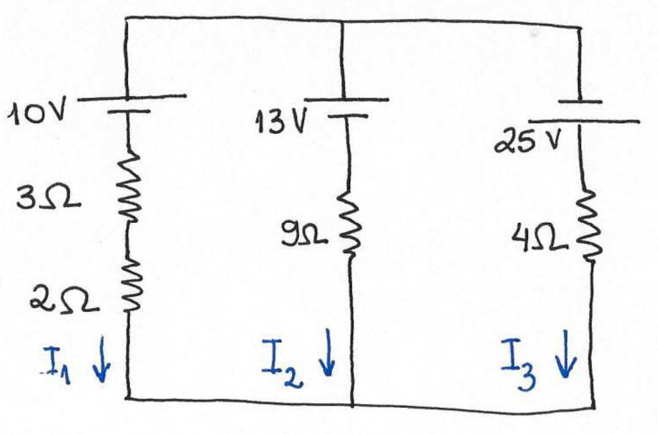
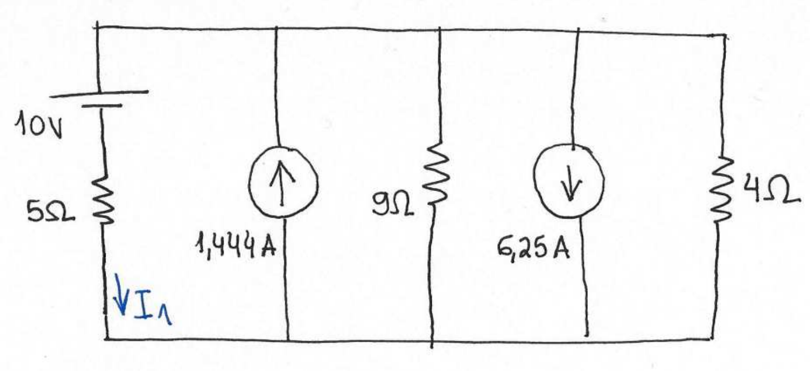
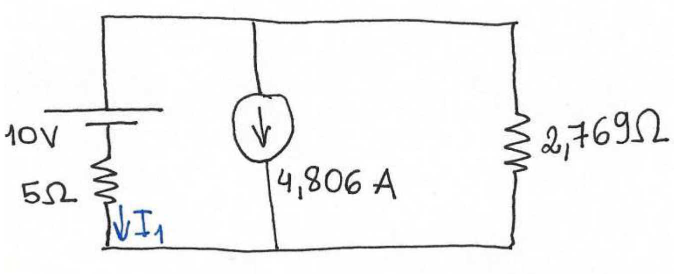
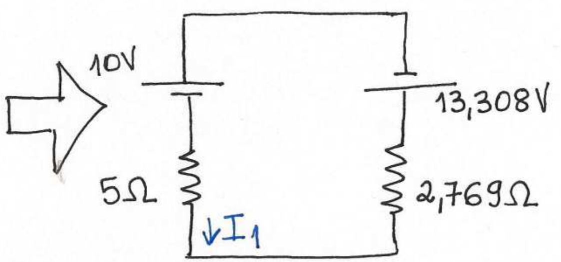
Ex. 1.3 (Lista Moodle), resolução por conversão de fontes



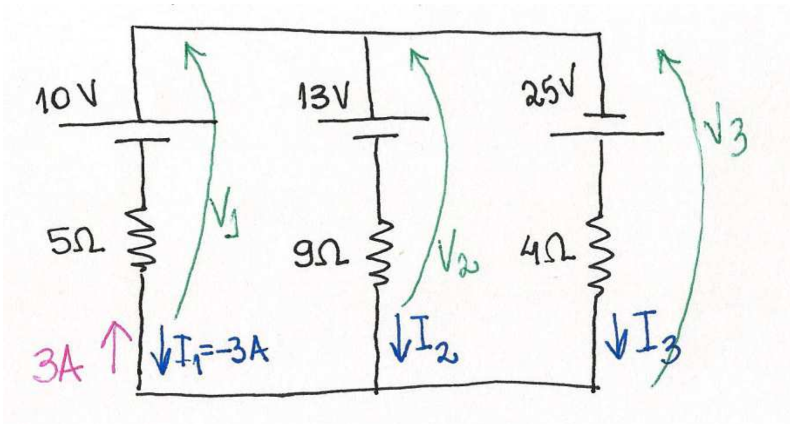






$$I_1 = -\frac{(10+13{,}308)}{5+2{,}769\,\Omega}$$

$$\boxed{I_1 = -3A}$$



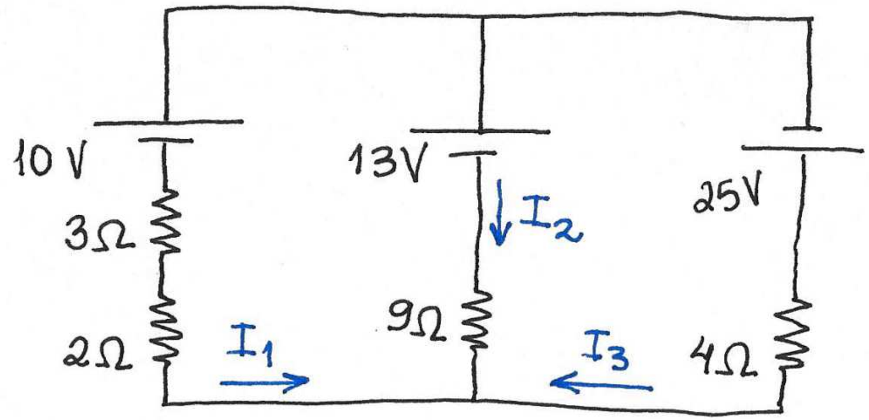
$$V_1 = 10 - 5.3 = -5V$$

$$V_2 = V_3 = V_1 = -5V$$

$$V_2 = -5 = 13 - 9(-I_2)$$

$$\hookrightarrow 9\,I_2 = -18 \rightarrow \boxed{I_2 = -2A}$$

$$V_3 = -5 = -25 + 4\,I_3 \rightarrow \boxed{I_3 = 5A}$$



PLK/SLK:

PLK: $I_1 + I_2 + I_3 = 0$

SLK: $-10 + 13 + 9I_2 - 5I_1 = 0$

$-13 - 25 + 4I_3 - 9I_2 = 0$

$$\begin{bmatrix} 1 & 1 & 1 \\ -5 & 9 & 0 \\ 0 & -9 & 4 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 0 \\ -3 \\ 38 \end{bmatrix}$$

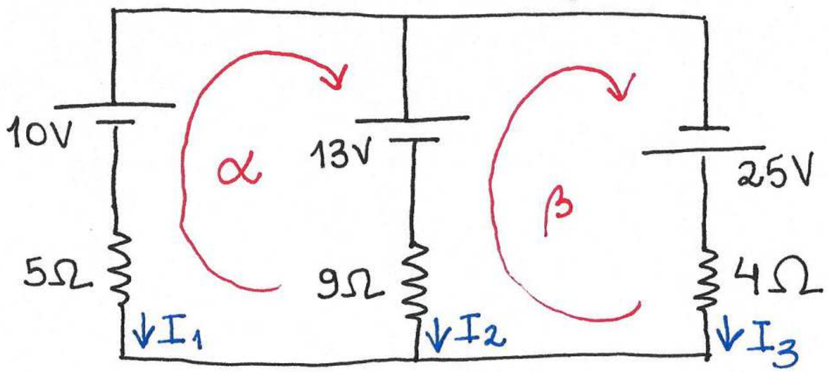
$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} -3 \\ -2 \\ 5 \end{bmatrix}$$

$I_1 = -3A$

$I_2 = -2A$

$I_3 = 5A$

Ex. 1.3 (Lista Moodle), resolução pelo método das correntes de Maxwell



$$5\alpha - 10 + 13 + 9(\alpha - \beta) = 0$$

$$9(\beta - \alpha) - 13 - 25 + 4\beta = 0$$

$$\begin{cases} 14\alpha - 9\beta = -3 \\ -9\alpha + 13\beta = 38 \end{cases}$$

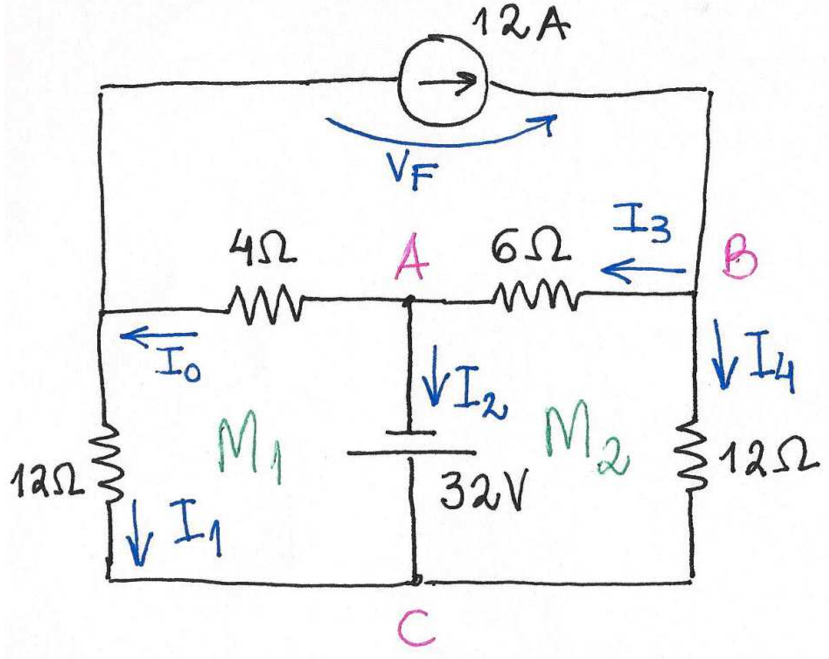
$$\begin{bmatrix} 14 & -9 \\ -9 & 13 \end{bmatrix} \begin{bmatrix} \alpha \\ \beta \end{bmatrix} = \begin{bmatrix} -3 \\ 38 \end{bmatrix} \quad \rightarrow \quad \begin{bmatrix} \alpha \\ \beta \end{bmatrix} = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$$

$$I_1 = -\alpha = -3A$$

$$I_2 = \alpha - \beta = -2A$$

$$I_3 = \beta = 5A$$

Análise de malhas – Circuito com fonte de corrente pertencente a apenas uma malha



PLK/SLK

(A) $-I_0 - I_2 + I_3 = 0$

(B) $-I_3 - I_4 + 12 = 0$

(C) $I_1 + I_2 + I_4 = 0$

(M_1) $-32 - 12I_1 - 4I_0 = 0$

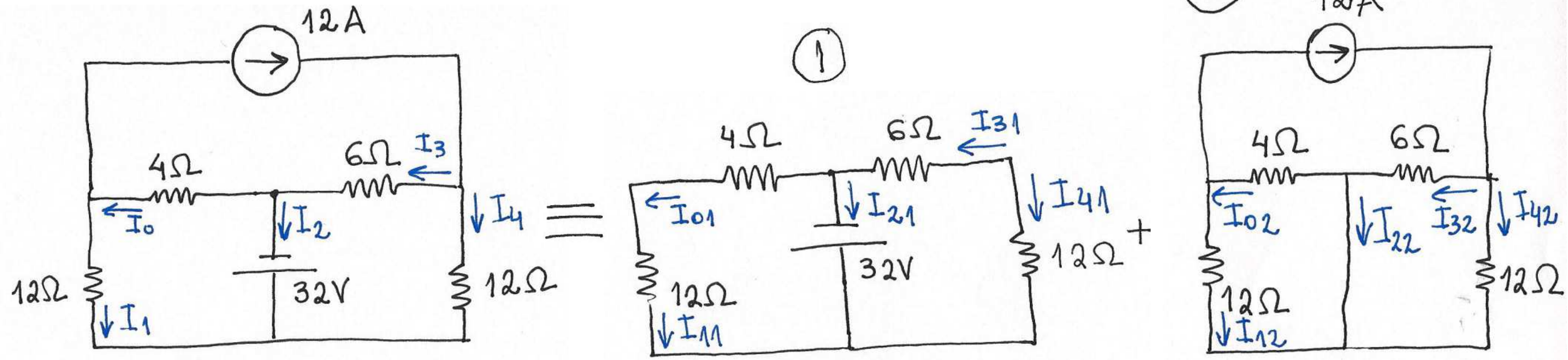
(M_2) $32 - 6I_3 + 12I_4 = 0$

$$\begin{bmatrix} -1 & 0 & -1 & 1 & 0 \\ 0 & 0 & 0 & -1 & -1 \\ 0 & 1 & 1 & 0 & 1 \\ -4 & -12 & 0 & 0 & 0 \\ 0 & 0 & 0 & -6 & 12 \end{bmatrix} \begin{bmatrix} I_0 \\ I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} 0 \\ -12 \\ 0 \\ 32 \\ -32 \end{bmatrix}$$

