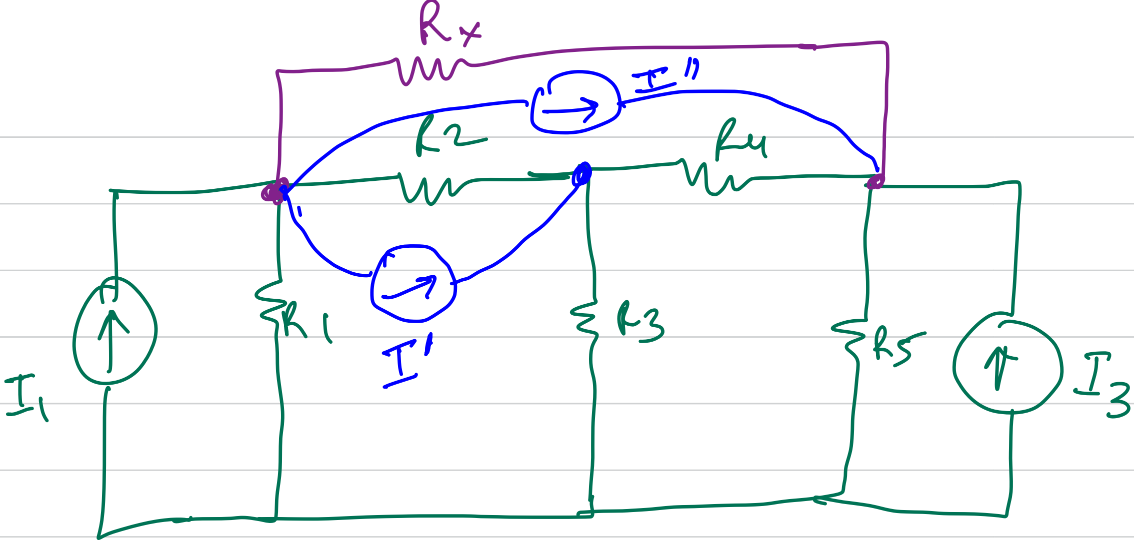
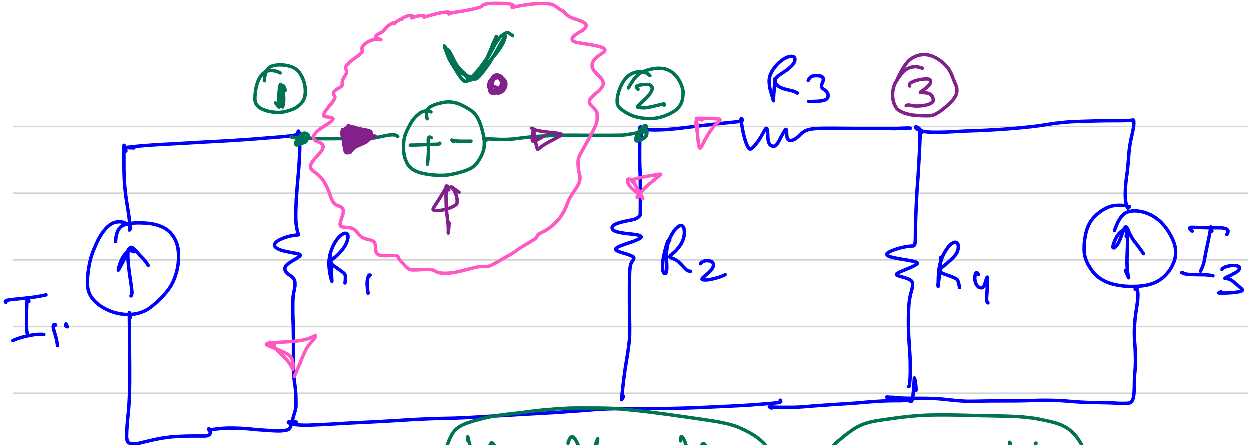
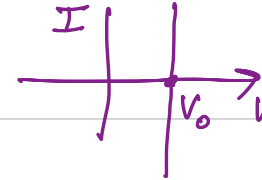


$$\begin{bmatrix} G_1+G_2+G_x & -G_2 & -G_x \\ -G_2 & G_2+G_3+G_4 & -G_4 \\ -G_x & -G_4 & G_5+G_4 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_B \end{bmatrix} = \begin{bmatrix} I_1 - I' - I'' \\ 0 + I' \\ I_3 + I'' \end{bmatrix}$$

