



$$y_{12} = \frac{1}{Z_{12}} \quad y_{13} = \frac{1}{Z_{13}} \quad y_{23} = \frac{1}{Z_{23}} \quad y_{24} = \frac{1}{Z_{24}}$$

For Bus 1

$$I_1 = I_{G1} - I_{D1} = I_{12} + I_{13} = \frac{V_1 - V_2}{Z_{12}} + \frac{V_1 - V_3}{Z_{13}}$$

$$\begin{aligned} &= (V_1 - V_2)y_{12} + (V_1 - V_3)y_{13} \\ &= V_1 y_{12} - V_2 y_{12} + V_1 y_{13} - V_3 y_{13} \\ &= V_1 (y_{12} + y_{13}) - V_2 y_{12} - V_3 y_{13} \end{aligned}$$

For Bus 2

$$I_2 = I_{G2} - I_{D2} = 0 - I_{D2}$$

$$= I_{21} + I_{23} + I_{24}$$

$$= -y_{12} V_1 + (y_{12} + y_{23} + y_{24}) V_2 - y_{23} V_3 - y_{24} V_4$$

For Bus 3

$$I_3 = \underline{\hspace{10em}}$$

For Bus 4

$$I_4 = \underline{\hspace{10em}}$$

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} y_{12} + y_{13} & -y_{12} & -y_{13} & 0 \\ -y_{12} & (y_{12} + y_{23} + y_{24}) & -y_{23} & -y_{24} \\ -y_{13} & -y_{23} & (y_{13} + y_{23}) & 0 \\ 0 & -y_{24} & 0 & y_{24} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix}$$

$$= \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} & Y_{14} \\ Y_{21} & Y_{22} & Y_{23} & Y_{24} \\ Y_{31} & Y_{32} & Y_{33} & Y_{34} \\ Y_{41} & Y_{42} & Y_{43} & Y_{44} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix}$$

$$\begin{aligned} I_1 &= I_{G1} - I_{D1} = Y_{11}V_1 + Y_{12}V_2 + Y_{13}V_3 + Y_{14}V_4 \\ &= \sum_{k=1}^4 Y_{1k}V_k \end{aligned}$$

$$\begin{aligned} I_2 &= I_{G2} - I_{D2} = Y_{21}V_1 + Y_{22}V_2 + Y_{23}V_3 + Y_{24}V_4 \\ &= \sum_{k=1}^4 Y_{2k}V_k \end{aligned}$$

$$I_i = I_{Gi} - I_{Di} = \sum_{k=1}^N Y_{ik}V_k$$