$$\begin{bmatrix} I_0 \\ I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} 7\text{ A} \\ -5\text{ A} \\ 2{,}778\text{ A} \\ 9{,}778\text{ A} \\ 2{,}222\text{ A} \end{bmatrix}$$

$$V_F = 6I_3 + 4I_0 = 58{,}667 + 28 = 86{,}667\text{ V}$$

Circuito com fonte de corrente – Princípio da superposição



Circuito ①:

$I_{01} = \frac{-32}{16} = -2A$; $I_{11} = -2A$

$I_{31} = \frac{32}{18} = 1,778A$; $I_{41} = -1,778A$

$I_{21} = I_{31} - I_{01} = 1,778 - (-2) = 3,778A$

$I_0 = I_{01} + I_{02} = -2 + 9 = 7A$

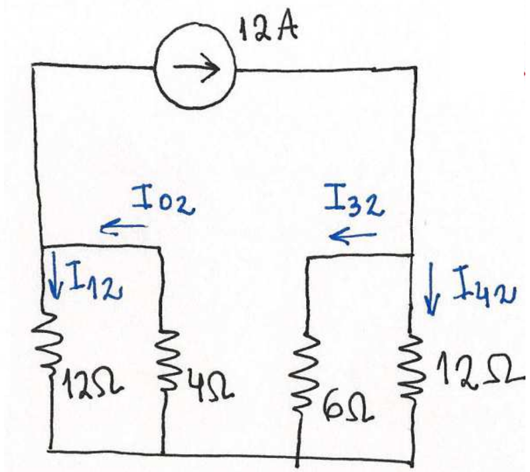
$I_1 = I_{11} + I_{12} = -2 - 3 = -5A$

$I_2 = I_{21} + I_{22} = 3,778 - 1 = 2,778A$

$I_3 = I_{31} + I_{32} = 1,778 + 8 = 9,778A$

$I_4 = I_{41} + I_{42} = -1,778 + 4 = 2,222A$

Circuito ②:



$I_{22} = I_{32} - I_{02}$

$$\begin{cases} -I_{32} - I_{42} + 12 = 0 \\ 6 I_{32} = 12 I_{42} \end{cases}$$

$I_{42} = 4A$

$I_{32} = 8A$

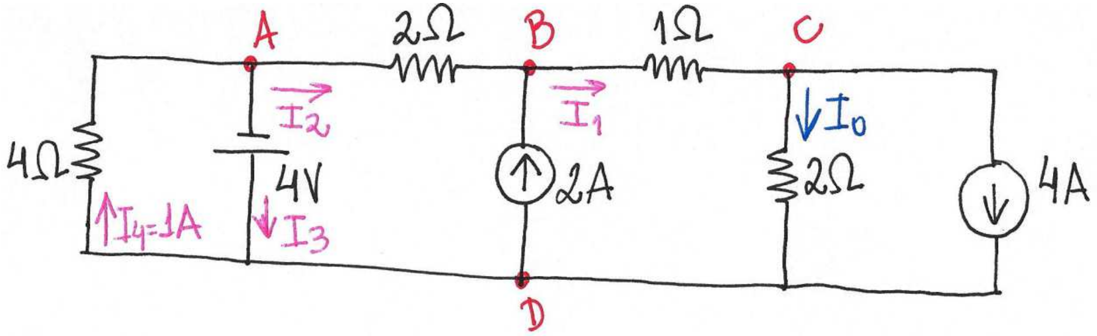
$$\begin{cases} -I_{12} + I_{02} - 12 = 0 \\ 12 I_{12} = -4 I_{02} \end{cases}$$

$I_{12} = -3A$

$I_{02} = 9A$

$I_{22} = 8 - 9 = -1A$

Análise de malhas – Circuito com fonte de corrente pertencente a duas malhas



$I_0 = ?$

A: $-I_2 - I_3 + 1 = 0$

B: $-I_1 + I_2 + 2 = 0$

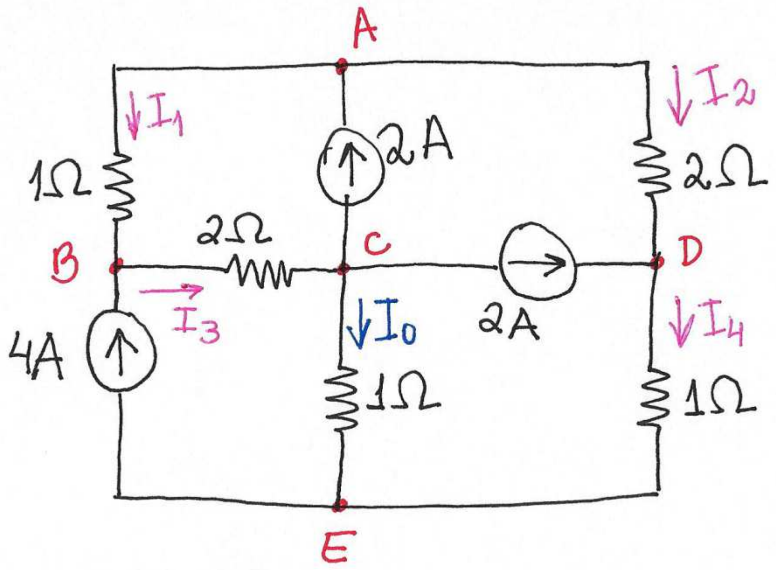
C: $-I_0 + I_1 - 4 = 0$

ABCDA: $2I_2 + 1.I_1 + 2.I_0 + 4 = 0$

$$\begin{bmatrix} 0 & 0 & -1 & -1 \\ 0 & -1 & 1 & 0 \\ -1 & 1 & 0 & 0 \\ 2 & 1 & 2 & 0 \end{bmatrix} \begin{bmatrix} I_0 \\ I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} -1 \\ -2 \\ 4 \\ -4 \end{bmatrix}$$

$$\begin{bmatrix} I_0 \\ I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} -2{,}4\,A \\ 1{,}6\,A \\ -0{,}4\,A \\ 1{,}4\,A \end{bmatrix}$$

