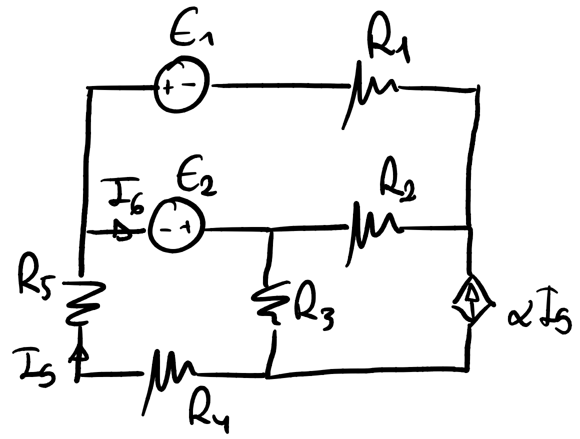
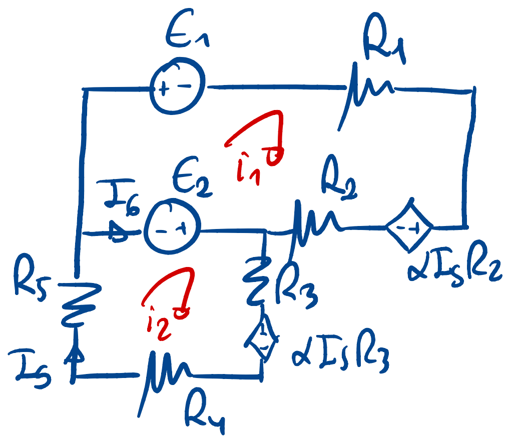
Problema 1 I_6, mallas αI_6 βU_5



$\rightarrow$



i_1: $-\varepsilon_1 - \alpha I_5 R_2 - \varepsilon_2 = i_1(R_1+R_2) \xrightarrow{I_5=i_2} -\varepsilon_1 - \varepsilon_2 = i_1(R_1+R_2) + i_2 \alpha R_2$

i_2: $\varepsilon_2 - \alpha I_5 R_3 = i_2(R_3+R_4+R_5) \xrightarrow{I_5=i_2} \varepsilon_2 = i_2(R_3(1+\alpha)+R_4+R_5)$

$$\hat{e}_s = Z_m \hat{i}_s \rightarrow \begin{pmatrix} -\varepsilon_1 - \varepsilon_2 \\ \varepsilon_2 \end{pmatrix} = \begin{pmatrix} R_1+R_2 & \alpha R_2 \\ 0 & R_3(1+\alpha)+R_4+R_5 \end{pmatrix} \begin{pmatrix} i_1 \\ i_2 \end{pmatrix}$$

$$i_1 = \frac{\begin{vmatrix} -(\varepsilon_1+\varepsilon_2) & \alpha R_2 \\ \varepsilon_2 & R_3(1+\alpha)+R_4+R_5 \end{vmatrix}}{\begin{vmatrix} R_1+R_2 & \alpha R_2 \\ 0 & R_3(1+\alpha)+R_4+R_5 \end{vmatrix}} = \frac{-(\varepsilon_1+\varepsilon_2)(R_3(1+\alpha)+R_4+R_5) - \varepsilon_2 \alpha R_2}{(R_1+R_2)(R_3(1+\alpha)+R_4+R_5)}$$

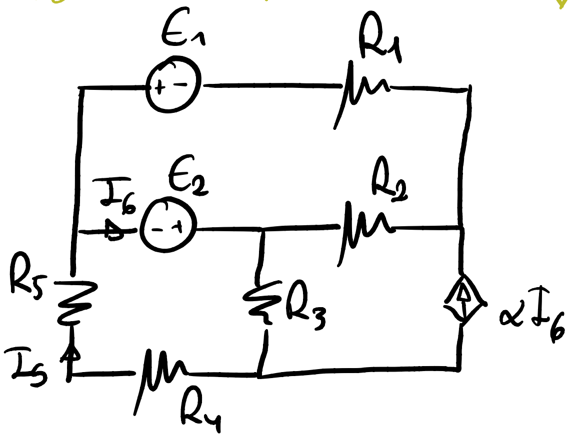
$$i_2 = \frac{\begin{vmatrix} R_1+R_2 & -(\varepsilon_1+\varepsilon_2) \\ 0 & \varepsilon_2 \end{vmatrix}}{\begin{vmatrix} R_1+R_2 & \alpha R_2 \\ 0 & R_3(1+\alpha)+R_4+R_5 \end{vmatrix}} = \frac{\varepsilon_2(R_1+R_2)}{(R_1+R_2)(R_3(1+\alpha)+R_4+R_5)}$$

