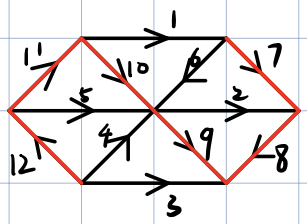
2-5 图 2-18 所示电路中电阻各为 1Ω，$I_{s1}=I_{s3}=1\text{A}$，$I_{s2}=I_{s4}=2\text{A}$，$V_s=3\text{V}$，试用回路法建立方程，并求各支路电流。



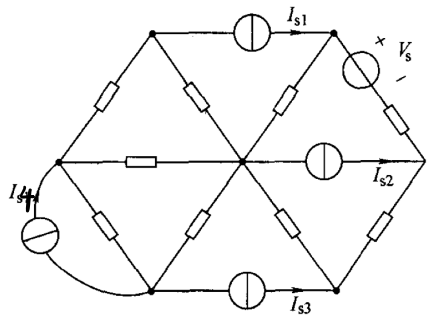


图 2-18　题 2-5 图

选 7, 8, 9, 10, 11, 12 为树支

$$B_f=\left[\begin{array}{cccccccccccc}
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \\
\hline
1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & -1 & -1 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & -1 & -1 & -1 & -1 \\
\hline
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & -1 & -1 & -1 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 & -1 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & -1 & -1 & 1 & 0 & 0 & 0
\end{array}\right]$$

$$B_{12}=\left[\begin{array}{ccccccccc}
4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \\
\hline
0 & 0 & 0 & 1 & 1 & -1 & -1 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & -1 & -1 & -1 & -1
\end{array}\right]$$

$$B_{22}=\left[\begin{array}{ccccccccc}
1 & 0 & 0 & 0 & 0 & 0 & -1 & -1 & -1 \\
0 & 1 & 0 & 0 & 0 & 0 & -1 & -1 & 0 \\
0 & 0 & 1 & -1 & -1 & 1 & 0 & 0 & 0
\end{array}\right]$$

$$I_{s1}=\begin{bmatrix}1 & 2 & 1\end{bmatrix}^T$$

$$I_{s2} = \begin{bmatrix} 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}^T$$

$$\begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \end{matrix}$$

$$U_{s2} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 3 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}^T$$

$$\begin{matrix} 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \end{matrix}$$

$$Z_{b2} = \text{diag}\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$B_{22} Z_{b2} B_{22}^T = \begin{bmatrix} 4 & 2 & 0 \\ 2 & 3 & 0 \\ 0 & 0 & 4 \end{bmatrix}$$

$$I_{l2} = (B_{22} Z_{b2} B_{22}^T)^{-1} \left[B_{22} Z_{b2} (I_{s2} - B_{12}^T I_{s1}) - B_{22} U_{s2} \right]$$

$$= \begin{bmatrix} 0 & -1 & 5 \end{bmatrix}^T$$

$$I_l = \begin{bmatrix} 1 & 2 & 1 & 0 & -1 & 5 \end{bmatrix}^T$$

$$I_b = B_f^T I_l$$

$$= \begin{bmatrix} 1 & 2 & 1 & 0 & -1 & 5 & -4 & -2 & 1 & -1 & 0 & -1 \end{bmatrix}^T$$

2-6 写出图 2-19 所示电路的节点电压方程。

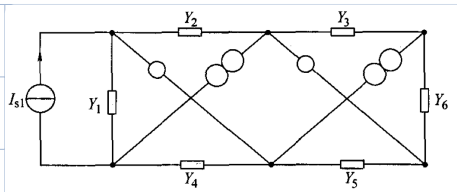
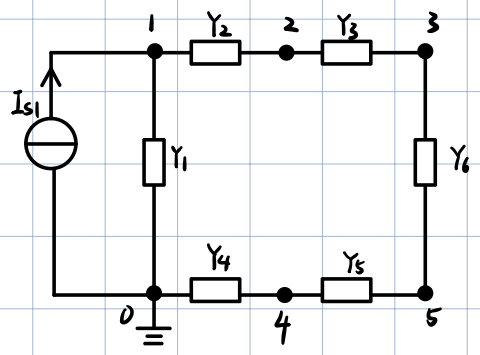


图 2-19 题 2-6 图

(1) 去零连器



$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array}\begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} Y_1+Y_2 & -Y_2 & 0 & 0 & 0 \\ -Y_2 & Y_2+Y_3 & -Y_3 & 0 & 0 \\ 0 & -Y_3 & Y_3+Y_6 & 0 & -Y_6 \\ 0 & 0 & 0 & Y_4+Y_5 & -Y_5 \\ 0 & 0 & -Y_6 & -Y_5 & Y_5+Y_6 \end{bmatrix} \end{array} \begin{bmatrix} U_{n1} \\ U_{n2} \\ U_{n3} \\ U_{n4} \\ U_{n5} \end{bmatrix} = \begin{bmatrix} I_{s1} \\ 0 \\ 0 \\ \\ 0 \end{bmatrix}$$

(2) 恢复零值器(节点 1、4 之间)(节点 2, 5 之间)

$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array}\begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} Y_1+Y_2 & -Y_2 & 0 \\ -Y_2 & Y_2+Y_3 & -Y_3 \\ 0 & -Y_3-Y_6 & Y_3+Y_6 \\ Y_4+Y_5 & -Y_5 & 0 \\ -Y_5 & Y_5+Y_6 & -Y_6 \end{bmatrix} \end{array} \begin{bmatrix} U_{1,4} \\ U_{2,5} \\ U_3 \end{bmatrix} = \begin{bmatrix} I_{s1} \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

(3) 恢复迭值器 (节点 0,2 之间) (节点 3,4 之间)

$$\begin{bmatrix} Y_1+Y_2 & -Y_2 & 0 \\ Y_4+Y_5 & -Y_3-Y_5-Y_6 & Y_3+Y_6 \\ -Y_5 & Y_5+Y_6 & -Y_6 \end{bmatrix} \begin{bmatrix} U_{1,4} \\ U_{2,5} \\ U_3 \end{bmatrix} = \begin{bmatrix} I_{S1} \\ 0 \\ 0 \end{bmatrix}$$