G_x





Super-node

$V_1 - V_0 = V_2$

$V_1 - V_2 = V_0$

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3} = I_1$$

$$V_3\left(\frac{1}{R_3} + \frac{1}{R_4}\right) - \frac{V_2}{R_3} = I_3$$

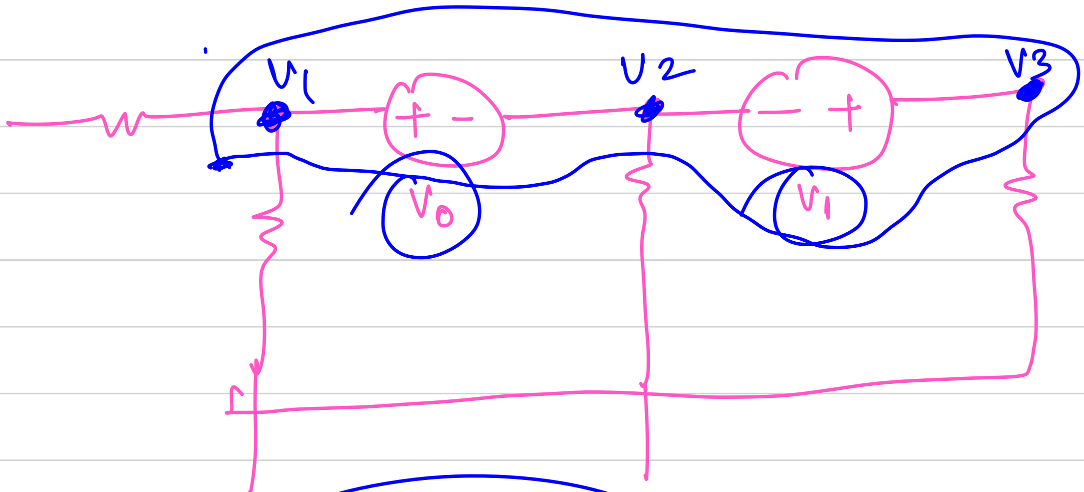
$$[G]\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$\boxed{V_1 - V_0 = V_2}$$

$V_1 - V_2 = V_0$

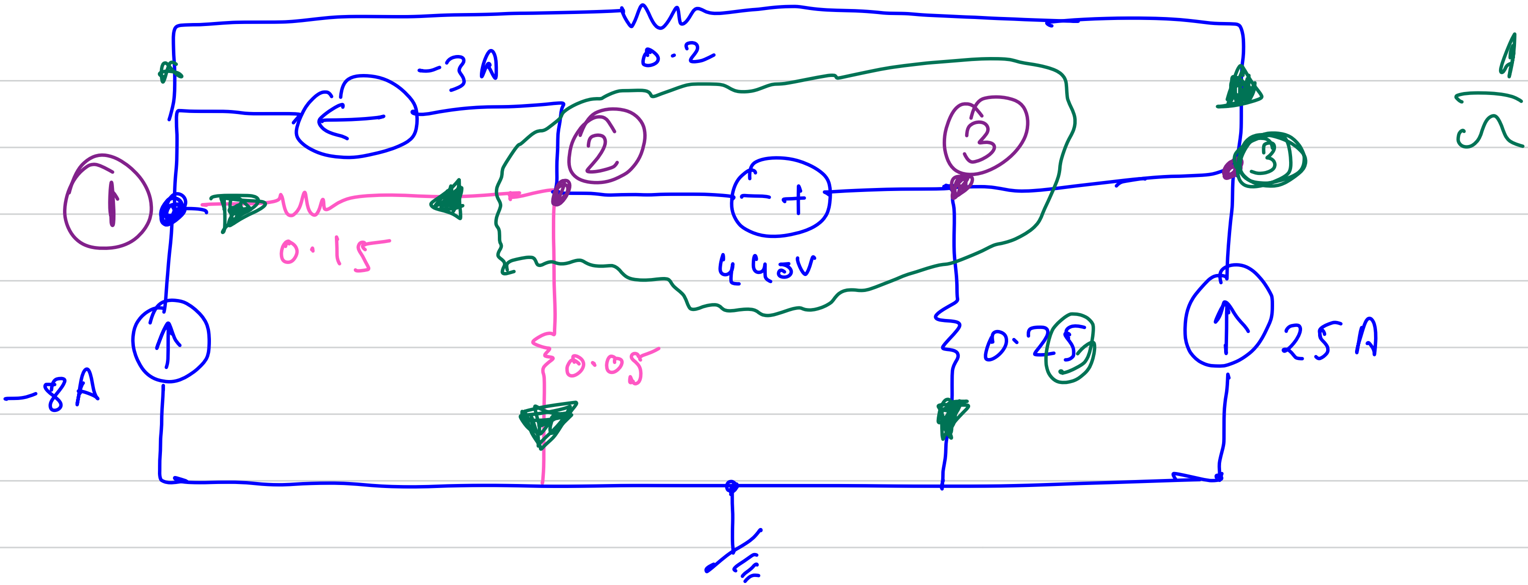
$$\begin{array}{ccc} V_1 & V_2 & V_3 \end{array}$$

$$\begin{bmatrix} & & -1 \\ & & \\ 1 & -1 & \end{bmatrix} = \begin{bmatrix} V_0 \end{bmatrix}$$