$I_5 = i_1 + I_6 \rightarrow I_6 = I_5 - i_1 = i_2 - i_1 =$

$$\frac{\varepsilon_2(R_1+R_2) + (\varepsilon_1+\varepsilon_2)(R_3(1+\alpha)+R_4+R_5) + \varepsilon_2 \alpha R_2}{(R_1+R_2)(R_3(1+\alpha)+R_4+R_5)}$$

Problema 1. Añadido 1 αI_6

$i_1 = I_6 + i_2$
$I_6 = i_1 - i_2$



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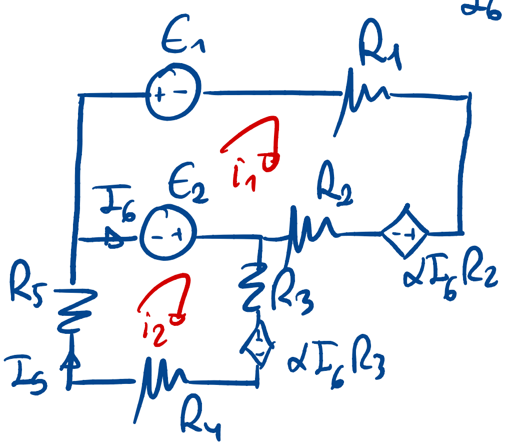
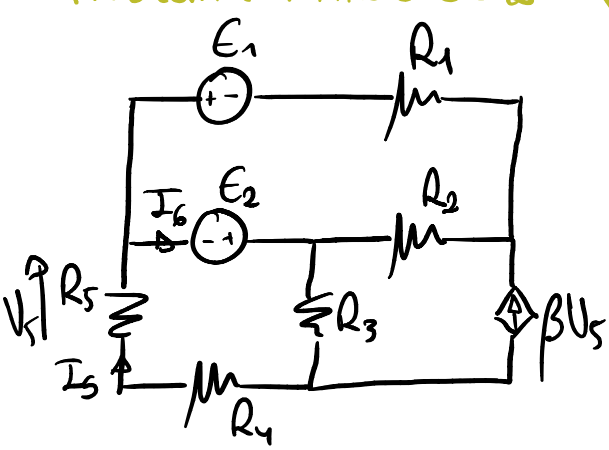


i_1: $-\mathcal{E}_1 - \alpha I_6 R_2 - \mathcal{E}_2 = i_1(R_1+R_2) \xrightarrow{I_6=i_1-i_2} -\mathcal{E}_1 - \mathcal{E}_2 = i_1(R_1+R_2(1+\alpha)) - i_2\alpha R_2$

i_2: $\mathcal{E}_2 - \alpha I_6 R_3 = i_2(R_3+R_4+R_5) \xrightarrow{I_6=i_1-i_2} \mathcal{E}_2 = i_2(R_3(1-\alpha)+R_4+R_5) + i_1\alpha R_3$

$$\hat{e_g} = Z_m \hat{i_g} \Rightarrow \begin{pmatrix} -(\mathcal{E}_1+\mathcal{E}_2) \\ \mathcal{E}_2 \end{pmatrix} = \begin{pmatrix} R_1+R_2(1+\alpha) & -\alpha R_2 \\ \alpha R_3 & R_3(1+\alpha)+R_4+R_5 \end{pmatrix} \begin{pmatrix} i_1 \\ i_2 \end{pmatrix}$$

