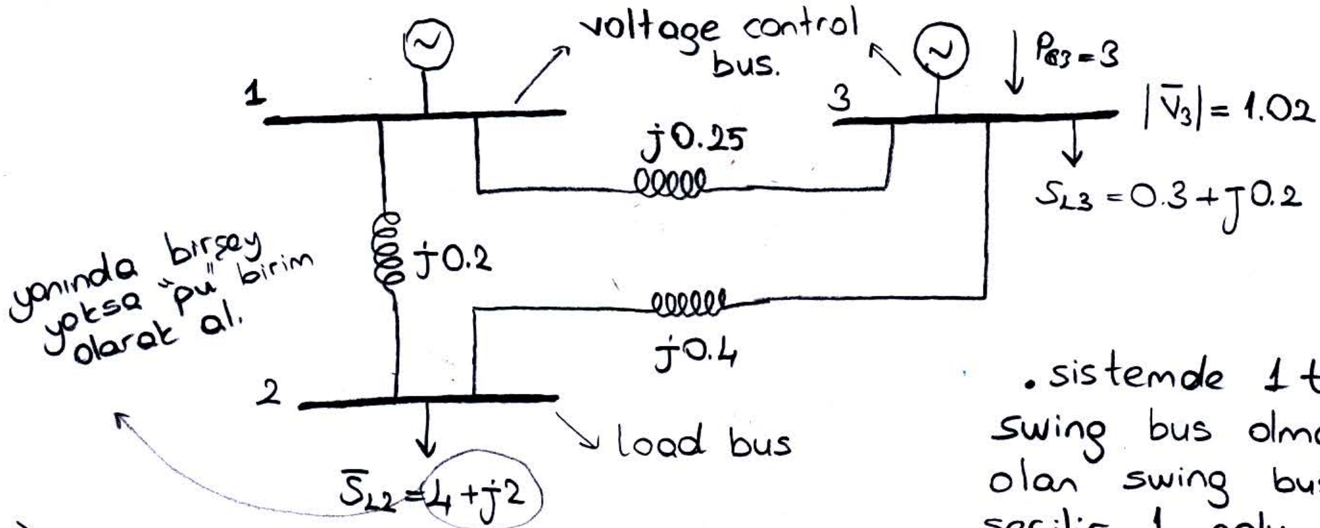
The figure below shows a single-line diagram of a 3-bus (1) power system. a) Determine the input data for the Power flow program: b) Calculate $\bar{Y}_{bus}$: and c) Calculate $V_3(1)$ using the Newton-Rahpson method. Take $\bar{V}_2(0) = 1.0\angle 0°$ and $\delta_3(0) = 0°$ as the initial guess. Assume that the magnitude of the voltage at bus 3 is maintained constant at 1.02 per-unit. d) Find $Q_{G3}(1)$ and check if the value is within the limits. Also make a suggestion for the next iteration. e) Find $\bar{S}_3(1)$.



. sistemde 1 tane swing bus olmalı. Simple olan swing bus olarak seçilir. 1 nolu bus!

a)

Bus	Bus Type	V_k	δ_k	P_{Gk}	Q_{Gk}	P_{Lk}	Q_{Lk}	P_k	Q_k	Q_{Gkmax}	Q_{Gkmin}
1	Swing	1.0	0	—	—	0	0	P_1	Q_1		
2	Load	V_2	δ_2	0	0	4	2	-4	-2		
3	Voltag. Controll.	1.02	δ_3	3	—	0,3	0.2	2.7	Q_3	5	-1

Bu değerler soruda verilecek.

$$\boxed{\begin{aligned} P_k &= P_{Gk} - P_{Lk} \\ Q_k &= Q_{Gk} - Q_{Lk} \end{aligned}}$$

Her bus için 4 variable gerekli
2 unknown
2 known

b) $\bar{Y}_{bus}$, 3 bus olduğundan 3x3 boyutludur.

$$\bar{Y}_{bus} = \begin{bmatrix} -j9 & j5 & j4 \\ j5 & -j7.5 & j2.5 \\ j4 & j2.5 & -j6.5 \end{bmatrix}$$

$$P_k[x(i)] = V_k(i) \sum_{n=1}^{N} Y_{kn} V_n(i) \cos[\delta_k(i) - \delta_n(i) - \theta_{kn}]$$

$$Q_k[x(i)] = V_k(i) \sum_{n=1}^{N} Y_{kn} V_n(i) \sin[\delta_k(i) - \delta_n(i) - \theta_{kn}]$$

swing bus'u çıkardık

$2(N-1) = 4$ Jacobian matrix'in boyutu.

STEP 1

$$\begin{bmatrix} \Delta P(i) \\ \Delta Q(i) \end{bmatrix} = \begin{bmatrix} P - P[x(i)] \\ Q - Q[x(i)] \end{bmatrix}$$

$$J(i) = \begin{bmatrix} \frac{\partial P_2}{\partial \delta_2} & \frac{\partial P_2}{\partial \delta_3} & \frac{\partial P_2}{\partial V_2} & \cancel{\frac{\partial P_2}{\partial V_3}} \\ \frac{\partial P_3}{\partial \delta_2} & \frac{\partial P_3}{\partial \delta_3} & \frac{\partial P_3}{\partial V_2} & \cancel{\frac{\partial P_3}{\partial V_3}} \\ \frac{\partial Q_2}{\partial \delta_2} & \frac{\partial Q_2}{\partial \delta_3} & \frac{\partial Q_2}{\partial V_2} & \cancel{\frac{\partial Q_2}{\partial V_3}} \\ \cancel{\frac{\partial Q_3}{\partial \delta_2}} & \cancel{\frac{\partial Q_3}{\partial \delta_3}} & \cancel{\frac{\partial Q_3}{\partial V_2}} & \cancel{\frac{\partial Q_3}{\partial V_3}} \end{bmatrix}_{4\times4}$$

$2(N-1) = 4 - 1 = 3$

V_3'ü bildiğimiz için 3x3 matrix.

