Sparsity and Optimal Power Flow, LPOPF algorithm

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Optimal Power Flow

$$\min \sum_{i=1}^{N_B} F_i(P_{gen_i})$$

$$(P_{gen_i} - P_{load_i}) - \text{Real}\left\{ V_i \left(\sum_{k=1}^{N_B} Y_{ik} V_k \right)^* \right\} = 0 \ (\forall i \in B) \qquad (2)$$

$$(Q_{gen_i} - Q_{load_i}) - \text{Imag}\left\{ V_i \left(\sum_{k=1}^{N_B} Y_{ik} V_k \right)^* \right\} = 0 \ (\forall i \in B) \qquad (3)$$

$$P_{gen_i}^{\min} \le P_{gen_i} \le P_{gen_i}^{\max} \quad (\forall i \in B) \qquad (4)$$

$$Q_{gen_i}^{\min} \le Q_{gen_i} \le Q_{gen_i}^{\max} \quad (\forall i \in B) \qquad (5)$$

$$P_{ij} \le P_{ij}^{\max} \quad (\forall i, j \in L) \qquad (6)$$

$$S_{ij} \le S_{ij}^{\max} \quad (\forall i, j \in L) \qquad (7)$$

$$|V_i|^{\min} \le |V_i| \le |V_i|^{\max} \quad (\forall i \in B) \qquad (8)$$

Incremental LP Method

$$\min \sum_{i=1}^{N_b} \left[F_i(P_{gen_i}) + \frac{\partial F_i(P_{gen_i})}{\partial P_{gen_i}} \Delta P_{gen_i} \right]$$

$s.t.$

$$\sum_{\forall j \in B} \frac{\partial P_i(V,\theta)}{\partial V_j} \Delta |V_j| + \sum_{\forall j \in B} \frac{\partial P_i(V,\theta)}{\partial \theta_j} \Delta \theta_j = \Delta P_{gen_i} \quad (\forall i \in B)$$

$$\sum_{\forall j \in B} \frac{\partial Q_i(V,\theta)}{\partial V_j} \Delta |V_j| + \sum_{\forall j \in B} \frac{\partial Q_i(V,\theta)}{\partial \theta_j} \Delta \theta_j = \Delta Q_{gen_i} \quad (\forall i \in B)$$

$$\Delta |V_i| = 0 \quad (i \in B_{refbus})$$

$$\Delta \theta_i = 0 \quad (i \in B_{refbus})$$

$$\Delta P_{gen_i} = 0 \quad (i \in B_L)$$

$$\Delta Q_{gen_i} = 0 \quad (i \in B_L)$$

$$P_{gen_i}^{\min} - P_{gen_i} \le \Delta P_{gen_i} \le P_{gen_i}^{\max} - P_{gen_i} \quad (\forall i \in B)$$

$$Q_{gen_i}^{\min} - Q_{gen_i} \le \Delta Q_{gen_i} \le Q_{gen_i}^{\max} - Q_{gen_i} \quad (\forall i \in B)$$

$$|V_i|^{\min} - |V_i| \le \Delta |V_i| \le |V_i|^{\max} - |V_i| \quad (\forall i \in B)$$

