end{bmatrix}$ (D) $\begin{bmatrix} -0.6 & 0.2 & 0 \\ 0.2 & -0.7 & 0.5 \\ 0 & 0.5 & 0.5 \end{bmatrix}$

21. With the usual notations the impedance matrix for the system shown in the figure is



(A) $\begin{bmatrix} 3 & 1 \\ 1 & 3 \end{bmatrix}$ (B) $\begin{bmatrix} 3/8 & -1/3 \\ -1/8 & 3/8 \end{bmatrix}$

(C) $\begin{bmatrix} 6/5 & 4/5 \\ 4/5 & 6/5 \end{bmatrix}$ (D) $\begin{bmatrix} 5 & 4 \\ 4 & 5 \end{bmatrix}$

22. A $1-\phi$ transformer is having primary winding impedance in pu $Z_{1(PU)} = (0.1 + j0.8)$, secondary winding impedance in pu $Z_{2(PU)} = (0.2 + j1.8)$ pu. What is the per unit equivalent impedance referred to secondary side of transformer.

(A) $0.1 + j0.8$ (B) $0.2 + j1.8$
(C) $0.3 + j2.6$ (D) Insufficient data

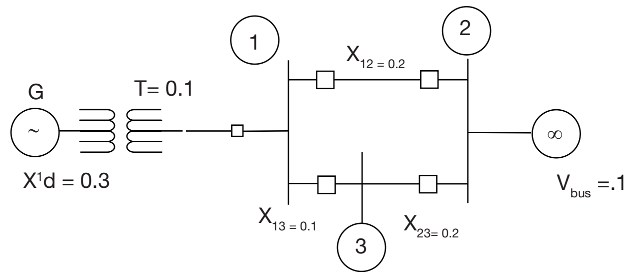
23. The maximum voltage drop of uniformly loaded *d. c* distributor fed at one end is 40V. If the same distributor fed at both end with equal voltages then the corresponding maximum voltage drop is

(A) 40 V (B) 20 V
(C) 160 V (D) 10 V

24. The per unit impedance of an alternator corresponding to base values 132kV and 100MVA is 0.4P.u. calculate the per unit impedance value for the base value of 66kV and 250MVA.

(A) 0.8 (B) 0.2
(C) 2 (D) 4

25.



Given the above 60 Hz system (all values in p.u), if the infinite bus draws real power of 1 p.u at 0.95 pf lagging, the internal voltage of the generator is ______.

(A) 1.05V (B) 1.18V
(C) 1.28V (D) 1.32V

Answer Keys

1. C	**2.** B	**3.** A	**4.** B	**5.** B	**6.** D	**7.** C	**8.** C	**9.** D	**10.** C
11. B	**12.** B	**13.** C	**14.** C	**15.** C	**16.** B	**17.** 50929.52 N–m		**18.** C	**19.** C
20. B	**23.** D	**24.** D	**25.** C						

Hints and Explanations

1. Choice (C)

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 (A)

4. Load factor $= \dfrac{\text{average demand}}{\text{maximum demand}}$

$$= \frac{800\times10^6}{24\times100\times10^6} = 0.34$$ Choice (B)

5. Choice (B)

6. $x_1 = \dfrac{10}{1+x_2}$; $x_2 = 6 - x_1$

$x_1^{(1)} = \dfrac{10}{1+1} = 5$	$x_1^{(2)} = \dfrac{10}{1+1} = 5$
$x_2^{(1)} = 6 - 5 = 1$	$x_2^{(2)} = 6 - 5 = 1$

and the same for third iteration. Choice (D)

7. Surge impedance loading $P = \dfrac{V^2}{Z_c} = \dfrac{400\times400}{500}$

$= 320$ M W Choice (C)

8. Choice (C)

9. $J = \begin{bmatrix} 2x_1 - 2 & -1 \\ 2x_1 & 2x_2 \end{bmatrix} \left(\text{Jacobian} = \begin{bmatrix} \dfrac{\partial f_1}{\partial x_1} & \dfrac{\partial f_1}{\partial x_2} \\ \dfrac{\partial f_2}{\partial x_1} & \dfrac{\partial f_2}{\partial x_2} \end{bmatrix}\right)$

Hence, last element $= 2x_2$ Choice (D)