Problema 1. Añadido 2 βU_5



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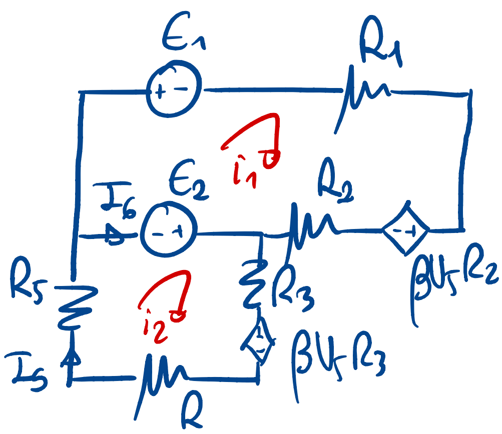
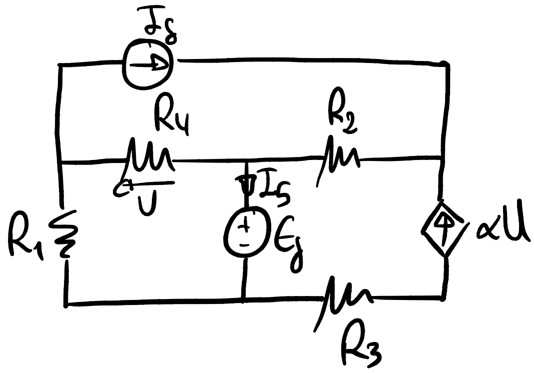
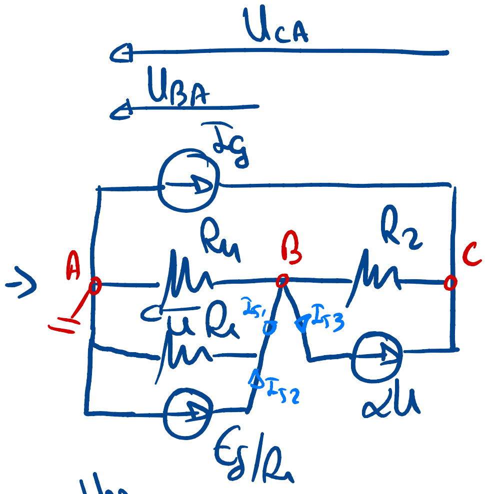


i_1: $-\mathcal{E}_1 - \beta U_5 R_2 - \mathcal{E}_2 = i_1(R_1+R_2) \xrightarrow{U_5=i_2R_5} -\mathcal{E}_1 - \mathcal{E}_2 = i_1(R_1+R_2) + i_2\beta R_2 R_5$

i_2: $\mathcal{E}_2 - \beta U_5 R_3 = i_2(R_3+R_4+R_5) \xrightarrow{U_5=i_2R_5} \mathcal{E}_2 = i_2(R_3(1+\beta R_5)+R_4+R_5)$

Problema 2. I_s, nudos αU_1





B: $\frac{\mathcal{E}_g}{R_1} - \alpha U = U_{BA}\left(\frac{1}{R_4}+\frac{1}{R_1}+\frac{1}{R_2}\right) - U_{CA}\frac{1}{R_2} \xrightarrow{U=U_{BA}} \frac{\mathcal{E}_g}{R_1} = U_{BA}\left(\alpha+\frac{1}{R_4}+\frac{1}{R_1}+\frac{1}{R_2}\right) - U_{CA}\frac{1}{R_2}$

C: $\alpha U + I_g = U_{CA}\frac{1}{R_2} - U_{BA}\frac{1}{R_2} \xrightarrow{U=U_{BA}} I_g = U_{BA}\left(-\frac{1}{R_2}-\alpha\right) + U_{CA}\frac{1}{R_2}$

$$\hat{i_g} = Y_m \hat{e_g} \rightarrow \begin{pmatrix} \frac{\mathcal{E}_g}{R_1} \\ I_g \end{pmatrix} = \begin{pmatrix} \alpha+\frac{1}{R_4}+\frac{1}{R_1}+\frac{1}{R_2} & -\frac{1}{R_2} \\ -\frac{1}{R_2}-\alpha & \frac{1}{R_2} \end{pmatrix} \begin{pmatrix} U_{BA} \\ U_{CA} \end{pmatrix}$$

