AC power flow using Pyomo: 25-Bus Case

Woong Ko

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Abstract

1 Nomenclature

1.1 Indices

i, j: Bus

1.2 Parameters

ω_i: Slack Bus indicator (If Bus i is slack bus, 1 otherwise 0)
α_i: PV Bus indicator (If Bus i is PV bus, 1 otherwise 0)
β_i: PQ Bus indicator (If Bus i is PQ bus, 1 otherwise 0)
P_i^{known}: Known value of active power in Bus i
Q_i^{known}: Known value of reactive power in Bus i
P_i^{gen}: Set point of generation of active power in Bus i
Q_i^{gen}: Set point of generation of reactive power in Bus i
P_i^{load}: Set point of load of active power in Bus i
Q_i^{load}: Set point of load of reactive power in Bus i
$P_i^{gen,max}$.$P_i^{gen,min}$: Maximum/Minimum value of active power of generator in Bus i
$P_i^{load,max}$, $P_i^{load,min}$: Maximum/Minimum value of active power of load in Bus i
$Q_i^{gen,max}$, $Q_i^{gen,min}$: Maximum/Minimum value of reactive power of generator in Bus i
$Q_i^{load,max}$, $Q_i^{load,min}$: Maximum/Minimum value of reactive power of load in Bus i
V^{slack}: Voltage magnitude in slack bus
V_i^{known}: Known value of voltage magnitude in Bus i
$V_i^{setpoint}$: Set point of voltage magnitude in Bus i
V_i^{max},V_i^{min}: Maximum/Minimum value of voltage magnitude in Bus i
G_{ij}: Conductance of the line between Bus i and Bus j
B_{ij}: Susceptance of the line between Bus i and Bus j

1.3 Variables

P_i^{cal}: Active power in Bus i
Q_i^{cal}: Reactive power in Bus i
V_i^{cal}: Voltage magnitude in Bus i
θ_i^{cal}: Voltage angle in Bus i

2 Formula

2.1 Obejctive function

$$
\begin{aligned}
Minimize \quad \sum_{\forall i} \Big[& (\alpha_i + \beta_i)(P_i^{known} - P_i^{cal}) \\
& + \beta_i(Q_i^{known} - Q_i^{cal}) \\
& + \alpha_i(V_i^{known} - V_i^{cal}) \\
& + \omega_i(V^{slack} - V_i^{cal}) \Big]
\end{aligned} \tag{1}
$$

2.2 Constraints

$$P_i^{cal} = \sum_{\forall j} V_i^{Cal} V_j^{Cal} (G_{ij} cos(\theta_i^{cal} - \theta_j^{cal}) + B_{ij} sin(\theta_i^{cal} - \theta_j^{cal})), \quad \forall i \tag{2}$$

$$Q_i^{cal} = \sum_{\forall j} V_i^{Cal} V_j^{Cal} (G_{ij} sin(\theta_i^{cal} - \theta_j^{cal}) - B_{ij} cos(\theta_i^{cal} - \theta_j^{cal})), \quad \forall i \tag{3}$$

$$P_i^{min} \leq P_i^{cal} \leq P_i^{max}, \quad \forall i \tag{4}$$

$$Q_i^{min} \leq Q_i^{cal} \leq Q_i^{max}, \quad \forall i \tag{5}$$

$$P_i^{min} = \alpha_i P_i^{gen,min} - \beta_i P_i^{load,min} - \omega_i \infty \tag{6}$$

$$P_i^{max} = \alpha_i P_i^{gen,max} - \beta_i P_i^{load,max} + \omega_i \infty \tag{7}$$

$$Q_i^{min} = \alpha_i Q_i^{gen,min} - \beta_i Q_i^{load,min} - \omega_i \infty \tag{8}$$

$$Q_i^{max} = \alpha_i Q_i^{gen,max} - \beta_i Q_i^{load,max} + \omega_i \infty \tag{9}$$

$$P_i^{known} = \alpha_i P_i^{gen} - \beta_i P_i^{load} \tag{10}$$

$$Q_i^{known} = \alpha_i Q_i^{gen} - \beta_i Q_i^{load} \tag{11}$$

$$V_i^{cal} \geq 0, \quad \forall i \tag{12}$$

$$-\infty \leq \theta_i^{cal} \leq \infty, \quad \forall i \tag{13}$$

$$\omega_i V_i^{cal} \leq V^{slack}, \quad \forall i \tag{14}$$

$$\alpha_i V_i^{cal} \leq V_i^{known}, \quad \forall i \tag{15}$$

$$\omega_i \theta_i^{cal} = 0, \quad \forall i \tag{16}$$