SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

Accredited by NBA-AICTE and Accredited by NAAC – UGC with A+ Grade

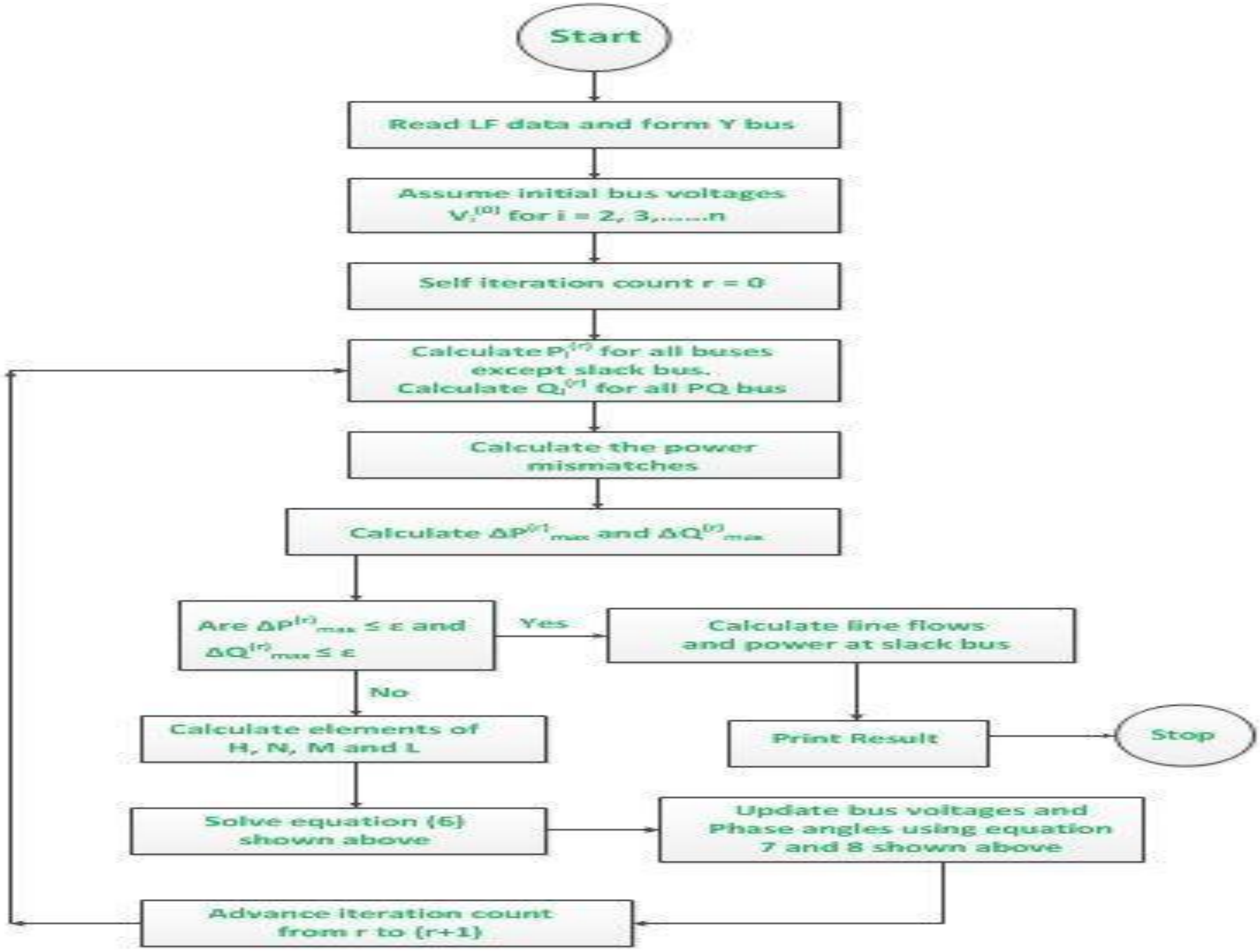
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

19EEB302/ POWER SYSTEMS – II

III YEAR / VI SEMESTER

UNIT-I: POWER FLOW ANALYSIS

NEWTON RAPHSON LOAD FLOW STUDIES


Start
Read LF data and form Y bus
Assume initial bus voltages
$V_i^{(0)}$ for i = 2, 3,.......n
Self iteration count r = 0
Calculate $P_i^{(r)}$ for all buses
except slack bus.
Calculate $Q_i^{(r)}$ for all PQ bus
Calculate the power
mismatches
Calculate $\Delta P^{(r)}_{max}$ and $\Delta Q^{(r)}_{max}$
Are $\Delta P^{(r)}_{max} \le \varepsilon$ and
$\Delta Q^{(r)}_{max} \le \varepsilon$
Yes
No
Calculate line flows
and power at slack bus
Print Result
Stop
Calculate elements of
H, N, M and L
Solve equation (6)
shown above
Update bus voltages and
Phase angles using equation
7 and 8 shown above
Advance iteration count
from r to (r+1)

Newton Raphson Method is an iterative technique for solving a set of various nonlinear equations with an equal number of unknowns.

Advantages of Newton Raphson Method

The various advantages of Newton Raphson Method are as follows:-

It possesses quadratic convergence characteristics. Therefore, the convergence is very fast.

