(1) A.

Power Test Mansi Suriyal 19EE10039.

2/3/2022.

Q1. A four bus power system.

Bus 2 → slack bus. $V(B_2) = 1.0\,V$, $\angle\theta = 0°$

Base MVA = 100

$y_{12} = (5-15j)$ pu

$y_{23} = (1.25 - 3.75j)$ pu

$y_{34} = (1.67 - 5j)$ pu

$P_{L_1} + jQ_{L_1} = (20+15j)$ MVA.

$P_{L_2} + jQ_{L_2} = (10+5j)$ MVA

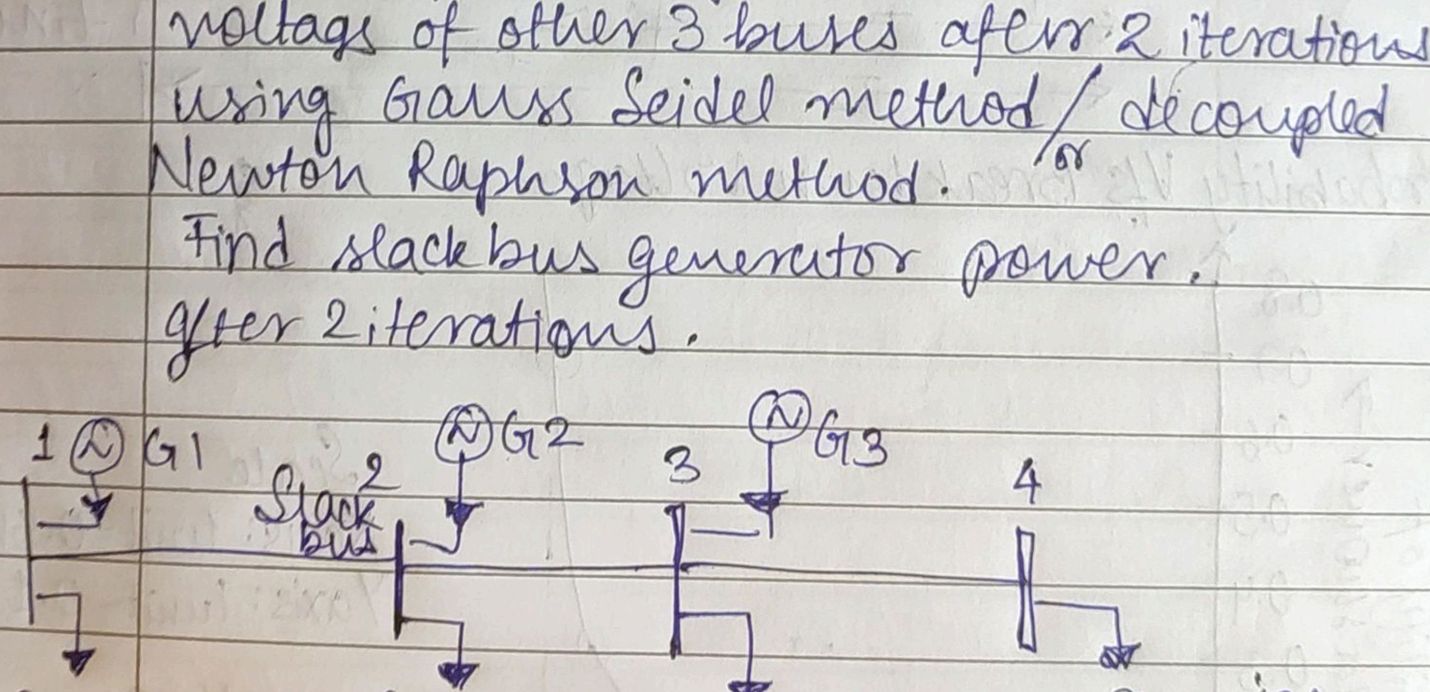
$P_{L_3} + jQ_{L_3} = (25+15j)$ MVA

$P_{L_4} + jQ_{L_4} = (20+10j)$ MVA.

$P_{g_1} + jQ_{g_1} = (6+6j)$ MVA

assume flat voltage start. Find out voltags of other 3 buses after 2 iterations using Gauss Seidel method / or decoupled Newton Raphson method.

Find slack bus generator power after 2 iterations.



1 B.

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Answer 1:

$P_1 = P_{g_1} - P_{L_1} = -14\,MVA = -0.14\,pu$
$Q_1 = Q_{g_1} - Q_{L_1} = -9\,MVA = -0.09\,pu.$

$P_2 = P_{g_2} - P_{L_2} = -10\,MVA = -0.1\,pu$
$Q_2 = Q_{g_2} - Q_{L_2} = -5\,MVA = -0.05\,pu$

Similarly

$P_3 = -0.25\,pu$
$Q_3 = -0.15\,pu$
$P_4 = -0.2\,pu$
$Q_4 = -0.1\,pu.$

Bus matrix :-

$Y_{11} = y_{12} + y_{13} + y_{14} = 5 - 15j\,pu = 15.84 \angle -71.56^\circ$

$Y_{22} = y_{12} + y_{23} + y_{24} = 6.25 - 18.75j\,pu = 19.76 \angle -71.56^\circ$

$Y_{33} = y_{31} + y_{32} + y_{34} = 2.92 - 8.75j\,pu = 9.224 \angle -71.54^\circ$

$Y_{44} = y_{41} + y_{42} + y_{43} = 1.67 - 5j\,pu = 5.27 \angle -71.53^\circ$

$Y_{12} = Y_{21} = -y_{12} = -5 + 15j$
$Y_{13} = Y_{31} = -y_{13} = 0$
$Y_{14} = Y_{41} = 0.$

① c.