Outro exemplo com fontes de corrente



$\boxed{I_0 = ?}$

PLK/SLK:

A: $-I_1 + 2 - I_2 = 0$

B: $I_1 - I_3 + 4 = 0$

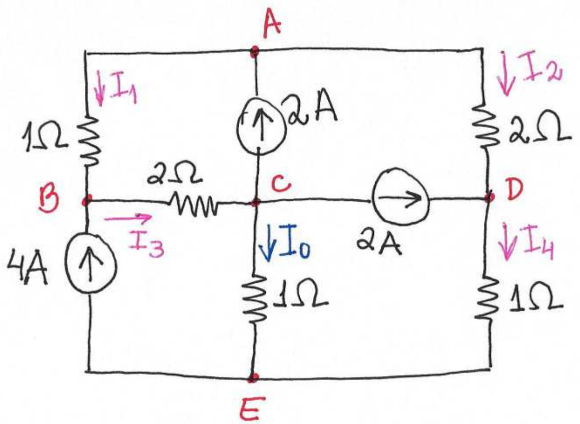
C: $-I_0 + I_3 - 2 - 2 = 0$

D: $I_2 - I_4 + 2 = 0$

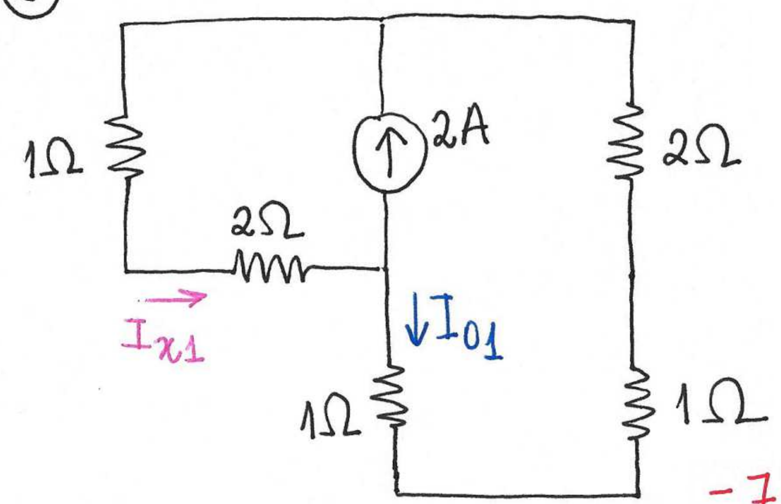
ABCEDA: $1 \cdot I_1 + 2 \cdot I_3 + 1 \cdot I_0 - 1\, I_4 - 2 \cdot I_2 = 0$

$$\begin{bmatrix} 0 & -1 & -1 & 0 & 0 \\ 0 & 1 & 0 & -1 & 0 \\ -1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & -1 \\ 1 & 1 & -2 & 2 & -1 \end{bmatrix} \begin{bmatrix} I_0 \\ I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} -2 \\ -4 \\ 4 \\ -2 \\ 0 \end{bmatrix}$$

$$\boxed{\begin{bmatrix} I_0 \\ I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} 0\ A \\ 0\ A \\ 2\ A \\ 4\ A \\ 4\ A \end{bmatrix}}$$



1



$$\begin{cases} -I_{01} + I_{x1} - 2 = 0 \\ I_{01} \cdot 4 = -I_{x1} \cdot 3 \end{cases}$$

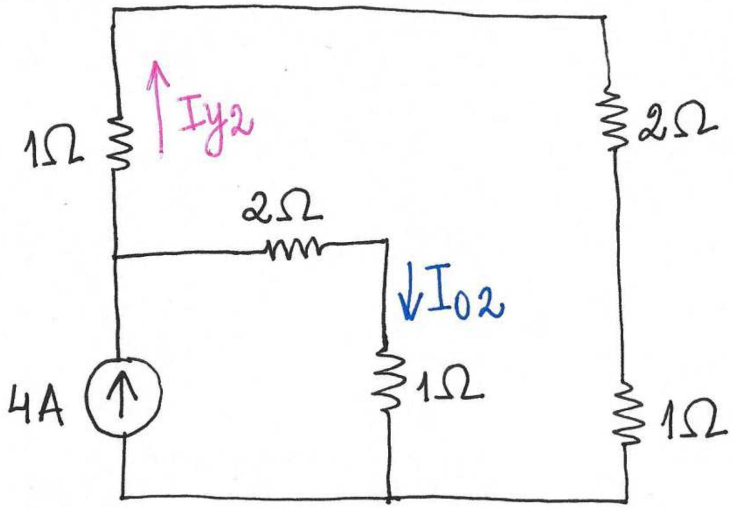
$$I_{x1} = \frac{-4}{3} I_{01}$$

$$-I_{01} - \frac{4}{3} I_{01} - 2 = 0$$

$$-\frac{7}{3} I_{01} = 2$$

$$\boxed{I_{01} = -\frac{6}{7} A}$$

2



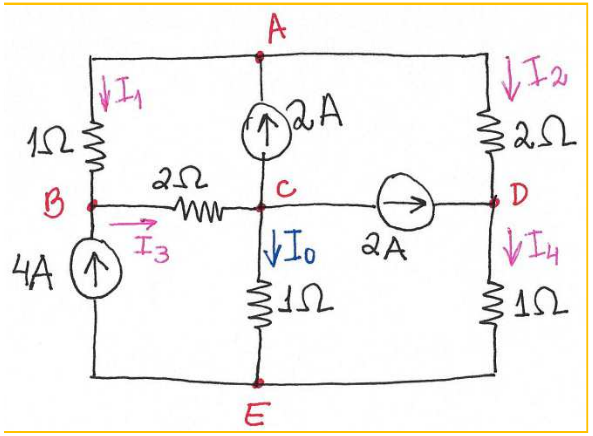
$$\begin{cases} 4 - I_{02} - I_{y2} = 0 \\ 3 I_{02} = 4 I_{y2} \end{cases}$$