Bus 3 is a voltage controlled bus, V_3 is already know, So, the function $Q_3(x)$ is not needed.

Also, we will omit the column from the Jacobian matrix that corresponds to the partial derivatives with respect to V_3 and the row corresponding to the partial derivatives of $Q_3(x)$

But, at end of each iteration we will compute $Q_3(x)$ and $Q_{G3}(x)$. If Q_{G3} exceeds its limits, then we will change the bus type to aload bus with Q_{G3} set to its limit value The power flow program then computes the new value for V_3

$$\begin{bmatrix} \Delta P_2(0) \\ \Delta P_3(0) \\ \Delta Q_2(0) \end{bmatrix} = \begin{bmatrix} -4 - 0 \\ 2.7 - 0 \\ -2 - \underbrace{(-0.05)} \end{bmatrix} = \begin{bmatrix} -4 \\ 2.7 \\ -1.95 \end{bmatrix}$$

→ Q_3 satırını silmiştik, burdada gerek yok.

formülden $P_2(0)$, $P_3(0)$ ve $Q_2(0)$'ı bulduk.

$$P_2(0) = V_2(0)Y_{21}V_1(0)\cos[\delta_2(0)-\delta_1(0)-\theta_{21}] + V_2^2(0)Y_{22}\cos(-\theta_{22}) + $$
$$+ V_2(0)Y_{23}V_3(0)\cos[\delta_2(0)-\delta_3(0)-\theta_{23}]$$

$$P_3(0) = V_3(0)Y_{31}V_1(0)\cos[\delta_3(0)-\delta_1(0)-\theta_{31}] + V_3(0)Y_{32}V_2(0)\cos[\delta_3(0)-\delta_2(0)-\theta_{32}]$$
$$+ V_3^2(0)Y_{33}\cos[-\theta_{33}]$$

$$Q_2(0) = V_2(0)Y_{21}V_1(0)\sin[\delta_2(0)-\delta_1(0)-\theta_{21}] + V_2^2(0)Y_{22}\sin(-\theta_{22}) +$$
$$+ V_2(0)Y_{23}V_3(0)\sin[\delta_2(0)-\delta_3(0)-\theta_{23}]$$

$V_1(0) = 1\angle 0^\circ \qquad V_2(0) = 1\angle 0^\circ \qquad V_3(0) = 1.02\angle 0^\circ$ initial guesses.

$P_2(0) = 0$

$P_3(0) = 0$

$Q_2(0) = -5 + 7.5 - 2.55 = -0.05$

$$\frac{\partial P_2}{\partial \delta_2} = 5 + 2.5(1.02) = 7.55 \qquad \frac{\partial P_2}{\partial \delta_3} = -2.55 \qquad \frac{\partial P_2}{\partial V_2} = 0$$

$$\frac{\partial P_3}{\partial \delta_2} = 2.55 \qquad \frac{\partial P_3}{\partial \delta_3} = 4.08 + 2.55 = 6.63 \qquad \frac{\partial P_3}{\partial V_2} = 0$$

$$\frac{\partial Q_2}{\partial \delta_2} = 0 \qquad \frac{\partial Q_2}{\partial \delta_3} = 0 \qquad \frac{\partial Q_2}{\partial V_2} = -5 - 15 - 2.55 = -22.55$$

STEP 2

$$\begin{bmatrix} 7.55 & -2.55 & 0 \\ 2.55 & 6.63 & 0 \\ 0 & 0 & -22.55 \end{bmatrix} \begin{bmatrix} \Delta\delta_2 \\ \Delta\delta_3 \\ \Delta V_2 \end{bmatrix} = \begin{bmatrix} -4 \\ 2.7 \\ 95 \end{bmatrix}$$

c)

$\bar{V}_3(1) = 1.02 \angle 0.54076$

STEP 3

$$\begin{cases} \Delta V_2(0) = 0.0864745 \\ \Delta\delta_2(0) = -0.34716 \\ \Delta\delta_3(0) = 0.54076 \end{cases}$$

$$\left. \begin{aligned} V_2(1) &= \Delta V_2(0) + V_2(0) \\ &= 1.0864745 \\ \delta_2(1) &= -0.34716 \\ \delta_3(1) &= 0.54076 \end{aligned} \right\}$$

radian

STEP 4

$$Q_3(1) = V_3(1)\, Y_{31} V_1(1) \sin\left[\delta_3(1) - \delta_1(1) - \theta_{31}\right] + V_3(1)\, Y_{32} V_2(1) \sin\left[\delta_3(1) - \delta_2(1) - \theta_{32}\right] + V_3^2(1)\, Y_{33} \sin(-\theta_{33})$$

radyanda hesapla!

$Q_3(1) = 1.5165$

tabloda yazmıştık

$Q_{G3}(1) = Q_3(1) - Q_{L3} = 1.5165 - 0.2 = 1.3165$ ← $Q_{GK max}$ ve $Q_{GK min}$ aralığında ✓

$\bar{V}_3(1) = 1.02 \angle +0.54076$

[Load bus olacak, ve voltage magnitude değişecek!
Sınır içinde olmasaydı!]

$\bar{S}_3(1) = 2.7 + j1.5165$