

Quick Recap

R, L, C ($v-i$ characteristics)

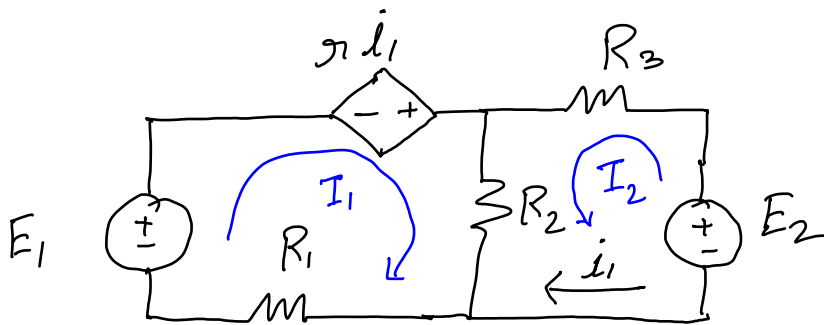
source $\left\{ \begin{array}{l} \text{voltage source} \\ \text{current source} \end{array} \right\}$

KCL (conservation of charge) ✓

KVL (conservation of energy) ✓

Node variable analysis }
Loop " " } mesh
(planar circuit)

Circuits with dependent sources



Mesh Analysis

KVL for Mesh 1, $i_1 = -I_2$

$$E_1 + \alpha i_1 - (I_1 + I_2)R_2 - I_1 R_1 = 0$$

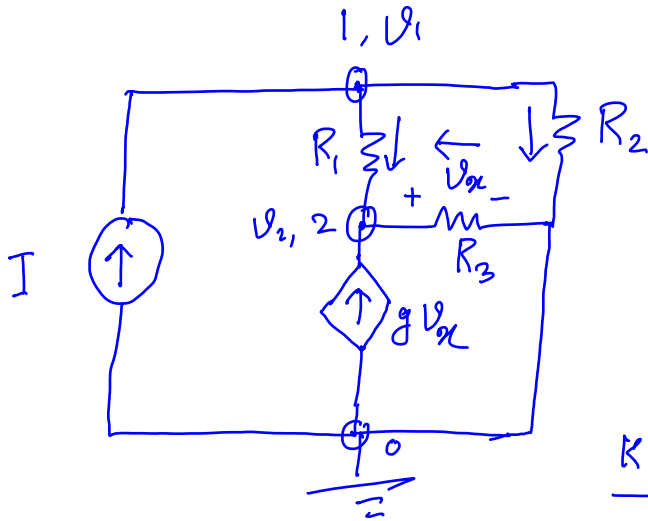
KVL for Mesh 2,

$$E_2 - I_2 R_3 - (I_1 + I_2)R_2 = 0$$

$$A \mathbf{x} = \mathbf{b}$$

$$\mathbf{x} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$A = \begin{bmatrix} -R_1 - R_2 & -1 - R_2 \\ -R_2 & -R_2 - R_3 \end{bmatrix} \quad b = \begin{bmatrix} -E_1 \\ -E_2 \end{bmatrix}$$



(Node Analysis)

KCL at node 1,

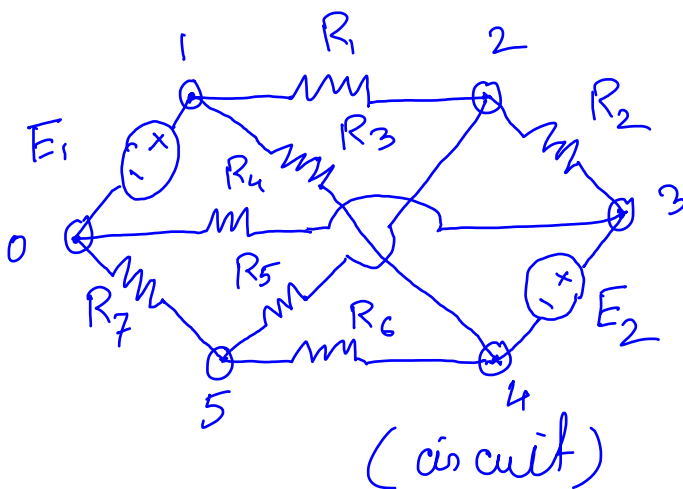
$$I = \frac{V_1 - V_2}{R_1} + \frac{V_1}{R_2}$$