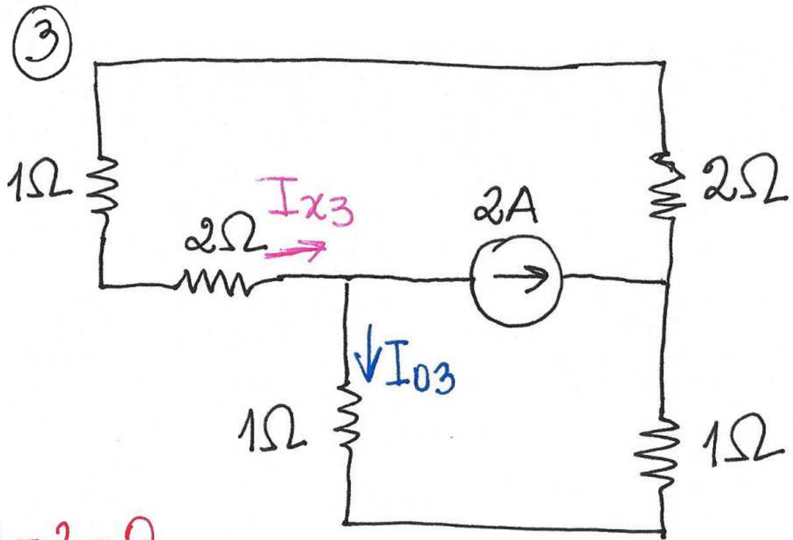
$$I_{y2} = \frac{3}{4} I_{02}$$

$$-I_{02} - \frac{3}{4} I_{02} = -4$$

$$\frac{7}{4} I_{02} = 4$$

$$\boxed{I_{02} = \frac{16}{7} A}$$





$$\begin{cases} -I_{03} + I_{x3} - 2 = 0 \\ 2 I_{03} = -5 I_{13} \end{cases}$$

$$I_{13} = \frac{-2}{5} I_{013}$$

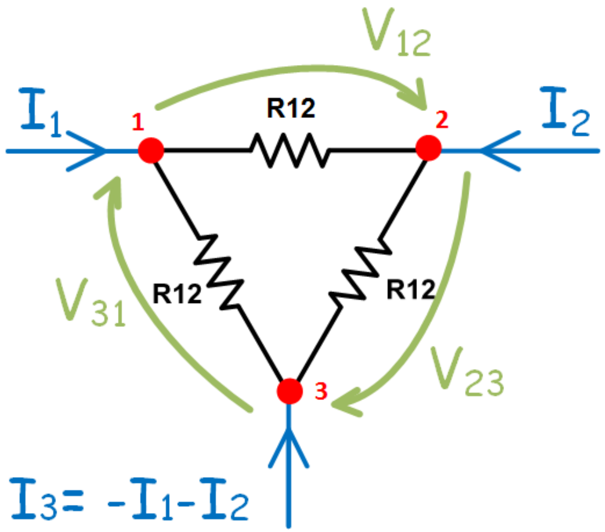
$$-I_{03} - \frac{2}{5} I_{03} - 2 = 0$$

