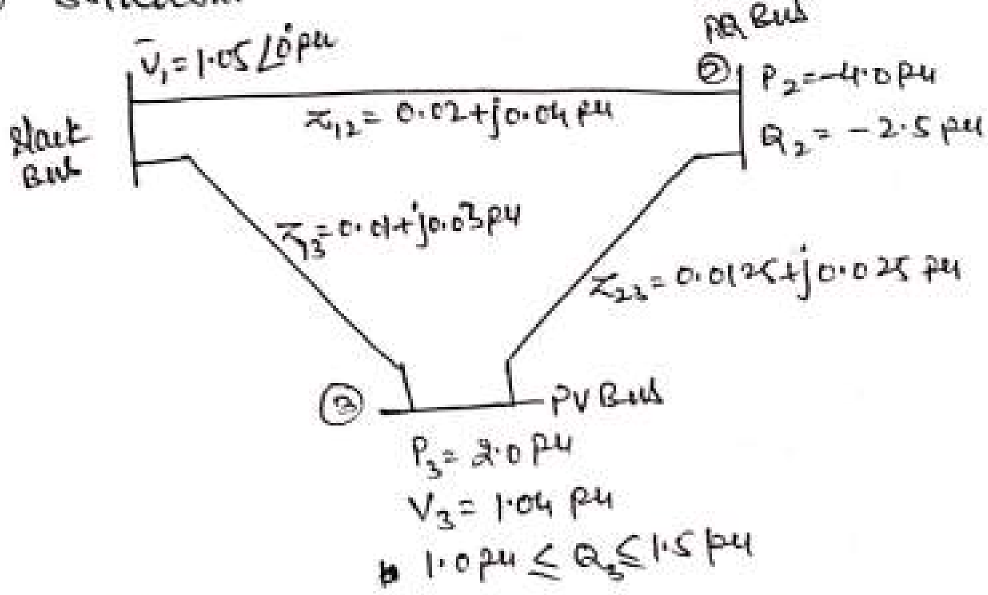
Qus- For the 3-bus system shown in fig., use fast DLF method to obtain one iteration of the load flow solution.



Sol.

$$Y_{Bus} = \begin{bmatrix} 20-j50 & -10+j20 & -10+j30 \\ -10+j20 & 26-j52 & -16+j32 \\ -10+j30 & -16+j32 & 26-j62 \end{bmatrix}$$

$$\left[\frac{\Delta P}{V}\right] = -[B_P][\Delta\delta]$$

$$\left[\frac{\Delta Q}{V}\right] = -[B_Q][\Delta V]$$

Assume $V_2^0 = 1.0$ pu $\quad \delta_2^0 = \delta_3^0 = 0^\circ$

$$\begin{bmatrix} \frac{\Delta P_2}{V_2} \\ \frac{\Delta P_3}{V_3} \end{bmatrix} = -[B_P]\begin{bmatrix} \Delta\delta_2 \\ \Delta\delta_3 \end{bmatrix}$$

$$\frac{\Delta Q_i^0}{V_i^0} = -\sum_{k=2}^{m} B_{ik}^{\prime\prime}\,\Delta V_k$$

$$B_Q = [-52]$$

$$\frac{\Delta P_i^0}{V_i^0} = -\sum_{j=2}^{n=3} B_{ij}^{\prime}\,\Delta\delta_j$$

$$B_P = \begin{bmatrix} -52 & 32 \\ 32 & -62 \end{bmatrix}$$

After I^{st} iteration the value of $\Delta\delta_2^1$ & $\Delta\delta_3^1$

$$\begin{bmatrix} \frac{\Delta P_2^0}{V_2^0} \\ \frac{\Delta P_3^0}{V_3} \end{bmatrix} = -[B_P] \times \begin{bmatrix} \Delta\delta_2^1 \\ \Delta\delta_3^1 \end{bmatrix}$$

$$\Delta P_2^0 = P_2^{s} - P_2^{cal.}$$

$$P_{2=i}^{cal} = V_2 \sum_{k=1}^{n=3} Y_{ik} V_k \cos(\theta_{ik} + \delta_k - \delta_i)$$

$i=2$

$$P_2^{cal} = V_2 \sum_{k=1}^{3} Y_{2k} V_k \cos(\theta_{2k} + \delta_k - \delta_2)$$

$$= V_2 \left[Y_{21} V_1 \cos(\theta_{21} + \delta_1 - \delta_2) + Y_{22} V_2 \cos(\theta_{22}) + Y_{23} V_3 \cos(\theta_{23} + \delta_3 - \delta_2) \right]$$

$$= V_2 \left[22.36 \times 1.05 \cos(116.52) + 58.13 \times 1 \cos(-63.43) + 35.77 \times 1.04 \cos(116.56) \right]$$

$$= V_2 [-10.49 + 26.03 - 16.63]$$

$$= 1.0 \times (-1.12)$$

$$= \underline{-1.12 \text{ pu}}$$

$$\Delta P_2^0 = -4 - (-1.12)$$

$$= -2.88 \text{ pu.}$$

$$\Delta P_3^0 = P_3^{s} - P_3^{cal.}$$

$$P_3^{cal} = V_3 \left[Y_{31} V_1 \cos(\theta_{31} + \delta_1 - \delta_3) + Y_{32} V_2 \cos(\theta_{32} + \delta_2 - \delta_3) + Y_{33} V_3 \cos(\theta_{33} + \delta_3 - \delta_3) \right]$$

