data:

$$S_k^{gl}, S_k^{gu} \quad \forall k \in G$$

$$S_l^{cl}, S_l^{cu} \quad \forall l \in C$$

$$c_{2k}, c_{1k}, c_{0k} \quad \forall k \in G$$

$$a_l, b_l, c_l \quad \forall l \in C$$

$$v_i^l, v_i^u \quad \forall i \in N$$

$$v_i^l, v_i^u \quad \forall i \in N_{dc}$$

$$S_i^d, Y_i^s \quad \forall i \in N$$

$$P_i^d, Y_i^s \quad \forall i \in N_{dc}$$

$$Y_{ij}, b_{ij}^c, T_{ij} \quad \forall (i,j) \in E$$

$$Y_{ij} \quad \forall (i,j) \in E_{dc}$$

$$s_{ij}^u, \theta_{ij}^{\Delta l}, \theta_{ij}^{\Delta u} \quad \forall (i,j) \in E$$

$$p_{ij}^u \quad \forall (i,j) \in E_{dc}$$

$$r$$

$$p_{dc}$$

variables:

$$S_k^g \quad \forall k \in G$$

$$S_l^c \quad \forall l \in C$$

$$P_l^{c,dc} \quad \forall l \in C$$

$$V_i \quad \forall i \in N$$

$$V_i \quad \forall i \in N_{dc}$$

$$S_{ij} \quad \forall (i,j) \in E \cup E^R$$

$$(1)$$

1

$$\text{minimize:} \quad \sum_{k \in G} \boldsymbol{c_{2k}}(\Re(S_k^g))^2 + \boldsymbol{c_{1k}}\Re(S_k^g) + \boldsymbol{c_{0k}} \tag{2}$$

subject to:

$$\angle V_{\boldsymbol{r}} = 0 \tag{3}$$

$$\boldsymbol{S_k^{gl}} \le S_k^g \le \boldsymbol{S_k^{gu}} \quad \forall k \in G \tag{4}$$

$$\boldsymbol{v_i^l} \le |V_i| \le \boldsymbol{v_i^u} \quad \forall i \in N \tag{5}$$

$$\sum_{k \in G_i} S_k^g + \sum_{l \in C_i} S_l^c - \boldsymbol{S_i^d} - \boldsymbol{Y_i^s}|V_i|^2 = \sum_{(i,j) \in E_i \cup E_i^R} S_{ij} \quad \forall i \in N \tag{6}$$

$$S_{ij} = \left(\boldsymbol{Y_{ij}^*} - \boldsymbol{i}\frac{\boldsymbol{b_{ij}^c}}{2}\right)\frac{|V_i|^2}{|\boldsymbol{T_{ij}}|^2} - \boldsymbol{Y_{ij}^*}\frac{V_i V_j^*}{\boldsymbol{T_{ij}}} \quad \forall(i,j) \in E \tag{7}$$

$$S_{ji} = \left(\boldsymbol{Y_{ij}^*} - \boldsymbol{i}\frac{\boldsymbol{b_{ij}^c}}{2}\right)|V_j|^2 - \boldsymbol{Y_{ij}^*}\frac{V_i^* V_j}{\boldsymbol{T_{ij}^*}} \quad \forall(i,j) \in E \tag{8}$$

$$|S_{ij}| \le \boldsymbol{s_{ij}^u} \quad \forall(i,j) \in E \cup E^R \tag{9}$$

$$\boldsymbol{\theta_{ij}^{\Delta l}} \le \angle(V_i V_j^*) \le \boldsymbol{\theta_{ij}^{\Delta u}} \quad \forall(i,j) \in E \tag{10}$$

$$\boldsymbol{S_l^{cl}} \le S_l^c \le \boldsymbol{S_l^{cu}} \quad \forall l \in C \tag{11}$$

$$\sum_{k \in G_i} P_k^g + \sum_{l \in C_i} P_l^{c,dc} - \boldsymbol{P_i^d} - \boldsymbol{Y_i^s}|V_i|^2 = \sum_{(i,j) \in E_{i,dc} \cup E_{i,dc}^R} P_{ij} \quad \forall i \in N_{dc} \tag{12}$$

$$P_{ij} = p_{dc}\boldsymbol{Y_{ij}} \cdot (V_i^2 - V_i V_j) \quad \forall(i,j) \in E_{dc} \tag{13}$$

$$|P_{ij}| \le \boldsymbol{p_{ij}^u} \quad \forall(i,j) \in E_{dc} \cup E_{dc}^R \tag{14}$$

$$P_l^c + P_l^{c,dc} = a + b|I_l^c| + c|I_l^c|^2 \quad \forall l \in C \tag{15}$$

$$|V_i|^2|I_l^c|^2 = (S_l^c)^2 \quad \forall l \in C_i \ \forall i \in N \tag{16}$$

$$\tag{17}$$