$$-\delta_k \le \Delta P_{gen_i} \le \delta_k \quad (\forall i \subset B)$$

$$-\delta_k \le \Delta Q_{gen_i} \le \delta_k \quad (\forall i \in B)$$

$$-\delta_k \le \Delta |V_i| \le \delta_k \quad (\forall i \in B)$$

$$-\delta_k \le \Delta \theta_i \le \delta_k \quad (\forall i \in B)$$

Trust Region Method

$$\sigma_k = \frac{f(x_k) - f(x_k + p_k)}{m_k(0) - m_k(p_k)}$$

$$If \;\; \sigma_k < \eta$$

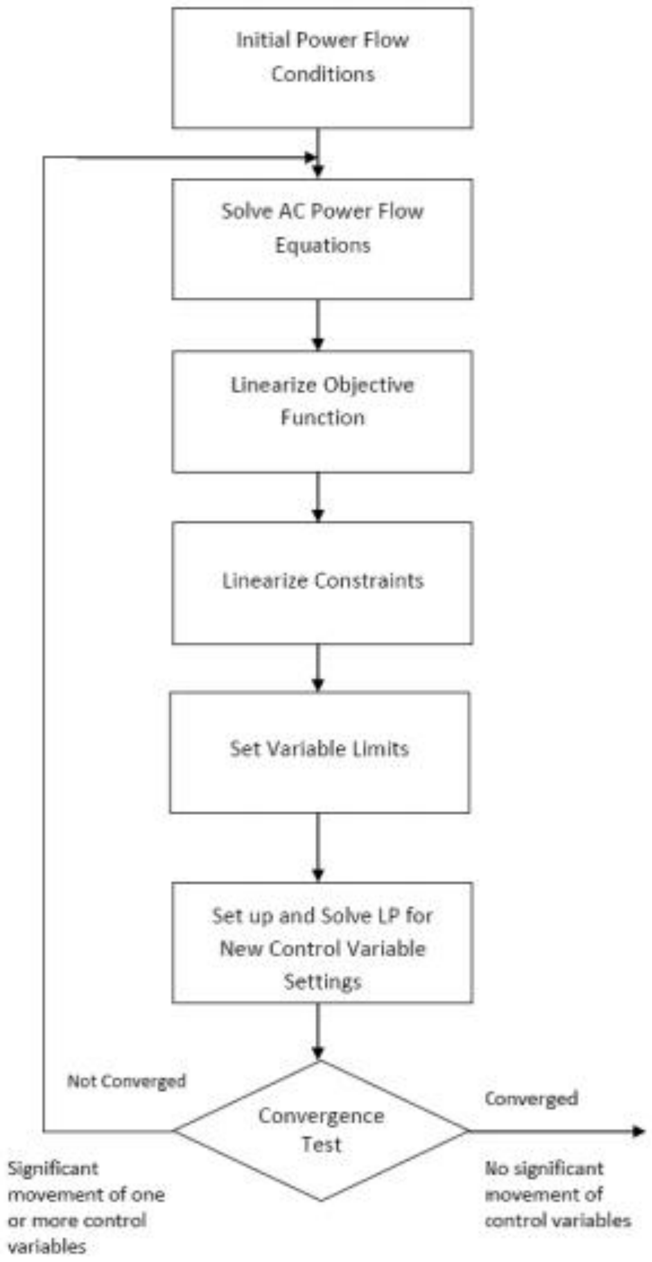
$$\delta_{k+1} - \gamma\delta_k$$

$$Else \; If \;\; \sigma_k > (1-\eta)$$

$$\delta_{k+1} = \min(2\delta_k, \; \delta^{\max})$$

$$If \;\; \sigma_k > \tau$$

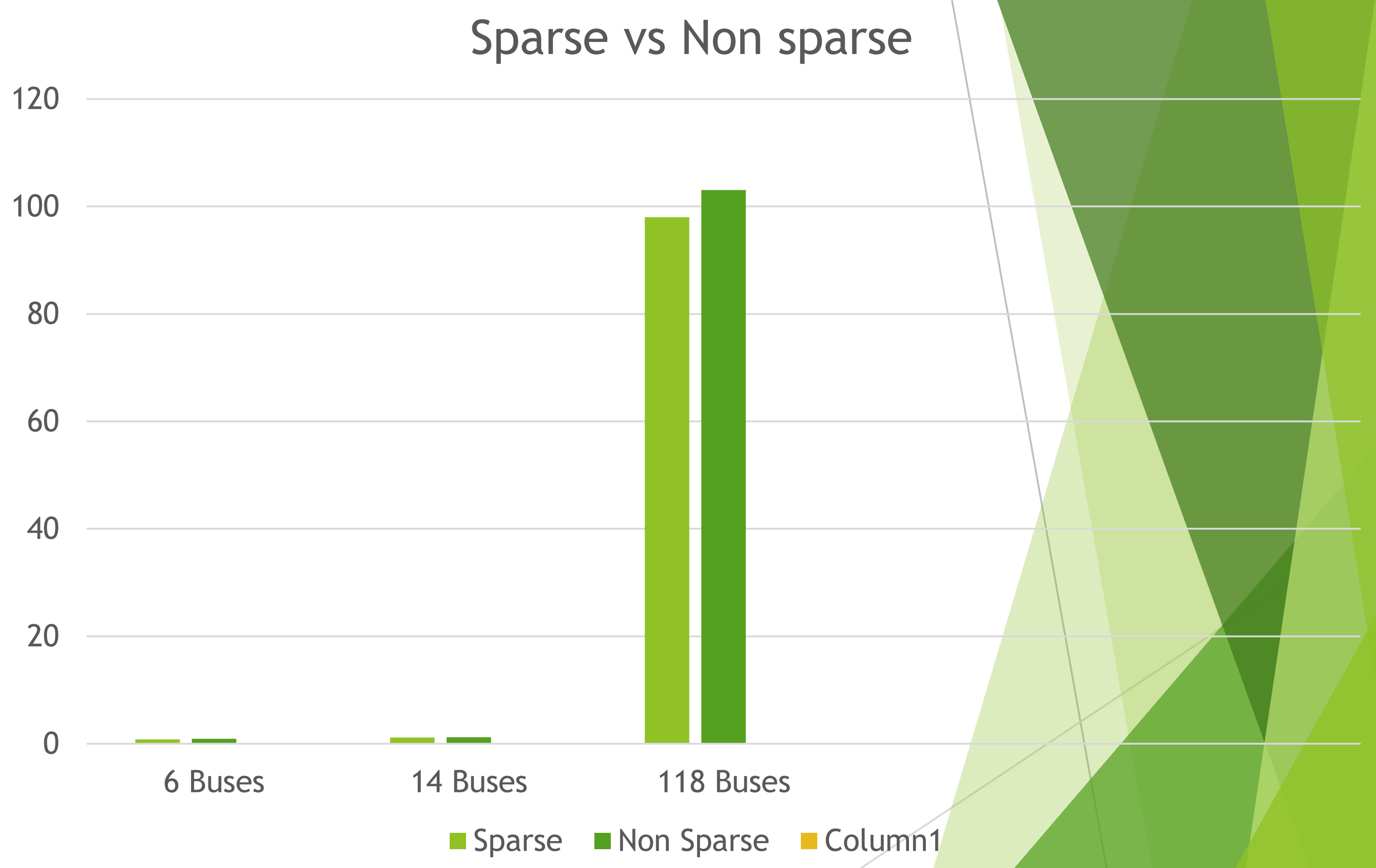
$$x_{k+1} = x_k + p_k$$



Initial Power Flow Conditions
Solve AC Power Flow Equations
Linearize Objective Function
Linearize Constraints