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Answer 1:

$$Y_{23} = Y_{32} = -1.25 + j\,3.75$$

$$Y_{24} = Y_{42} = 0$$

$$Y_{34} = Y_{43} = -1.67 + 5j$$

$$V_2 = 1.0 \angle 0^\circ$$

$$Y = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} & Y_{14} \\ Y_{21} & Y_{22} & Y_{23} & Y_{24} \\ Y_{31} & Y_{32} & Y_{33} & Y_{34} \\ Y_{41} & Y_{42} & Y_{43} & Y_{44} \end{bmatrix}$$

$$Y = \begin{bmatrix} 15.84\angle -71.56^\circ & -5+15j & 0 & 0 \\ -5+15j & 19.76\angle -71.56^\circ & -1.25+j3.75 & 0 \\ 0 & -1.25+j3.75 & 9.224\angle -71.54^\circ & -1.67+5j \\ 0 & 0 & -1.67+5j & 5.27\angle -71.53^\circ \end{bmatrix}$$

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<u>Answer 1</u>:
Gauss - Si

$$V_i^{(P+1)} = \frac{1}{Y_{ii}}\left[\frac{P_i - jQ_i}{(V_i^{(P)})^*} - \sum_{\substack{k=1 \\ k\neq i}}^{4} Y_{ik}\cdot V_k\right].$$

$$V_2^{(0)} = 1\angle 0 = V_1^{(0)} = V_3^{(0)} = V_4^{(0)}$$

<u>Iteration 1</u>:-

$$V_1^{(1)} = \frac{1}{Y_{11}}\left(\frac{P_1 - jQ_1}{(V_1^{(0)})^*} - Y_{12}V_2^{(0)} - Y_{13}V_3^{(0)} - Y_{14}V_4^{(0)}\right]$$

$$= \frac{1}{5-15j}\left[-0.14 + 0.009j + 5 - 15j\right]$$

$$V_1^{(1)} = 0.991\angle 0.38^\circ \text{ pu}.$$

$$V_3^{(1)} = \frac{1}{Y_{33}}\left[\frac{P_3 - jQ_3}{(V_3^{(0)})^*} - Y_{31}V_1^{(0)} - Y_{32}V_2^{(0)} - Y_{34}V_4^{(0)}\right]$$

$$= 0.976\angle -1.21^\circ \text{ pu}.$$

① E

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Answer 1:

$$V_4^{(1)} = \frac{1}{Y_{44}}\left[\frac{P_4 - jQ_4}{(V_4^{(0)})^*} - Y_{41}V_1^{(0)} - Y_{42}V_2^{(0)} - Y_{43}V_3^{(0)}\right]$$

$$V_4^{(1)} = 0.970 \angle -1.77^\circ \text{ pu.}$$

Iteration 2:

$$V_1^{(1)} = 0.991 \angle -0.38^\circ \text{ pu}$$

$$V_2^{(1)} = 1\angle 0^\circ \text{ (pu)} \longrightarrow \text{slack bus}$$

$$V_3^{(1)} = 0.976 \angle -1.21^\circ \text{ pu}$$

$$V_4^{(1)} = 0.970 \angle -1.77^\circ \text{ pu.}$$

$$V_1^{(2)} = \frac{1}{Y_{11}}\left[\frac{P_1 - jQ_1}{(V_1^{(1)})^*} - Y_{12}V_2^{(1)} - 0 - 0\right],$$

$$\boxed{V_1^{(1)} = 0.9917 \angle -0.38^\circ \text{ pu}}$$

$$V_3^{(2)} = \frac{1}{Y_{33}}\left[\frac{P_3 - jQ_3}{(V_3^{(1)})^*} - Y_{31}V_1^{(1)} - Y_{23}V_2^{(1)} - Y_{34}V_4^{(1)}\right]$$

$$\boxed{V_3^{(2)} = 0.959 \angle -2.31^\circ \text{ pu}}$$

$$V_4^{(2)} = \frac{1}{Y_{44}}\left[\frac{P_4 - jQ_4}{(V_4^{(1)})^*} - 0 - 0 - Y_{43}V_3^{(1)}\right]$$

$$\boxed{V_4^{(2)} = 0.945 \angle -3.06^\circ \text{ pu}}$$

① F.