The number of iterations is independent of the size of the system. Solutions to a high accuracy is obtained nearly always in two to three iterations for both small and large systems.

The Newton Raphson Method convergence is not sensitive to the choice of slack bus.

Overall, there is a saving in computation time since fewer number of iterations are required.

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Let us understand this method with the help of the equations.

$$S_i = P_i + jQ_i = V_i \sum_{k=1}^{n} V_{ik} V_k \;.......(1)$$

$$S_i = \sum_{k=1}^{n} (V_i\, V_k\, Y_{ik}) \Big/ (\delta_i - \delta_k - \theta_{ik}) \;\ldots\ldots(2)$$

$$P_i = \sum_{k=1}^{n} (V_i\, V_k\, Y_{ik}) \cos(\delta_i - \delta_k - \theta_{ik}) \;\ldots\ldots(3)$$

$$Q_i = \sum_{k=1}^{n} (V_i\, V_k\, Y_{ik}) \sin(\delta_i - \delta_k - \theta_{ik}) \;\ldots\ldots(4)$$

The above equation (3) and (4) can also be written as shown below.

$$P_i = V_i V_i Y_{ii} \cos\theta_{ii} + \sum_{\substack{k=1 \\ k \neq 1}}^{n} (V_i\, V_k\, Y_{ik}) \cos(\delta_i - \delta_k - \theta_{ik}) \;\ldots\ldots(5)$$

$$Q_i = -V_i V_i Y_{ii} \cos\theta_{ii} + \sum_{\substack{k=1 \\ k \neq 1}}^{n} (V_i V_k Y_{ik}) \sin(\delta_i - \delta_k - \theta_{ik}) \ldots\ldots\ldots (6)$$

We have Δf = J ΔX

$$\text{If } \Delta P_i = P_{i\,(sp)} - P_{i\,(cal)} \ldots\ldots (7)$$

then I = 1, 2, ...n, I ≠ slack, and if

$$\Delta Q_i = Q_{i\,(sp)} - Q_{i\,(cal)}$$

Then I = 1, 2, ...n,   i ≠ slack,   i ≠ PV bus

Where, the subscripts sp and cal denote the specified and calculated values, respectively, then the equation (7) can be written as shown below.

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} H & N \\ M & L \end{bmatrix} \begin{bmatrix} \Delta \delta \\ \Delta V \end{bmatrix} \ldots\ldots (8)$$

$$\Delta P_i^{(r)} < \varepsilon, \qquad \Delta Q_i^{(r)} < \varepsilon$$

Procedure of Newton Raphson Method

The computational procedure for Newton Raphson Method using polar coordinate is given below.

- Form Y bus.
- Assume the initial value of the bus voltages $|Vi|^0$ and phase angle δi^0 for i = 2, 3, ...n for load buses and phase angles for PV buses. Normally we set the assumed bus voltage magnitude and its phase angle equal to the slack bus quantities $|V_1| = 1.0$, $\delta_1 = 0^o$.
- Compute P_i and Q_i for each load bus from the following equation (5) and (6) shown above.
- Now, compute the scheduled errors ΔPi and ΔQi for each load bus from the following relations given below.

$$\Delta P_i^{(r)} = P_{i\,sp} - P_{i\,(cal)}^{(r)} \qquad i = 2, 3, \ldots .n$$

$$\Delta Q_i^{(r)} = Q_{i\,sp} - Q_{i\,(cal)}^{(r)} \qquad i = 2, 3, \ldots .n$$

- For PV buses, the exact value of Qi is not specified, but its limits are known. If the calculated value of Qi is within the limits only ΔPi is calculated. If the calculated value of Qi is beyond the limits, then an appropriate limit is imposed and ΔQi is also calculated by subtracting the calculated value of Qi from the appropriate limit. The bus under consideration is now treated as a load bus.
- Compute the elements of the Jacobian matrix.

$$\begin{bmatrix} H & N' \\ M & L' \end{bmatrix}$$

- Obtain the value of Δδ and Δ|Vi| from the equation shown below.

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} H & N' \\ M & L' \end{bmatrix} \begin{bmatrix} \Delta \delta \\ \dfrac{\Delta V}{V} \end{bmatrix} \ldots\ldots\ldots (6)$$

- Using the values of Δδi and Δ|Vi| calculated in the above step, modify the voltage magnitude and phase angle at all load buses by the equations shown below.

$$\left|V_i^{(r+1)}\right| = \left|V_i^{(r)}\right| + \Delta \left|V_i^{(r)}\right| \quad \ldots\ldots (7)$$

$$\delta_i^{(r+1)} = \delta_i^{(r)} + \Delta\delta_i^{(r)} \quad \ldots\ldots (8)$$

- Start the next iteration cycle following the step 2 with the modified values of $|V_i|$ and δ_i.
- Continue until scheduled errors for all the load buses are within a specified tolerance that is

$$\Delta P_i^{(r)} < \varepsilon, \qquad \Delta Q_i^{(r)} < \varepsilon$$

Where, ε denotes the tolerance level for load buses.

- Calculate the line and power flow at the slack bus same as in the Gauss Seidel method.

RECAP….

…THANK YOU