KCL at node 2,

$$\frac{V_1 - V_2}{R_1} - \frac{V_2}{R_3} + gV_x = 0$$

$$V_x = V_2$$

Non-planar Circuit



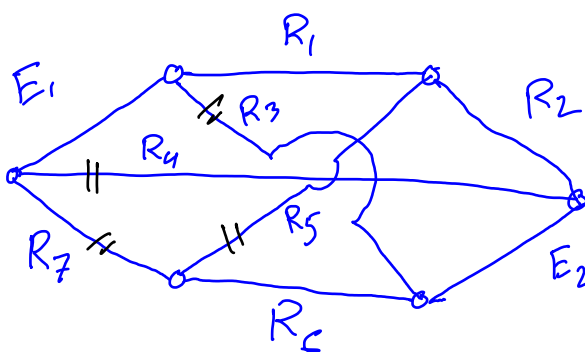
$$n = 6$$

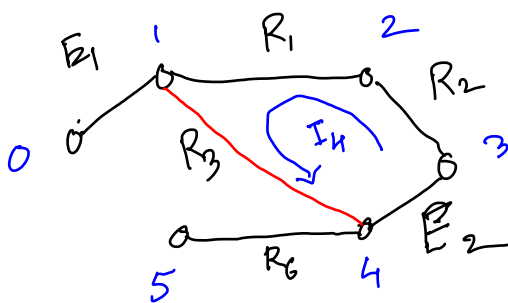
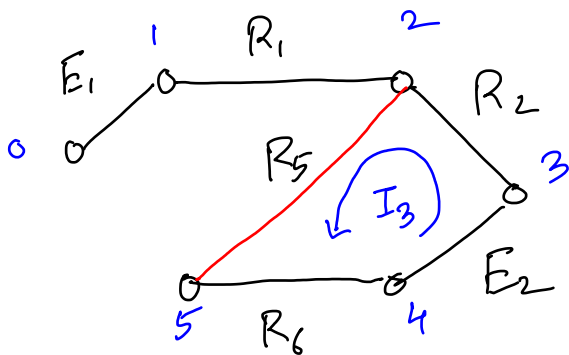
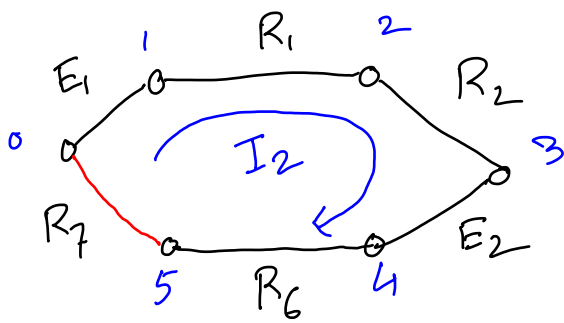
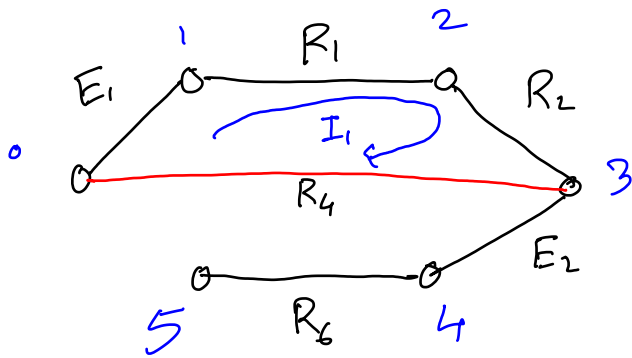
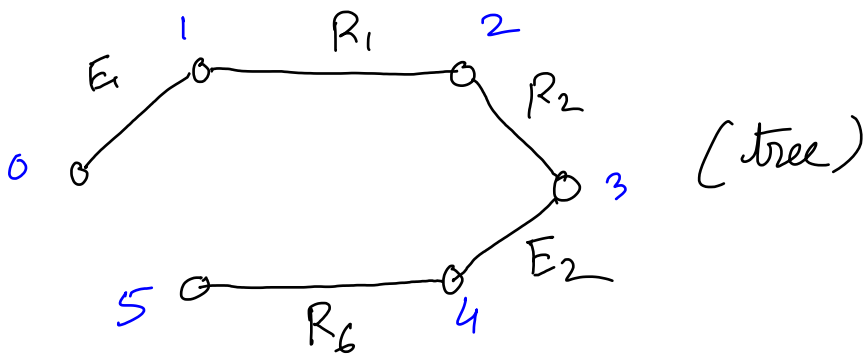
$$b = 9$$

