EET 109 Handout #1

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Power Flow Equation Representations

1. **Rectangular Form:**

$$\mathbf{Y} = \mathbf{G} + j\mathbf{B},$$
$$V = V_d + jV_q$$

$$P_i = \sum_{k=1}^{n} \left[V_{di}\left(G_{ik}V_{dk} - B_{ik}V_{qk}\right) + V_{qi}\left(B_{ik}V_{dk} + G_{ik}V_{qk}\right)\right]$$
$$Q_i = \sum_{k=1}^{n} \left[V_{di}\left(-B_{ik}V_{dk} - G_{ik}V_{qk}\right) + V_{qi}\left(G_{ik}V_{dk} - B_{ik}V_{qk}\right)\right]$$

2. **Polar Form with Conductance and Susceptance:**

$$\mathbf{Y} = \mathbf{G} + j\mathbf{B},$$
$$V = |V|e^{j\theta}$$

$$P_i = |V_i| \sum_{k=1}^{n} |V_k| \left(G_{ik}\cos(\theta_i - \theta_k) + B_{ik}\sin(\theta_i - \theta_k)\right)$$
$$Q_i = |V_i| \sum_{k=1}^{n} |V_k| \left(G_{ik}\sin(\theta_i - \theta_k) - B_{ik}\cos(\theta_i - \theta_k)\right)$$

3. **Polar Form with Magnitude and Phase of Y:**

$$\mathbf{Y} = |\mathbf{Y}|e^{j\psi},$$
$$V = |V|e^{j\theta}$$

$$P_i = |V_i| \sum_{k=1}^{n} |V_k||\mathbf{Y}_{ik}| \cos(\theta_i - \theta_k - \psi_{ik})$$
$$Q_i = |V_i| \sum_{k=1}^{n} |V_k||\mathbf{Y}_{ik}| \sin(\theta_i - \theta_k - \psi_{ik})$$

Power Flow Space

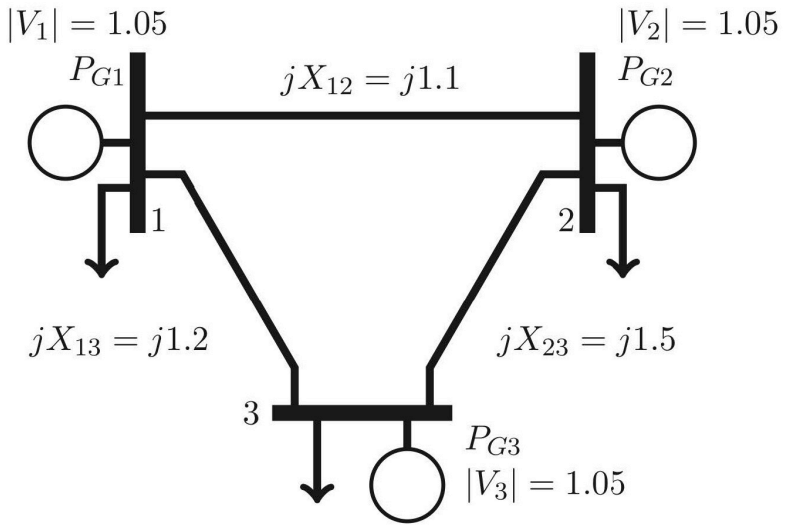

Figure 1: A Three Bus Network

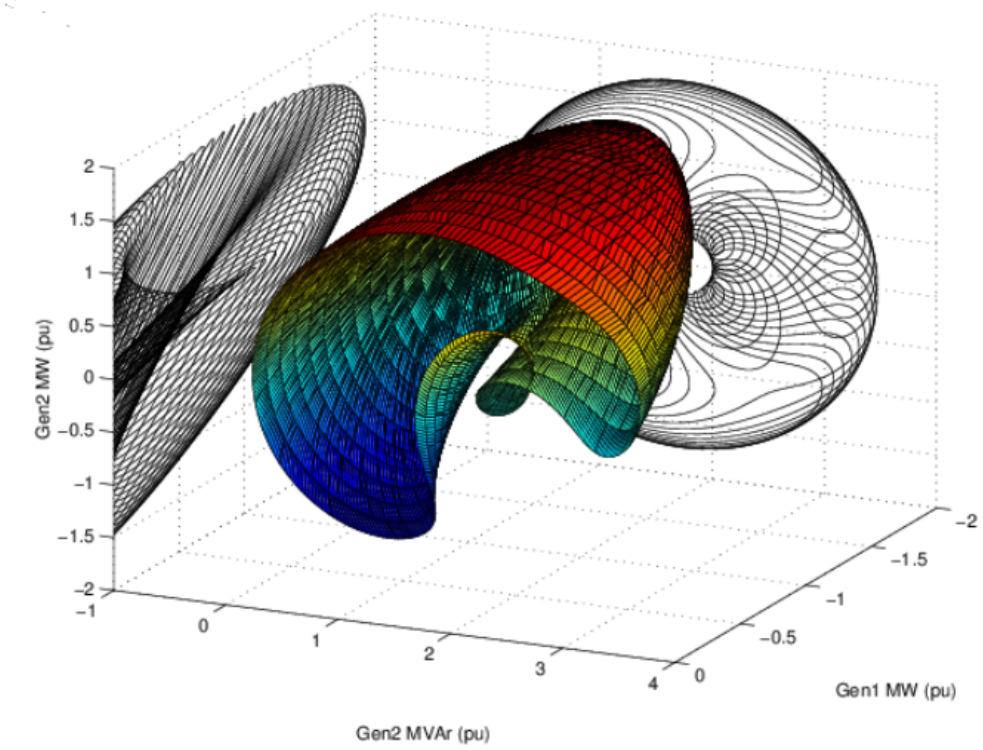

Figure 2: Power Flow Feasible Space on Generator Dispatch Plane

The feasible space figure is adapted from A. Hiskens and R. J. Davy, Exploring the power flow solution space boundary, IEEE Transactions on Power Systems, vol. 16, no. 3, pp. 389395, 2001.