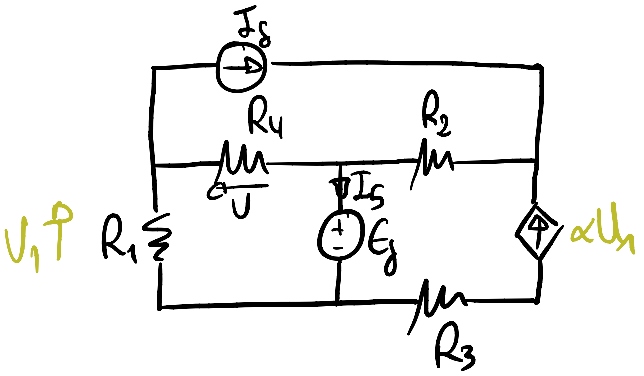
$$U_{BA} = \frac{\begin{vmatrix} \frac{\mathcal{E}_g}{R_1} & -\frac{1}{R_2} \\ I_g & \frac{1}{R_2} \end{vmatrix}}{\begin{vmatrix} \alpha+\frac{1}{R_4}+\frac{1}{R_1}+\frac{1}{R_2} & -\frac{1}{R_2} \\ -\left(\frac{1}{R_2}+\alpha\right) & \frac{1}{R_2} \end{vmatrix}} = \frac{\frac{\mathcal{E}_g}{R_1\cancel{R_2}} + \frac{I_g}{\cancel{R_2}}}{\left(\cancel{\alpha}+\frac{1}{R_4}+\frac{1}{R_1}+\cancel{\frac{1}{R_2}}\right)\left(\cancel{\frac{1}{R_2}}\right) - \cancel{\frac{1}{R_2}}\left(\cancel{\frac{1}{R_2}}+\cancel{\alpha}\right)} =$$

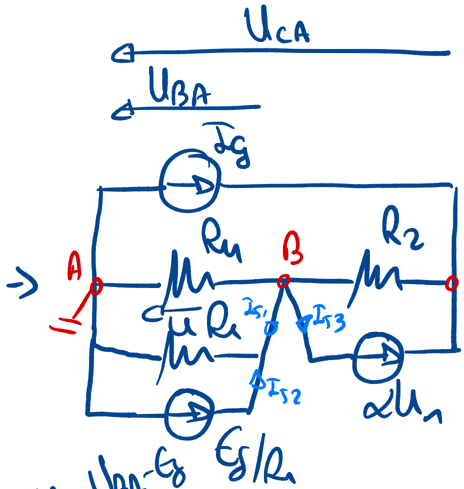
$$= \frac{\frac{\mathcal{E}_g}{R_1}+I_g}{\frac{1}{R_4}+\frac{1}{R_1}} = \frac{(\mathcal{E}_g+I_g R_1)R_4}{R_1+R_4}$$

$$I_S = I_{S1}+I_{S3}-I_{S2} = \frac{U_{BA}}{R_1} + \alpha U_{BA} - \frac{\mathcal{E}_g}{R_1} = U_{BA}\left(\frac{1}{R_1}+\alpha\right) - \mathcal{E}_g\frac{1}{R_1} =$$

$$= \frac{(\mathcal{E}_g+I_g R_1)R_4}{R_1+R_4}\left(\frac{1}{R_1}+\alpha\right) - \mathcal{E}_g\frac{1}{R_1}$$

Problema 2. Añadido αU_1





$U_1 = U_{BA} - E_g$

B: $\frac{E_g}{R_1} - \alpha U_1 = U_{BA}\left(\frac{1}{R_4} + \frac{1}{R_1} + \frac{1}{R_2}\right) - U_{CA}\frac{1}{R_2} \rightarrow E_g\left(\frac{1}{R_1} + \alpha\right) = U_{BA}\left(\alpha + \frac{1}{R_4} + \frac{1}{R_1} + \frac{1}{R_2}\right) - U_{CA}\frac{1}{R_2}$