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Answer 1

$V_1^{(2)} = 0.9917 \angle -0.38° pu.$

$V_2^{(2)} = 1\angle 0° pu \longrightarrow$ slack bus

$V_3^{(2)} = 0.959\angle -2.31° pu$

$V_4^{(2)} = 0.945° \angle -3.06° pu.$

Slack Bus generator power: $\longrightarrow$

$$P_2 = \sum_{k=1}^{4} |V_2||V_k||Y_{2k}| \cos(\theta_{2k} - \delta_2 + \delta_k)$$

$$P_2 = |V_1||V_2||Y_{21}| \cos(\theta_{12} - \delta_2 + \delta_1)$$

$$+ |V_2|^2 |Y_{22}| \cos(\theta_{22})$$
$$+ |V_2||V_3||Y_{23}| \cos(\theta_{23} - \delta_2 + \delta_3)$$
$$+ |V_2||V_4||Y_{24}| \cos(\theta_{24} - \delta_2 + \delta_4)$$

$$\boxed{P_2 \simeq 0.154 \, Pu = 15.4 MW}$$

$$Q_2 = -\sum_{k=1}^{4} |V_2||V_k||Y_{2k}| \sin(\theta_{2k} - \delta_2 + \delta_k)$$

$$\boxed{\begin{aligned} Q_2 &= 0.0938 \, pu \\ &= 9.38 MW \end{aligned}}$$

(2) A.

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Q2. A 3 ϕ transmission line has resistance and capacitance per ϕ of $10\,\Omega$, 0.1 H, 0.9 micro F. and delivers a load of 35 MW at 132 kV and 0.8 pf lagging. System frequency = 50 Hz.

Determine efficiency and regulation of line using
(a) nominal-pi and
(b) exact solution method.

Q. 2 B.

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Answer 2:

$R = 10\,\Omega$

$L = 0.1\,H$

$C = 0.9\,\mu F$

$X = j2\pi f L = j2\pi \times 50 \times 0.1 = j31.41\,\Omega$

$Y = j\omega C = j2\pi \times 50 \times 0.9 \times 10^{-6}$

$= j282.74 \times 10^{-6}$ mho

$Z = 10 + j31.41\,\Omega$

$= 32.96 \angle 72.34^\circ\,\Omega$.

Load = 35 MW, 132 kV, 0.8 lagging

$\sqrt{3}\,|I_R| \times 132 \times 0.8 = 35 \times 1000$

$|I_R| = 191.35$ A at 0.8 pf lag

$|V_R| = \dfrac{132}{\sqrt{3}}$ kV $= 76.21$ kV.

recieving end current

recieving end voltage.

②c

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Answer 2:
(a)

Nominal-pi method

$$V_S = \left(1 + \frac{ZY}{2}\right) V_R + Z I_R$$

where $I_R = 191.35 \angle -36.87° \; A$
$V_R = 76.21 \angle 0° \; kV$

$$V_S = \left(1 + \frac{32.96 \angle 72.34° \times j \times 282 \times 10^{-6}}{2}\right) V_R + 32.96 \angle 72.34° \, I_R$$

$$\boxed{V_S = 81.09 \angle 2.66° \; kV}$$

$$V_{S_{L-L}} = \sqrt{3} V_S = 140.45 \angle 2.66° \; kV$$

voltage regulation $V_R = \dfrac{\dfrac{|V_S|}{|A|} - |V_R|}{|V_R|}$ $\left\{ A \rightarrow 1 + \dfrac{ZY}{2} \right.$

$$V_R = \frac{\dfrac{140.45}{0.995} - 132}{132} = 6.9\%$$

Answer

(2) D

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Answer 2:

Powerloss/phase $= |I|^2 R$
$= (191.35)^2 \times 10 \times 10^{-6}$ MW
$= \underline{0.366 \text{ MW}}$

perphase recieving end power
$= \frac{35}{3}$ MW $= \underline{11.67 \text{ MW}}$

perphase sending end power
$= P_s = \frac{35}{3} + 0.366$

$= \underline{12.032 \text{ MW}}$

efficiency (η) $= \frac{11.67}{12.032} = 96.99\%$

Answer

2 E.

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Answer 2:

(b) Exact Solution Method

$\gamma_L = \sqrt{zy} = 0.096\angle 81.17^\circ$

$z_c = \sqrt{\frac{z}{y}} = 341.42\angle -8.83^\circ$

$A = \left(1 + \frac{yz}{2}\right) = 0.995\angle 0.081^\circ$

$\sinh(\gamma_L) = \sqrt{yz}\left(1 + \frac{yz}{6}\right)$

$= 0.095\angle 81.14^\circ$

$B = z_c \sinh(\gamma_L) = 32.434\angle 72.36^\circ$

$V_S = AV_R + BI_R$

$V_S = 80.967\angle 2.62^\circ$ kV

$V_{S_{L-L}} = \sqrt{3}V_S = 140.239\angle 2.62^\circ$ kV.

voltage regulation $V_R = \frac{\frac{|V_S|}{|A|} - |V_R|}{|V_R|} = 6.77\%$

Answer

(2) F.

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Power loss per phase
$= |I|^2 R = 0.366$ MW

Per phase recieving end power
$= \frac{35}{3}$ MW $= 11.67$ MW

Per phase sending end power
$= \frac{35}{3} + 0.366 = 12.032$ MW

efficiency $(\eta) = \frac{11.67}{12.032}$
$= 96.99\%$ Answer.