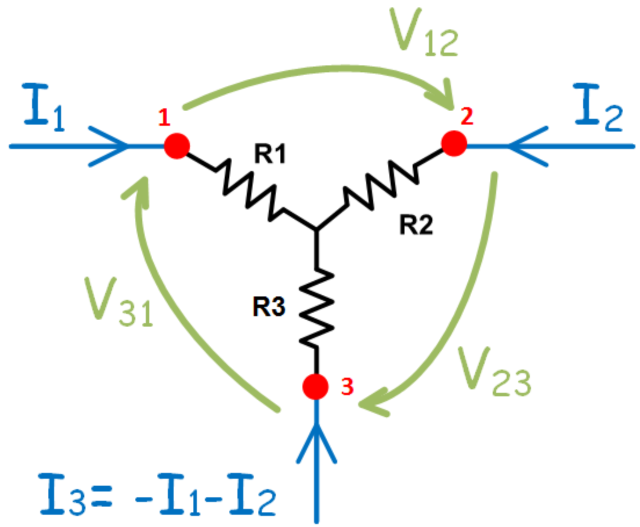
$$\frac{7}{5} I_{03} = -2$$

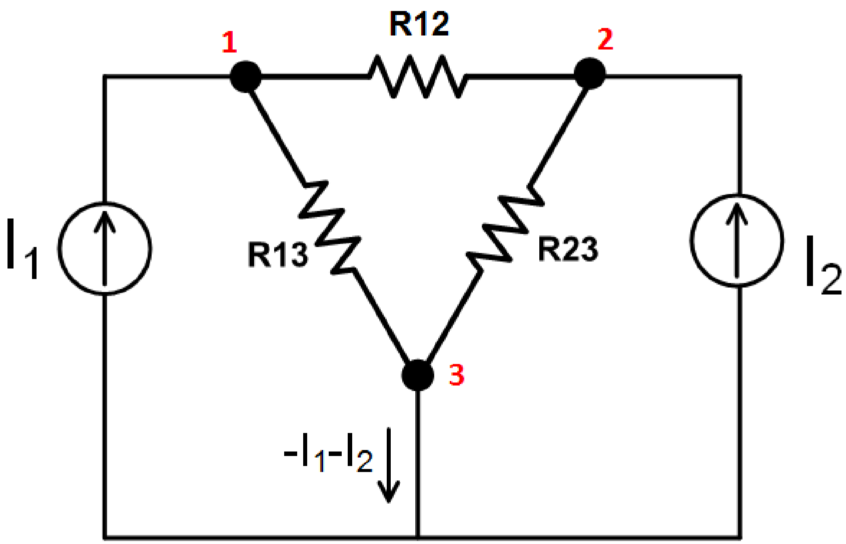
$$I_{03} = \frac{-10}{7} \text{ A}$$

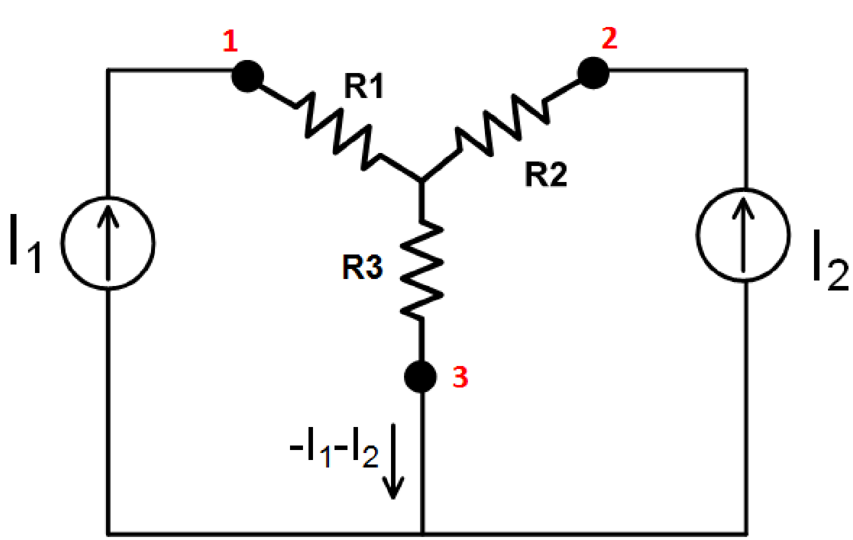
$$\boxed{\begin{aligned} I_0 &= I_{01} + I_{02} + I_{03} \\ I_0 &= \frac{-6}{7} + \frac{16}{7} - \frac{10}{7} \\ I_0 &= 0 \text{ A} \end{aligned}}$$

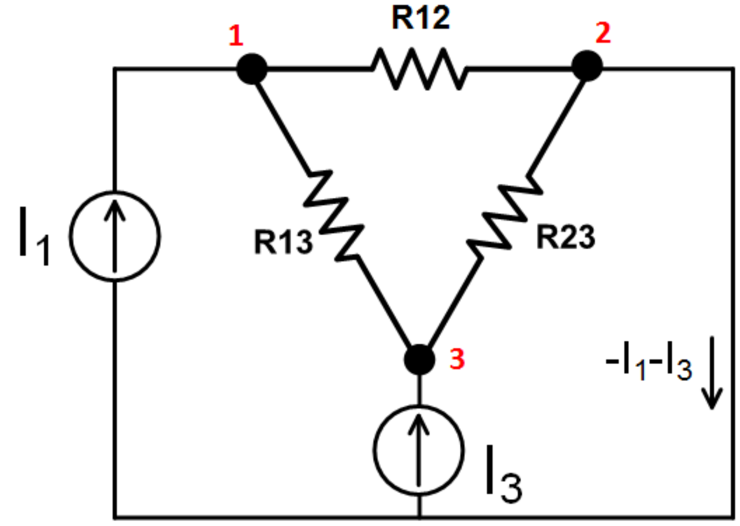
Transformação $\Delta \leftrightarrow Y$