$V_1 - V_0 = V_2 \rightarrow 2$

$V_2 + V_1 = V_3 \rightarrow 3$



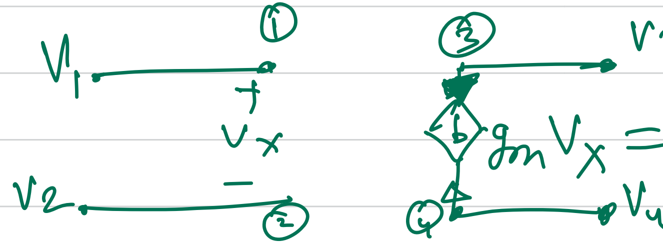
$$V_2\, 0.05 + 0.15\,(V_2 - V_1) + V_3 \cdot 0.25 + (V_3 - V_1)\, 0.2$$
$$= 25A + 3$$

$$V_2 + 440 = V_3$$

$$(V_1 - V_2)\, 0.15 + (V_1 - V_3) \cdot 0.2$$
$$= -3 - 8$$

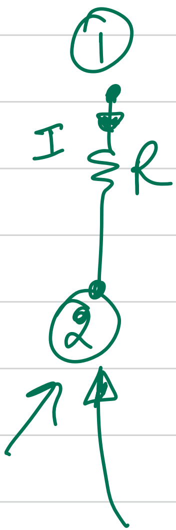
Nodal Analysis with dependent Cause

VCCS



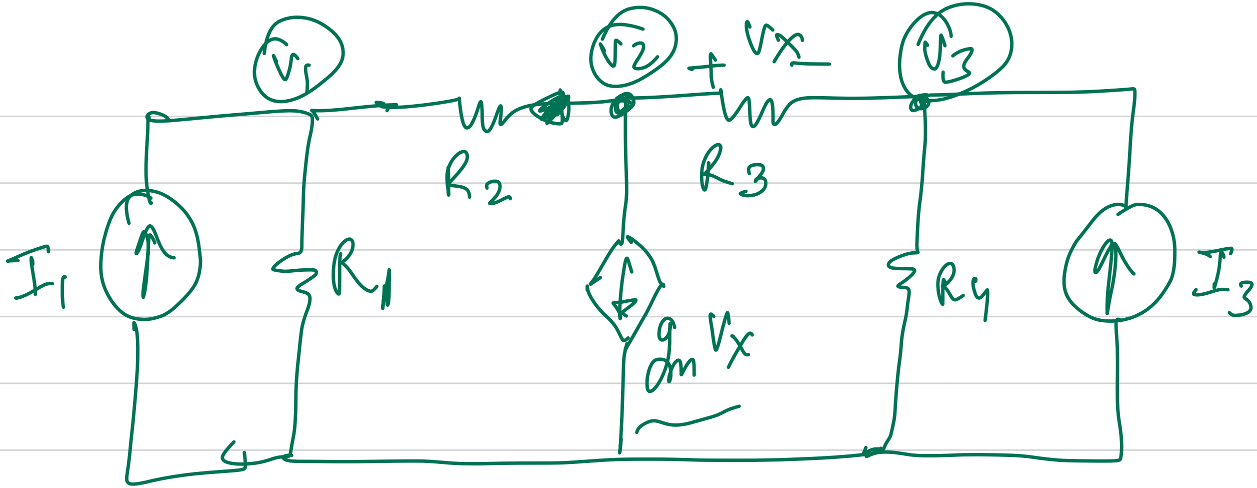
$g_m V_x = g_m(V_1 - V_2)$

$g_m(V_1 - V_2)$



$$
\begin{array}{c|cc}
 & V_1 & V_2 \\
\hline
1 & G & -G \\
2 & -G & G
\end{array}
\begin{bmatrix} V_1 \\ V_2 \end{bmatrix}
$$

