



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

Computer aided power system analysis

Fast decoupled load flow (FDLF)

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NRLF (POLAR)

$$\begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix} \begin{bmatrix} \Delta \bar{\theta} \\ \Delta \bar{v} \end{bmatrix} = \begin{bmatrix} \Delta \bar{P} \\ \Delta \bar{Q} \end{bmatrix}$$

$$\Rightarrow J_1 \Delta \bar{\theta} + J_2 \Delta \bar{v} = \Delta \bar{P}$$

$$J_3 \Delta \bar{\theta} + J_4 \Delta \bar{v} = \Delta \bar{Q}$$

$$g_{ij} = \frac{r}{r^2 + x^2} ; b_{ij} = -\frac{x}{r^2 + x^2}$$

Simplifying assumptions:

i) All voltage magnitudes are nearly equal to 1.0 p.u. i.e.

$$V_i \approx 1.0 \text{ p.u.}$$

ii) For all transmission line $g_{ij} \ll b_{ij}$

$$\bar{y} = \frac{1}{\bar{z}} = g_{ij} + j b_{ij}$$

$$\bar{z} = r + jx \quad r \ll x$$
$$\bar{y} = \frac{1}{r + jx} = \frac{r - jx}{r^2 + x^2} = \frac{r}{r^2 + x^2} - j \frac{x}{r^2 + x^2}$$

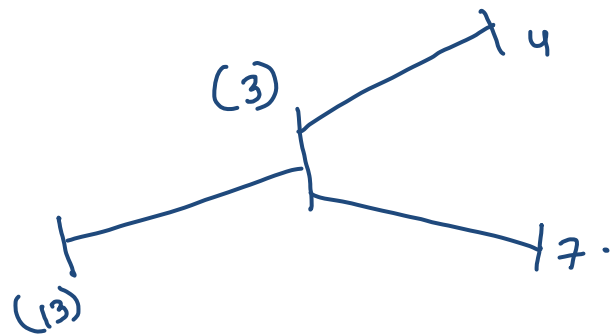


iii) For any Transmission line between bus 'i' and 'j',
 $(\theta_i - \theta_j) \approx 5-10^\circ$ (approximately equal to zero).

iv) In per unit, $Q_i \ll B_{ii} V_i^2$

$$B_{ii} = \sum_{j \in \Omega} b_{ij}$$

$\Omega \rightarrow$ is the set of indices of lines directly connected to bus i



$$i = 3$$

$$\Omega = \{4, 7, 13\}$$

$$j \in \Omega$$

50 MVAR

$S = 100 \text{ MVA}$

In p.u. $|Q_i| = 0.5$



NRLF (Polar)

$$\begin{bmatrix} \bar{J}_1 & \bar{J}_2 \\ \bar{J}_3 & \bar{J}_4 \end{bmatrix} \begin{bmatrix} \Delta \bar{\theta} \\ \Delta \bar{v} \end{bmatrix} = \begin{bmatrix} \Delta \bar{P} \\ \Delta \bar{\alpha} \end{bmatrix}$$

$$\bar{J}_1 = \frac{\partial \bar{P}}{\partial \bar{\theta}} ; \quad \bar{J}_2 = \frac{\partial \bar{P}}{\partial \bar{v}} ;$$

$$\bar{J}_3 = \frac{\partial \bar{\alpha}}{\partial \bar{\theta}} ; \quad \bar{J}_4 = \frac{\partial \bar{\alpha}}{\partial \bar{v}}$$

$$\bar{J}_2 = \frac{\partial \bar{P}}{\partial \bar{v}} ; \quad \left. \frac{\partial P_i}{\partial v_i} ; \quad \frac{\partial P_i}{\partial v_j} \right|_{j \neq i}$$

$$P_i = \sum_{j=1}^N v_i v_j \gamma_{ij} \cos(\theta_i - \theta_j - \alpha_{ij})$$

$$= v_i^2 G_{ii} + \sum_{\substack{j=1 \\ j \neq i}}^N v_i v_j \gamma_{ij} \cos(\theta_i - \theta_j - \alpha_{ij})$$

$$\left. \frac{\partial P_i}{\partial V_j} \right|_{j \neq i} = V_i Y_{ij} \cos(\theta_i - \theta_j - d_{ij})$$

$$= V_i Y_{ij} [\cos(\theta_i - \theta_j) \cos d_{ij} + \sin(\theta_i - \theta_j) \sin d_{ij}]$$

$$= V_i \left[\underbrace{G_{ij}}_0 \cos(\theta_i - \theta_j) + B_{ij} \underbrace{\sin(\theta_i - \theta_j)}_0 \right]$$

$$\boxed{\begin{aligned} d_{ij} &\ll \pi_{ij} \\ (\theta_i - \theta_j) &\approx 0^\circ \end{aligned}}$$

$$G_{ij} = \sum_{j \in \Omega} g_{ij}$$

$$\Rightarrow \left. \frac{\partial P_i}{\partial V_j} \right|_{j \neq i} \approx 0$$

$$\frac{\partial P_i}{\partial V_i} = 2 V_i G_{ii} + \sum_{\substack{j=1 \\ j \neq i}}^N V_j Y_{ij} \cos(\theta_i - \theta_j - d_{ij})$$

$$\frac{\partial P_i}{\partial V_i} = 2 V_i \underbrace{G_{ii}}_0 + \sum_{\substack{j=1 \\ j \neq i}}^N V_j \left[\underbrace{G_{ij}}_0 \cos(\theta_i - \theta_j) + B_{ij} \underbrace{\sin(\theta_i - \theta_j)}_0 \right]$$



$$\boxed{\frac{\partial P_i}{\partial v_i} \approx 0}$$

$$J_2 : \frac{\partial P_i}{\partial v_i} \approx 0 ; \frac{\partial P_i}{\partial v_j} \approx 0$$

$$\boxed{J_2 \approx 0}$$

$$J_3 = \frac{\partial \bar{Q}}{\partial \theta} ; \left. \frac{\partial Q_i}{\partial \theta_j} \right|_{j=i} ; \left. \frac{\partial Q_i}{\partial \theta_j} \right|_{j \neq i}$$

$$\boxed{\begin{array}{l} i = m+1, \dots, n \\ j = 2, \dots, n \end{array}}$$