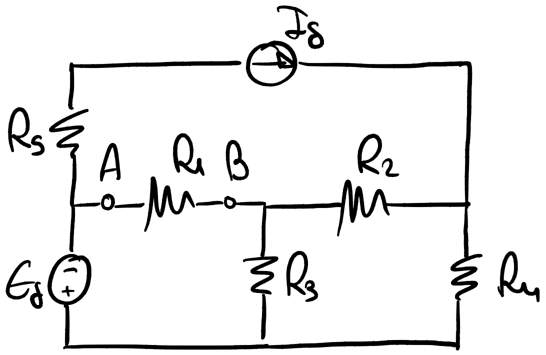
$U_1 = U_{BA} - E_g$

C: $\alpha U_1 + I_g = U_{CA}\frac{1}{R_2} - U_{BA}\frac{1}{R_2} \rightarrow I_g - \alpha E_g = U_{BA}\left(-\frac{1}{R_2} - \alpha\right) + U_{CA}\frac{1}{R_2}$

$$\hat{i}_g = Y_n \hat{e}_g = \begin{pmatrix} \alpha + \frac{1}{R_4} + \frac{1}{R_1} + \frac{1}{R_2} & -\frac{1}{R_2} \\ -\left(\frac{1}{R_2} + \alpha\right) & \frac{1}{R_2} \end{pmatrix} \begin{pmatrix} \frac{E_g}{R_1} + \alpha \\ I_g - \alpha E_g \end{pmatrix}$$

fuente tensión independiente → circuito abierto
fuente intensidad independiente → cortocircuito

Problema 3. Thevenin, Norton



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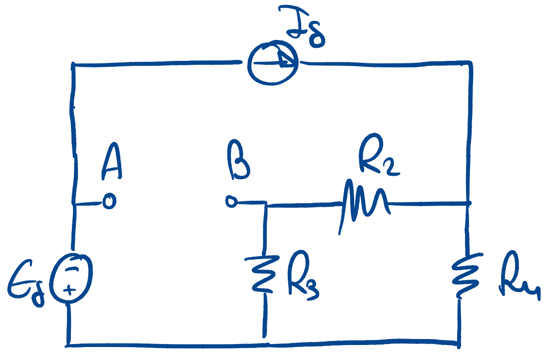
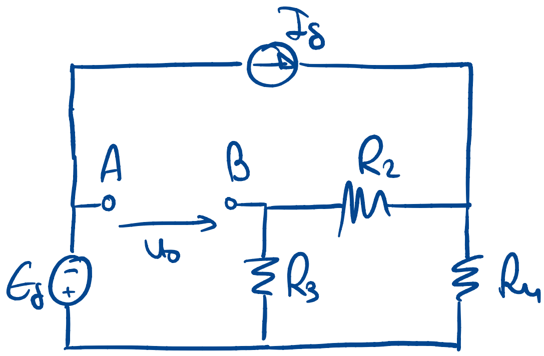


- Tensión a circuito abierto U_0? $I_0 = 0$



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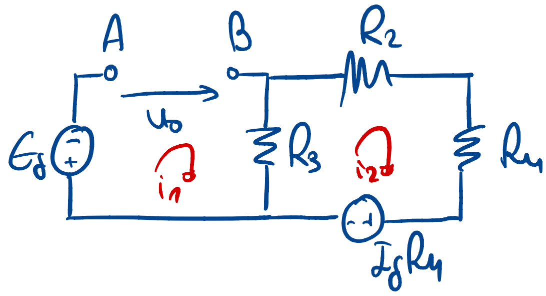


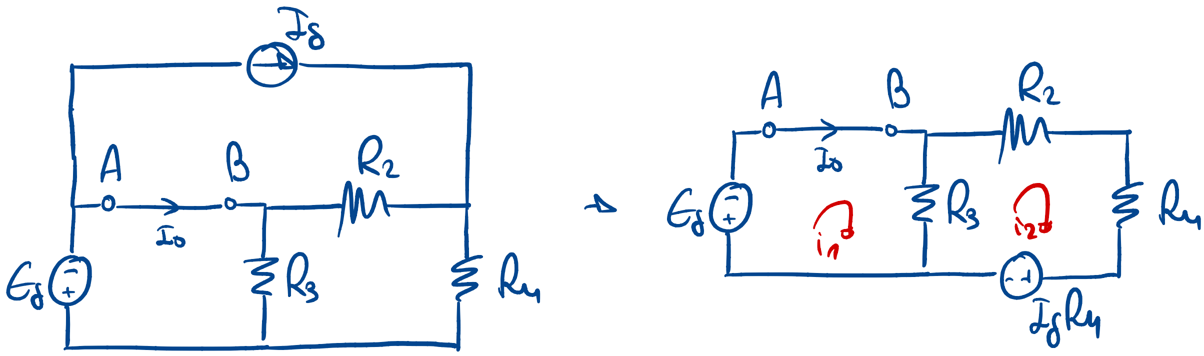
i_1: $-E_g = i_1 R_3 - i_2 R_3 \xrightarrow{i_1=0} -E_g = -i_2 R_3$