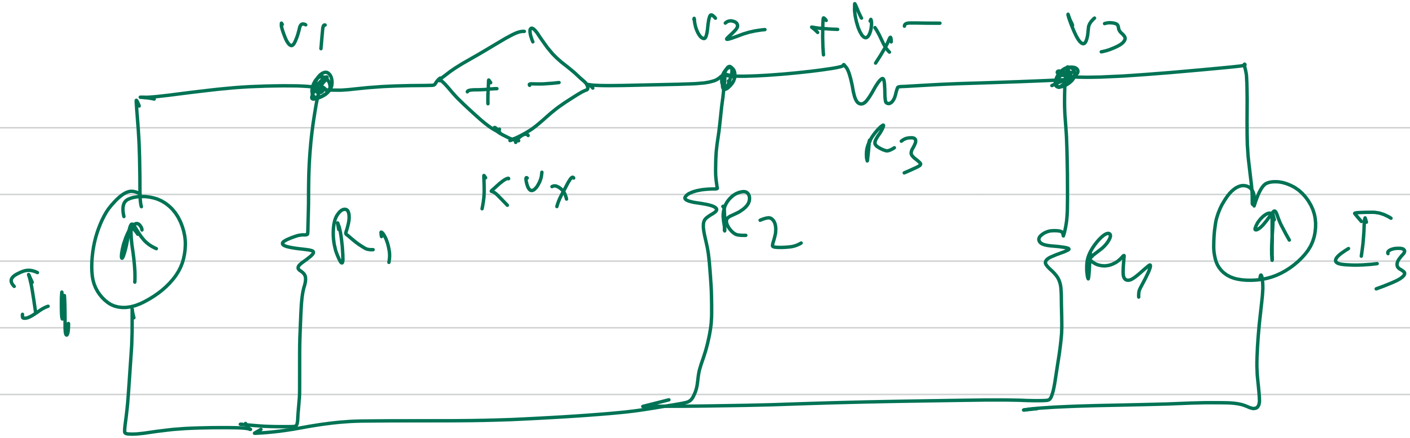
$$
\begin{array}{c|cccc}
 & v_1 & v_2 & v_3 & v_4 \\
\hline
1 & & & & \\
2 & & & & \\
3 & & & g_m & -g_m \\
4 & & & -g_m & g_m
\end{array}
$$



Symmetric matrix ?

$$g_m V_x + (V_2 - V_1)G_2 + (V_2 - V_3)G_3 = 0$$

$$(V_x = V_2 - V_3)$$

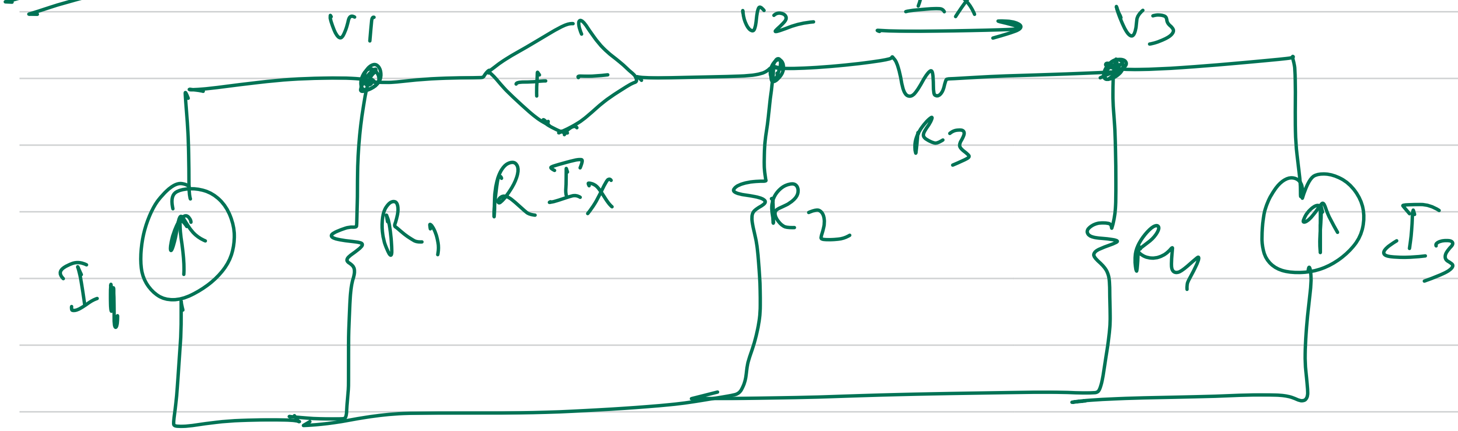


$V_1 - KV_x = V_2$ — 2 $\qquad V_x = V_2 - V_3$

Conductance Matrix → Not symmetric

$GV = I$

CCVS



CCCS