$$= 1.04 \left(31.62 \times 1.05 \cos(108.43) + 35.77 \times 1 \times \cos(116.56) + 67.23 \times 1.04 \cos(-67.24) \right)$$

$$= 1.04 (-10.49 - 15.99 + 27.05)$$

$$= 0.59 \text{ pu}$$

$$\Delta P_3^0 = 2 - 0.59 = \underline{1.407 \text{ pu.}}$$

$$\begin{bmatrix}\Delta\delta_2^1\\ \Delta\delta_3^1\end{bmatrix} = -[B_P]^{-1}\begin{bmatrix}\frac{\Delta P_2^0}{V_2^0}\\ \frac{\Delta P_3^0}{V_3}\end{bmatrix} \qquad -[B_P] = \begin{bmatrix}52 & -32\\ -32 & 62\end{bmatrix}$$

$$[-B_P]^{-1} = \frac{1}{2200}\begin{bmatrix}62 & 32\\ 32 & 52\end{bmatrix}$$

$$= \begin{bmatrix}0.028 & 0.0146\\ 0.0146 & 0.0236\end{bmatrix}\begin{bmatrix}\frac{-2.88}{1.0}\\ \frac{1.407}{1.04} = 1.353\end{bmatrix}$$

$$\begin{bmatrix}\Delta\delta_2^1\\ \Delta\delta_3^1\end{bmatrix} = \begin{bmatrix}-0.061\\ -0.010\end{bmatrix}$$

$$\begin{bmatrix}\delta_2^1\\ \delta_3^1\end{bmatrix} = \begin{bmatrix}\delta_2^{0\to 0} + \Delta\delta_2^1\\ \delta_3^{0\to 0} + \Delta\delta_3^1\end{bmatrix}$$

$$= \begin{bmatrix}-3.49^\circ\\ -0.57^\circ\end{bmatrix}$$

$$\begin{bmatrix}\frac{\Delta Q_2^0}{V_2^0}\end{bmatrix} = -[B_{22}]\Delta V_2^0$$

$$\Delta Q_2^0 = Q_2^1 - Q_2^{cal.}$$

$$Q_2^{cal} = -V_2\sum_{k=1}^{3} Y_{2k}V_k \sin(\theta_{2k}+\delta_k-\delta_2)$$

$$= -V_2\left[Y_{21}V_1 \sin(\theta_{21}) + Y_{22}V_2 \sin\theta_{22} + Y_{23}V_3 \sin(\theta_{23})\right]$$

$$= -1.0[21.00 - 51.99 + 33.27] = \underline{-2.28\ pu}$$

→

→ $\Delta Q_2^0 = -2.5 + 2.28$

$= -0.215\ pu.$

$$\begin{bmatrix}\frac{-0.215}{1.0}\end{bmatrix} = 52 \times \Delta V_2^0$$

$$\Delta V_2^0 = -0.00413\ pu$$

$$V_2^1 = V_2^1 + \Delta V_2^0$$
$$= 1 - 0.00413$$
$$= \underline{\underline{0.9958\ pu}}$$

We have calculated three variable δ_2^1, δ_3^1 & V_2^1. One more variable Q_3^1 which we need to calculate —

$$Q_3^1 = -V_3Y_{31}V_1 \sin(\theta_{31}+\delta_1-\delta_3^1) - V_3Y_{32}V_2^1 \sin(\theta_{32}+\delta_2^1-\delta_3^1) - V_3Y_{33}V_3 \sin(\theta_{33}+\delta_3^1-\delta_3^1)$$

$$= -\left[1.04 \times 31.62 \times 1.05 \sin(108.43 + 0.57) + 1.04 \times 35.77 \times 0.9958 \sin(116.56 - 3.49 + 0.57) + 1.04 \times 67.23 \times 1.04 \sin(-67.24)\right]$$

$$= -\left[32.64 + 33.94 - 67.05\right]$$

$Q_3^1 = 0.474$ pu.

Q_3^1 is not in the prespecified range hence it will behave like ~~PV Bus~~ PQ Bus. Now the unknowns are V, δ

Value of $Q_3^1 = 1.0$ pu. $(Q_{3min}) = Q_3^s$

Calculation for ΔV_3^1

Now Bus 2, & 3 both are PQ Bus

$$\Delta Q_3^0 = Q_3^s - Q_3^{cal}$$
$$= 1.0 - 0.474$$
$$= 0.526$$

$$\begin{bmatrix} \frac{\Delta Q_2^0}{V_2^0} \\ \frac{\Delta Q_3^0}{V_3^0} \end{bmatrix} = -\underbrace{[B_Q]}_{\substack{\text{same as} \\ -[B_P]}} \begin{bmatrix} \Delta V_2^0 \\ \Delta V_3^0 \end{bmatrix}$$

$$\begin{bmatrix} \Delta V_2^0 \\ \Delta V_3^0 \end{bmatrix} = \begin{bmatrix} 0.028 & 0.0146 \\ 0.0146 & 0.0236 \end{bmatrix} \begin{bmatrix} \frac{-2.88}{1.0} \\ \frac{0.526}{1.04} = 0.505 \end{bmatrix}$$

$\Delta V_3^0 = -0.0283$ pu $\left\{ \text{Need not to calculate } \Delta V_2^1 \text{ again} \right\}$

$$V_3^1 = V_3^0 + \Delta V_3^0$$
$$= 1.04 - 0.0283$$
$$V_3^1 = \underline{0.97 \text{ pu}}$$