i_2: $-I_g R_4 = i_2 (R_2 + R_3 + R_4) - i_1 R_3 \xrightarrow{i_1=0} -I_g R_4 = i_2 (R_2 + R_3 + R_4)$

$$i_2 = \frac{-I_g R_4}{R_2 + R_3 + R_4}$$

$$U_0 = + i_2 R_3 - E_g = \frac{-I_g R_4 R_3}{R_2 + R_3 + R_4} - E_g = \frac{-E_g (R_2 + R_3 + R_4) - I_g R_4 R_3}{R_2 + R_3 + R_4}$$

- Intensidad de cortocircuito I_0? $U_0=0$



i_1: $-E_g = i_1 R_3 - i_2 R_3$

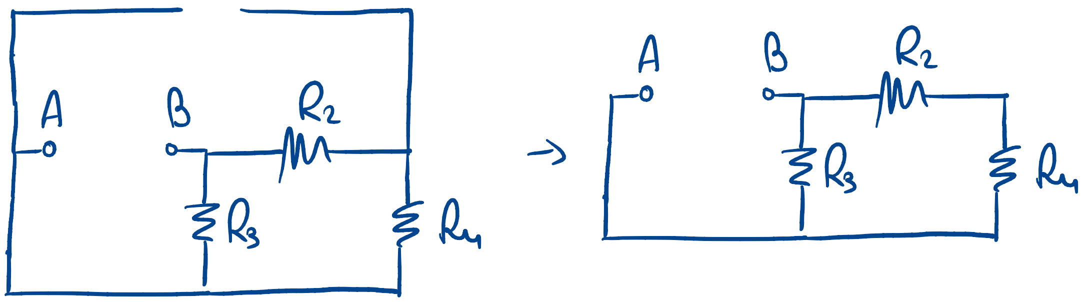
i_2: $-I_g R_4 = i_2 (R_2+R_3+R_4) - i_1 R_3$

$$i_1 = \frac{\begin{vmatrix} -E_g & -R_3 \\ -I_g R_4 & R_2+R_3+R_4 \end{vmatrix}}{\begin{vmatrix} R_3 & -R_3 \\ -R_3 & R_2+R_3+R_4 \end{vmatrix}} = \frac{-E_g(R_2+R_3+R_4) - I_g R_4 R_3}{R_3(R_2+\cancel{R_3}+R_4) - \cancel{R_3^2}} =$$

$$= \frac{-E_g(R_2+R_3+R_4) - I_g R_4 R_3}{R_3(R_2+R_4)} = I_0$$

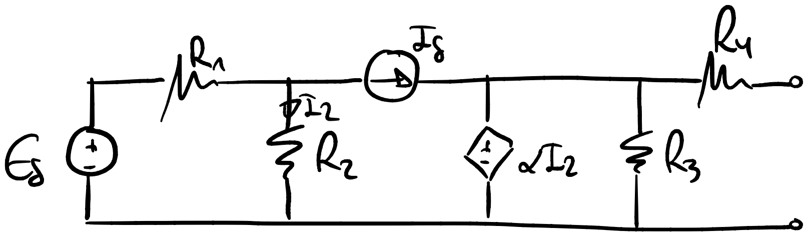
- Resistencia equivalente R_{eq}?