$$\text{no. of chords} = b - n + 1$$

$$= 9 - 6 + 1$$

$$= 4$$





branch

Magnitude

Direction

R_1

$(I_1 + I_2 - I_4)$

① \longrightarrow ②

R_2

$(I_1 + I_2 - I_3 - I_4)$

$(2) \rightarrow (3)$

 E_2

$(I_3 + I_4 - I_2)$

$(4) \rightarrow (3)$

 R_6

$(I_2 - I_3)$

$(4) \rightarrow (5)$

 E_1

$(I_1 + I_2)$

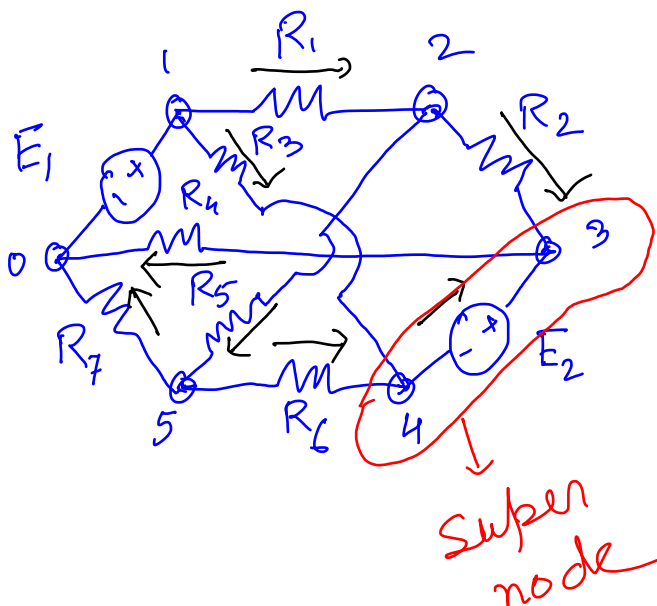
$(0) \rightarrow (1)$

KVL for loop 1,

$$E_1 = (I_1 + I_2 - I_4) R_1 + (I_1 + I_2 - I_3 - I_4) R_2 + I_1 R_4$$

KVL for loop 2,

$$E_1 = (I_1 + I_2 - I_4) R_1 + (I_1 + I_2 - I_3 - I_4) R_2 + E_2 + (I_2 - I_3) R_6 + I_2 R_7$$



(Node Analysis)

$V_1 = E_1$

KCL at node 2,

$$\frac{V_1 - V_2}{R_1} = \frac{V_2 - V_3}{R_2} + \frac{V_2 - V_5}{R_5}$$

KCL at node 5,

$$\frac{V_2 - V_5}{R_5} = \frac{V_5}{R_7} + \frac{V_5 - V_4}{R_6}$$

KCL at super node,

$$\frac{V_5 - V_4}{R_6} + \frac{V_1 - V_4}{R_3} + \frac{V_2 - V_3}{R_2} = \frac{V_3}{R_4}$$

$$V_3 - V_4 = E_2$$