10. In load flow studies BUS admittance matrix is sparse matrix because most of the elements are zero.

Choice (C)

11. $V_S = \dfrac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}[V_P]$

$$\Rightarrow V_s = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}\begin{bmatrix} 8\angle 0^o \\ 6\angle -90^o \\ 16\angle -143.1^o \end{bmatrix}$$

$$\begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 2\angle 143.1^o \\ 9.8\angle 18.4^o \\ 4.3\angle -86.2^o \end{bmatrix}$$

Choice (B)

12. The voltage in overhead line $= 30\times\dfrac{500}{2\times50}$

$= 150$kV Choice (B)

13. $I_4 = \frac{V_4(0)}{Z_{44}} = \frac{1.0}{j0.5} = -j2\,p.u$

$V_4(f) = V_4(0) - Z_{44}\, I_4(f) = 1 - j0.5 \times (-j2) = 0$ p.u

(Since the bus is solidly connected to ground during fault voltage should anyway be zero volts)

Choice (C)

14. $P_1 + P_2 = 500\text{MW}$ ——(1)

$0.2P_1 + 6 = 0.4P_2 + 5.0$

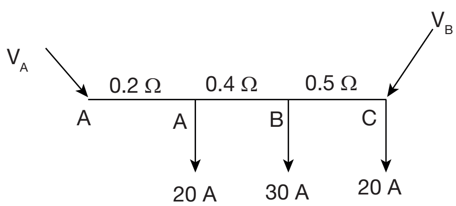
$0.2P_1 - 0.4P_2 = -1$

$\Rightarrow\ 4P_2 - 2P_1 = 10$ ——(2)

Solving (1) and (2)

$P_1 = 331.66\text{MW},\ P_2 = 168.34\text{MW}$ Choice (C)

15.



$V_A - V_B = I \times 0.2 + (I - 20)\,0.4 + (I - 50)\,0.5$

$5 = I(1.1) - 8 - 25$

$I = \frac{38}{1.1} = 34.54\text{A}$

Direction of current will be opposite in BC section

$V_A = 300 + (34.54 \times 0.2) + (34.54 - 20) \times 0.4$

$= 312.724\text{V}$ Choice (C)

16. $V^1_2 = \frac{1}{y_{22}}\left[\frac{P_2 - jQ_2}{V_2^*} - y_{21}V_1^\circ - y_{23}V_3^\circ - y_{24}V_4^\circ\right]$

$$= \frac{1}{3.5 - j10.4}\left[\begin{array}{l}\frac{-0.4 + j0.2}{1} - (-2 + j6)1.05 \\ -(-0.5 + j2.4)1.0 - (-1 + j2)1.0\end{array}\right]$$

$= 1.0\angle{-1.6508°}$

$V^1_{2acc} = (1.0\angle{-1.6508}) + 1.5\,(1.0\angle{-1.6508} - 1.0\angle 0)$

$= 1.0\angle{-4.123}$ Choice (B)

17. Output power before fault $(P_S) = 20000 \times 0.8$

$= 16000$ kW.

Accelerating power $P_e = 0.5 \times 16000$

$= 8000$ kW

$P_a = P_S - P_e$

$= 16000 - 8000$

$T_a W_s = P_a$

$$T_a = \frac{8000}{2\pi \times \frac{120 \times 50}{4 \times 60}}$$

$= 50929.52$ N-m.

18. $P_{\max} = \frac{EV}{X_{eq}}$

$X_{eq} = j0.15 + j0.05 + j0.25$

$= j0.45\Omega$

$P_{\max} = \frac{1.2 \times 1.0}{0.45} = 2.67$P.u Choice (C)

19. Reflection coefficient $= \frac{Z - 500}{Z + 500}$

$0.8 = \frac{Z - 500}{Z + 500}$

$0.8Z + 0.8 \times 500 = Z - 500$

$400 + 500 = 0.2Z$

$Z = \frac{9000}{2} = 4500\Omega$ Choice (C)