$$R_{eq} = \frac{U_0}{I_0} = \frac{\dfrac{\cancel{-E_g(R_2+R_3+R_4) - I_g R_4 R_3}}{R_2+R_3+R_4}}{\dfrac{\cancel{-E_g(R_2+R_3+R_4) - I_g R_4 R_3}}{R_3(R_2+R_4)}} = \frac{R_3(R_2+R_4)}{R_2+R_3+R_4}$$

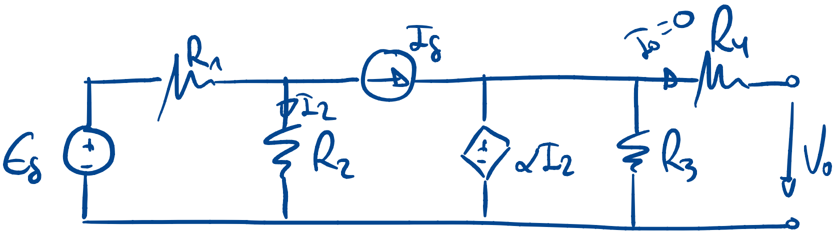


$$R_{eq} = \frac{1}{\frac{1}{R_3} + \frac{1}{R_2+R_4}} = \frac{1}{\frac{R_2+R_4+R_3}{R_3(R_2+R_4)}} = \frac{R_3(R_2+R_4)}{R_2+R_4+R}$$

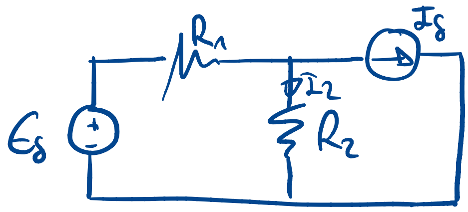
Problema 4 Thevenin, Norton



- Tensión circuito abierto U_0? $I_0 = 0$



$\rightarrow$



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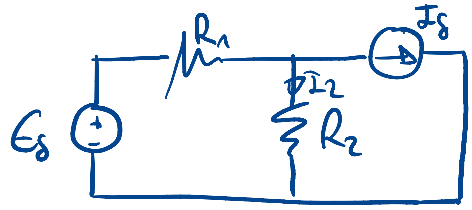
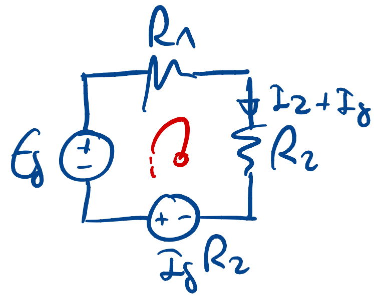


$\rightarrow$



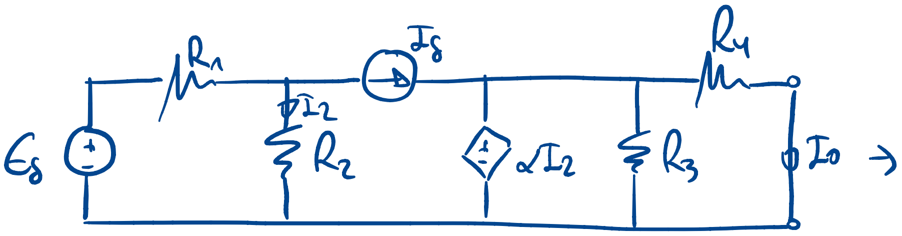
$$i: \quad E_g + I_g R_2 = i(R_1+R_2) \Rightarrow i = \frac{E_g + I_g R_2}{R_1+R_2}$$

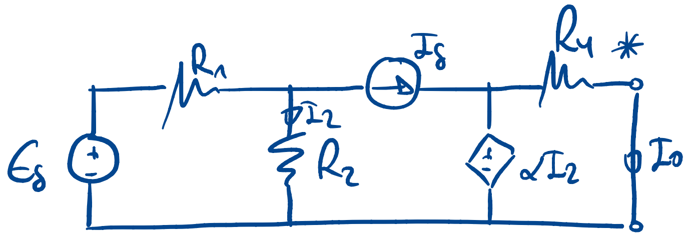
$$i = I_2 + I_g \Rightarrow I_2 = i - I_g = \frac{E_g + I_g R_2}{R_1+R_2} - I_g = \frac{E_g + \cancel{I_g R_2} - I_g(\cancel{R_1}+R_2)}{R_1+R_2} =$$