Set Variable Limits
Set up and Solve LP for New Control Variable Settings
Convergence Test
Not Converged
Significant movement of one or more control variables
Converged
No significant movement of control variables

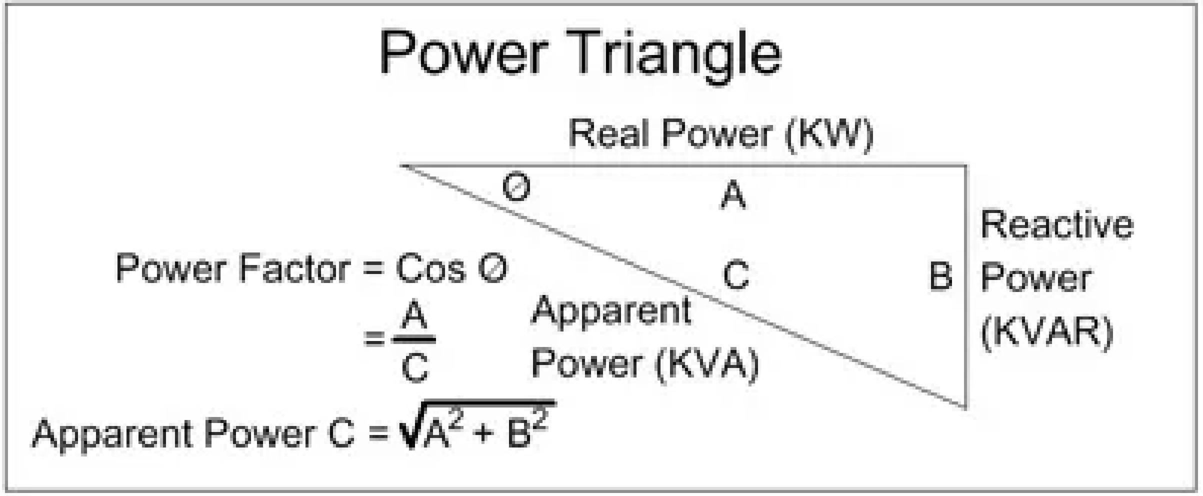
Sparse vs Non sparse

- 118 Buses: 98.010157 103.059276
- 14 Buses: 1.140880 1.232643
- 6 Buses: 0.811251 0.906258



Add MVA Constrains

- MVA stands for Mega Volt Amp or Volts * Amp /1000,000



Questions

- Reference:

A. Giacomoni and B. Wollenberg, "Linear programming optimal power flow utilizing a trust region method," in Proc. of 2010 North American Power Symposium, Arlington, TX, USA, Sep. 2010, pp. 1-6.

B. Quora. Retrieved from https://www.quora.com/What-is-the-meaning-when-we-say-load-requirement-is-10-MVA

Thanks for watching