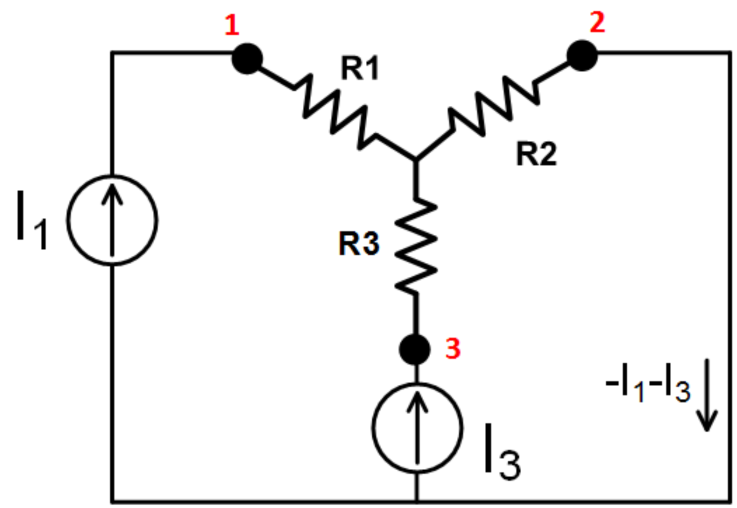


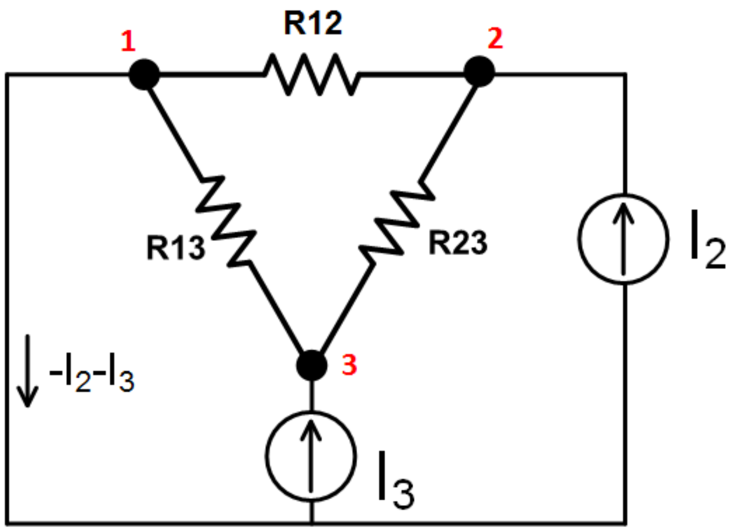


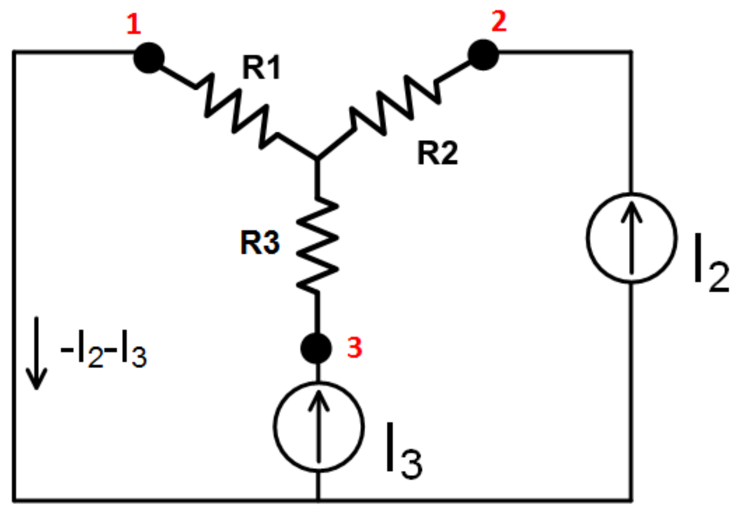


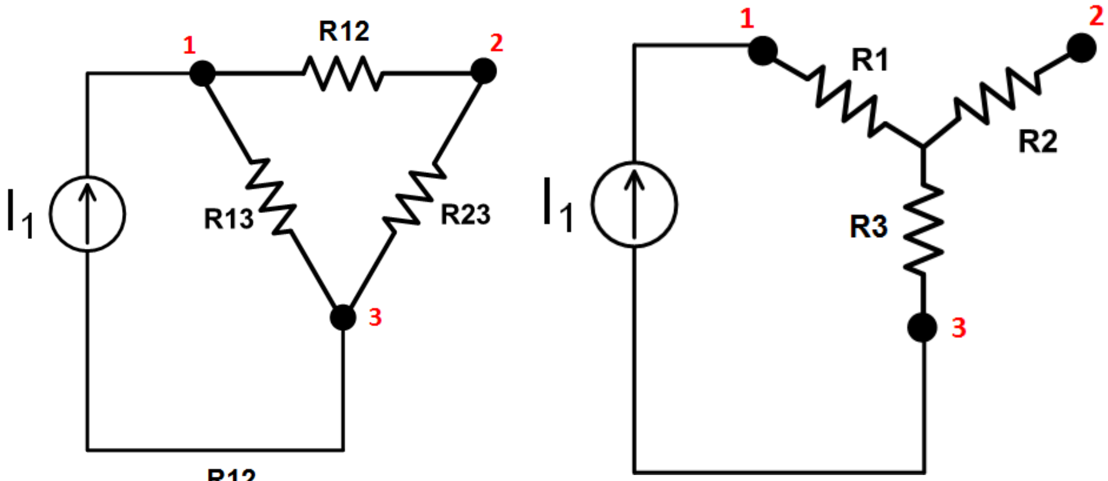



R12
1
2
I1
R13
R23
3
-I1-I3
I3

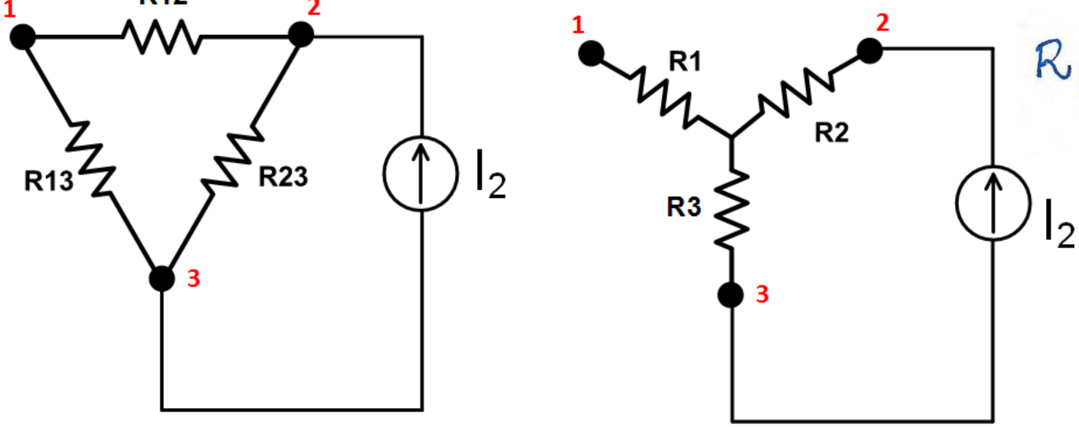

1
2
R1
R2
I1
R3
3
-I1-I3
I3


R12
1
2
R13
R23
I2
-I2-I3
3
I3

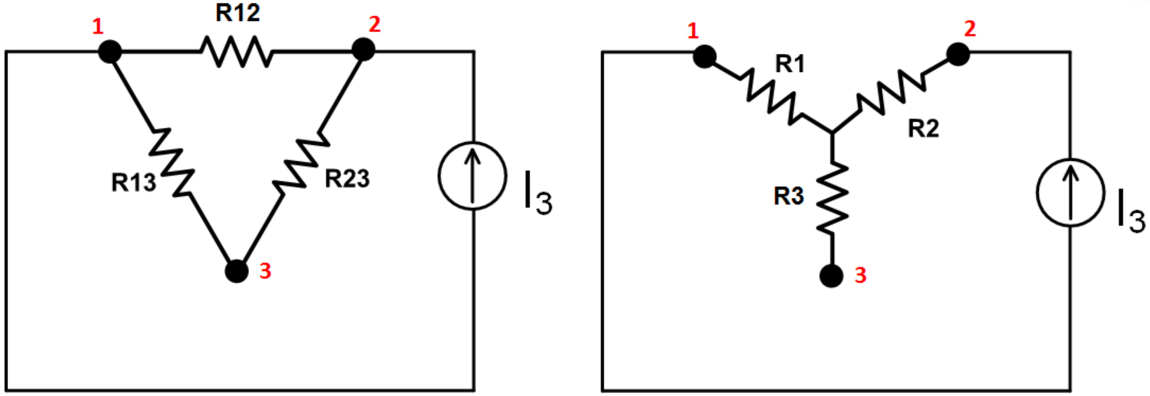

1
2
R1
R2
R3
I2
-I2-I3
3
I3



$$R_1 + R_3 = R_{13} // (R_{12} + R_{23})$$
$$= \frac{R_{12}R_{13} + R_{13}R_{23}}{R_{12} + R_{13} + R_{23}}$$



$$R_2 + R_3 = R_{23} // (R_{12} + R_{13})$$
$$= \frac{R_{12}R_{23} + R_{13}R_{23}}{R_{12} + R_{13} + R_{23}}$$