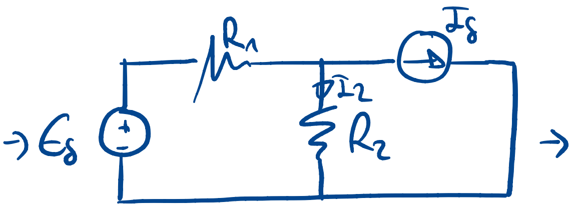
$$= \frac{E_g - I_g R_2}{R_1+R_2}$$

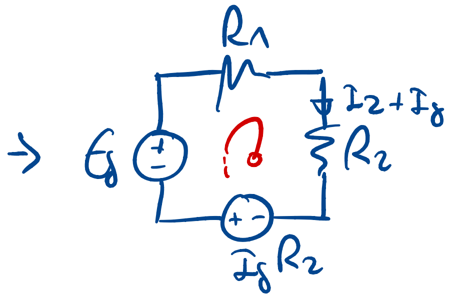
$$U_0 = \alpha \frac{E_g - I_g R_2}{R_1+R_2}$$

- Intensidad cortocircuito I_o? $U_o = 0$









$$E_g + I_g R_2 = i(R_1+R_2) \rightarrow i = \frac{E_g + I_g R_2}{R_1+R_2}$$

$$i = I_2 + I_g \rightarrow I_2 = i - I_g = \frac{E_g + I_g R_2}{R_1+R_2} - I_g = \frac{E_g + \cancel{I_g R_2} - I_g(\cancel{R_1} + R_2)}{R_1+R_2} =$$

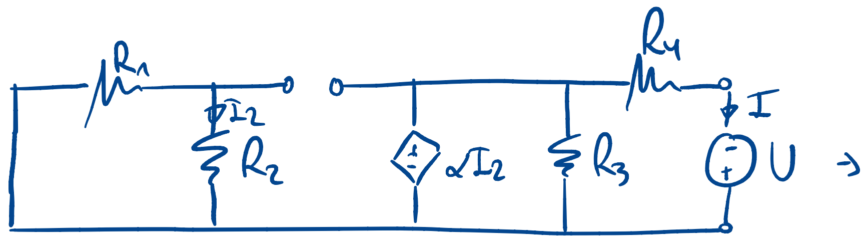
$$= \frac{E_g - I_g R_2}{R_1+R_2}$$

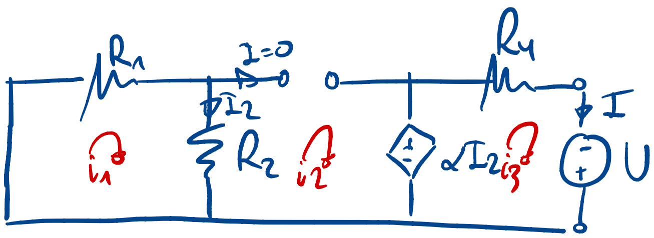
$$^*\, 0 = -\alpha I_2 + R_4 I_o \rightarrow R_4 I_o = \alpha I_2 \rightarrow I_o = \frac{\alpha I_2}{R_4}$$

$$I_o = \frac{\alpha(E_g - I_g R_2)}{R_4(R_1+R_2)}$$

- Resistencia equivalente R_{eq}?

$$R_{eq} = \frac{U_o}{I_o} = \frac{\cancel{\alpha}\,\frac{\cancel{E_g - I_g R_2}}{\cancel{R_1+R_2}}}{\frac{\cancel{\alpha(E_g - I_g R_2)}}{R_4\cancel{(R_1+R_2)}}} = R_4$$





i_1: $0 = i_1(R_1+R_2) - \cancel{i_2 R_2}^{\to 0} \to i_1 = 0$

i_2: $\alpha I_2 = \cancel{i_2}^{\to 0} R_2 - \cancel{i_1}^{\to 0} R_2 \to I_2 = 0$

i_3: $U + \cancel{\alpha I_2}^{\to 0} = i_3 R_4 \to \frac{U}{i_3} = R_4 \to R_{eq} = R_4$