20. $Y_{11} = \frac{1}{0.4} + \frac{1}{0.2} = 5.25$

$Y_{12} = Y_{21} = -\frac{1}{0.2} = -5$

$Y_{13} = Y_{31} = 0$

$Y_{22} = \frac{1}{0.2} + \frac{1}{0.5} = 7$

$Y_{23} = Y_{32} = -\frac{1}{0.5} = -2$

$Y_{33} = \frac{1}{0.5} = 2$ Choice (B)

21. $[Z]_{1\times 1} = [2]$

$[Z]_{2\times 2} = \begin{bmatrix} 2 & 2 \\ 2 & 3 \end{bmatrix}$

$[Z]_{2\times 2} = \left[\begin{bmatrix} 2 & 2 \\ 2 & 3 \end{bmatrix} - \left(\frac{1}{3+2}\right)\begin{bmatrix} 2 \\ 3 \end{bmatrix}\begin{bmatrix} 2 & 3 \end{bmatrix}\right]$

$[Z]_{2\times 2} = \left[\begin{bmatrix} 2 & 3 \\ 2 & 3 \end{bmatrix} - \left(\frac{1}{5}\right)\begin{bmatrix} 4 & 6 \\ 6 & 9 \end{bmatrix}\right]$

$[Z]_{2\times 2} = \left[\begin{bmatrix} 2 & 2 \\ 2 & 3 \end{bmatrix} - \begin{bmatrix} 4/5 & 6/5 \\ 6/5 & 9/5 \end{bmatrix}\right]$

$[Z]_{2\times 2} = \begin{bmatrix} 6/5 & 4/5 \\ 4/5 & 6/5 \end{bmatrix}$

(or) By using Z parameters of two port networks.

Choice (C)

22. $Z_{02(PU)} = \left(\dfrac{Z_1K^2 + Z_2}{Z_{base2}}\right)$

$= \left(\dfrac{Z_1K^2}{Z_{base2}} + \dfrac{Z_2}{Z_{base2}}\right)$ [In transformer $Z_{2base} = K^2 Z_{1\,base}$]

$= \left(\dfrac{Z_1}{\frac{Z_{base2}}{K^2}} + \dfrac{Z_2}{Z_{base2}}\right)$

$= \left(\dfrac{Z_1}{Z_{base1}} + \dfrac{Z_2}{Z_{base2}}\right)$

$= Z_{1(PU)} + Z_{2(PU)}$

$\therefore Z_{01(PU)} = Z_{02(PU)} = Z_{1(PU)} + Z_{2(PU)}$

$= (0.3 + j2.6)$ Choice (C)

23. The maximum voltage drop fed at both ends

$= \dfrac{1}{4}\times$ The maximum voltage drop fed at one end

$= \dfrac{1}{4}\times 40 = 10V$ Choice (D)

24. The new per unit value

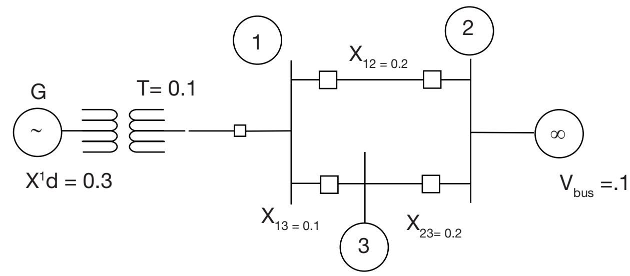
$$Z_{new} = 0.4\left(\frac{MVA_{new}}{MVA_{old}}\right)\left(\frac{kV_{old}}{kV_{new}}\right)^2$$

$$= 0.4\left(\frac{250}{100}\right)\left(\frac{132}{66}\right)^2$$

$= 4P.u.$ Choice (D)

25. Equivalent circuit;

$X_{eq} = X_d^1 + X_{TR} + X_{12} \parallel (X_{13} + X_{23}) = 0.52$ pu



Current to the infinite bus is

$$I = \frac{P}{V_{bus}\,(p.f)}\angle\cos^{-1}(pf) = \frac{1}{1\times 0.95}\angle -\cos^{-1}(0.95)$$

$= 1.0526\ \angle -18.195^\circ$ pu

$E\ \angle\ \delta = V_{bus} + jX_{eq}I$

$= 1\ \angle\ 0^\circ + j0.52(1.0526\ \angle -18.195^\circ)$

$= 1.2812\ \angle\ 23.946^\circ$ pu Choice (C)