$$R_1 + R_2 = R_{12} // (R_{13} + R_{23})$$
$$= \frac{R_{12}R_{13} + R_{12}R_{23}}{R_{12} + R_{13} + R_{23}}$$

$$R_1 + R_3 = R_{13} // (R_{12} + = \frac{R_{12} R_{13} + R_{13} R_{23}}{R_{12} + R_{13} + R_{23}}$$

$$\boxed{R_1 = \frac{R_{12} R_{13}}{R_{12} + R_{13} + R_{23}}}$$

$$R_2 + R_3 = R_{23} // (R_{12} + R_{13}) = \frac{R_{12} R_{23} + R_{13} R_{23}}{R_{12} + R_{13} + R_{23}}$$

$$\boxed{R_2 = \frac{R_{12} R_{23}}{R_{12} + R_{13} + R_{23}}}$$

$$R_1 + R_2 = R_{12} // (R_{13} + R_{23}) = \frac{R_{12} R_{13} + R_{12} R_{23}}{R_{12} + R_{13} + R_{23}}$$

$$\boxed{R_3 = \frac{R_{13} R_{23}}{R_{12} + R_{13} + R_{23}}}$$

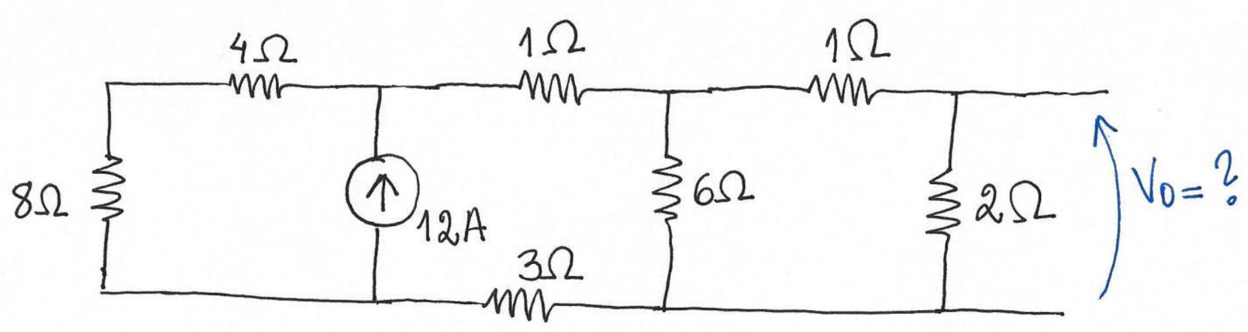
$$\frac{R_1}{R_3} = \frac{R_{12}}{R_{23}} \longrightarrow R_{23} = R_{12} \frac{R_3}{R_1} \qquad \frac{R_2}{R_3} = \frac{R_{12}}{R_{13}} \longrightarrow R_{13} = R_{12} \frac{R_3}{R_2}$$

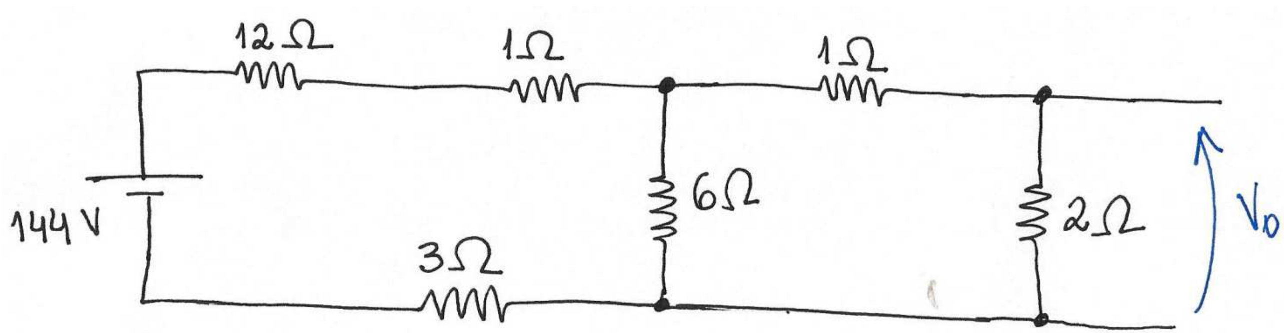
$$R_1 = \frac{R_{12} \left(R_{12} \frac{R_3}{R_2} \right)}{R_{12} + \left(R_{12} \frac{R_3}{R_2} \right) + \left(R_{12} \frac{R_3}{R_1} \right)} \begin{matrix} \times \frac{R_2 R_1}{R_{12}} \\ \times \frac{R_2 R_1}{R_{12}} \end{matrix} \Rightarrow R_1 = \frac{R_{12} R_1 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}$$

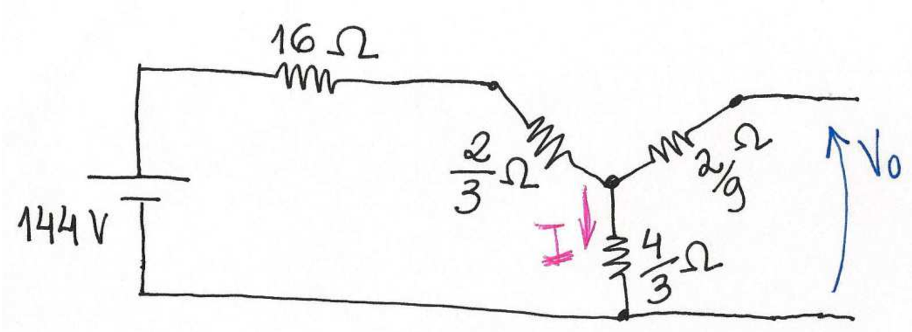
$$\boxed{R_{12} = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_3}}$$

$$\boxed{R_{13} = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_2}} \qquad \boxed{R_{23} = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_1}}$$

Exemplo de resolução por transformação $\Delta \leftrightarrow Y$







$$V_0 = 0 \cdot \frac{2}{9} + \frac{4}{3} I$$

$$I = \frac{144}{16 + \frac{2}{3} + \frac{4}{3}} = 8A$$

$$\boxed{V_0 = \frac{4}{3} \cdot 8 = \frac{32}{3} A}$$