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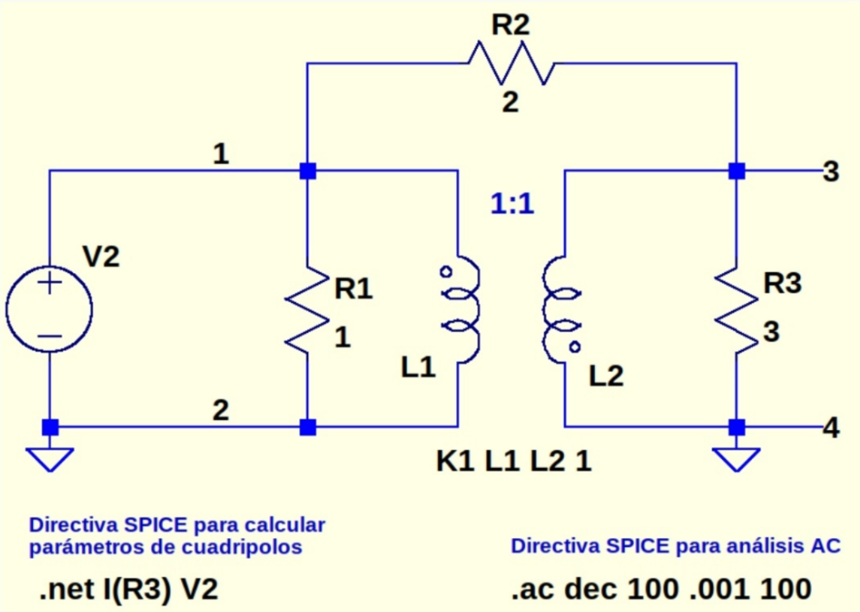
#Ejercicio 1:

Para el siguiente cuadripolo se pide calcular los parámetros Z.

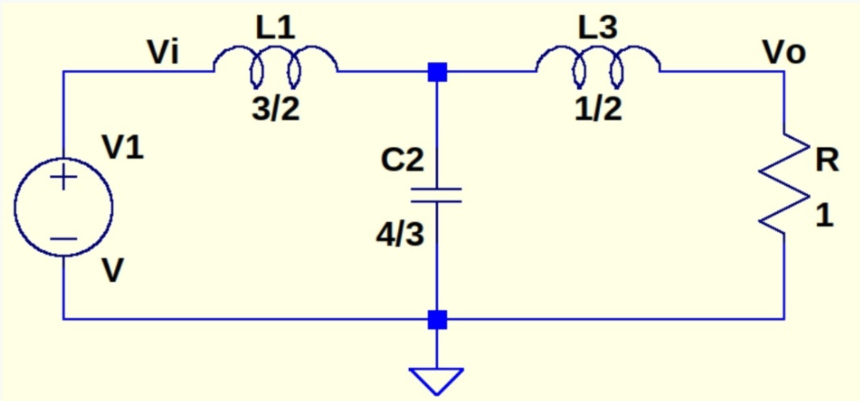


Bonus:

- +1 💎 Simular en SPICE los parámetros de cuadripolo con la directiva **.net**
- +1 🎓 Verifique mediante el módulo de simulación simbólica **SymPy** la **impedancia de entrada**
- +1 🤯 Presentación en jupyter notebook

#Ejercicio 2:

Dado el siguiente circuito:



👉 Obtener la transferencia de tensión $\frac{V_o}{V_i}$ por método de cuadripolos (se sugiere referirse a alguno de los métodos de interconexión ya vistos). Ayuda: si $C_2 = \frac{4}{3}$ (se utilizó 1.333 para la simulación), los polos de la transferencia están ubicados sobre una circunferencia de radio unitario.

👉 Construya la matriz de admitancia indefinida (MAI) del circuito.

👉 Compute la misma transferencia de tensión $\frac{V_o}{V_i}$ mediante MAI.

👉 Verifique la transferencia mediante [Análisis Nodal Modificado (MNA)](#).

Bonus:

- +1 💎 Simular en SPICE para verificar la transferencia.
- +1 🤯 Compute la impedancia de entrada con la MAI.
- +1 🤯 Presentación en jupyter notebook

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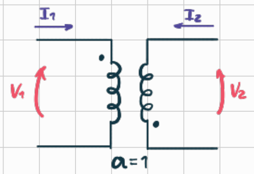
Ejercicio #1

* Modelo Transformador Ideal:



$$\begin{cases} V_1 = -a\,V_2 \\ I_1 = \frac{1}{a} I_2 \end{cases}$$

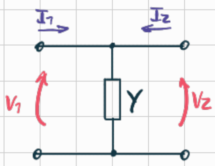
$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0} = -a \qquad B = \left.\frac{V_1}{(-I_2)}\right|_{V_2=0} = 0$$

$$C = \left.\frac{I_1}{V_2}\right|_{(-I_2)=0} = 0 \qquad D = \left.\frac{I_1}{(-I_2)}\right|_{V_2=0} = -1/a$$

$$T_{TR} = \begin{pmatrix} -a & 0 \\ 0 & -1/a \end{pmatrix}$$

$$\Delta T_{TR} = AD - BC = 1$$

*

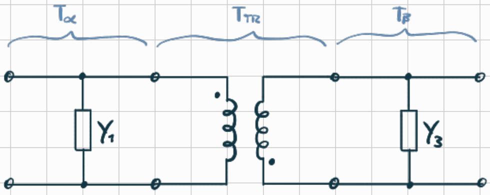


$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0} = 1 \qquad B = \left.\frac{V_1}{(-I_2)}\right|_{V_2=0} = 0$$

$$C = \left.\frac{I_1}{V_2}\right|_{(-I_2)=0} = Y \qquad D = \left.\frac{I_1}{(-I_2)}\right|_{V_2=0} = 1$$

$$T_\alpha = T_\beta = \begin{pmatrix} 1 & 0 \\ Y & 1 \end{pmatrix}$$

*



$$T = T_\alpha \cdot T_{TR} \cdot T_\beta = \begin{pmatrix} 1 & 0 \\ Y_1 & 1 \end{pmatrix}\begin{pmatrix} -a & 0 \\ 0 & -1/a \end{pmatrix}\begin{pmatrix} 1 & 0 \\ Y_3 & 1 \end{pmatrix} = \begin{pmatrix} -a & 0 \\ -aY_1 - Y_3/a & -1/a \end{pmatrix}$$

$$\Delta T = AD - BC = 1$$

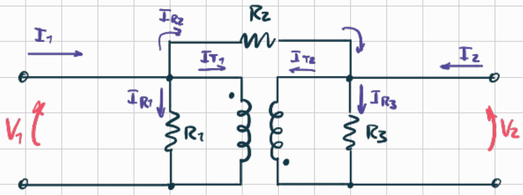
$$A = \frac{Z_{11}}{Z_{21}} \qquad B = \frac{\Delta Z}{Z_{21}} \qquad C = \frac{1}{Z_{21}} \qquad D = \frac{Z_{22}}{Z_{21}}$$

Como $B = 0 \longrightarrow \Delta Z = 0 \quad \therefore \nexists\, Z$

$$A = \frac{-Y_{22}}{Y_{21}} \qquad B = \frac{-1}{Y_{21}} \qquad C = \frac{-\Delta Y}{Y_{21}} \qquad D = \frac{-Y_{11}}{Y_{21}}$$

$B = 0 \longrightarrow \nexists\, Y$

* Se calculan los parámetros por análisis circuital:



$$\begin{cases} I_1 = I_{R_1} + I_{R_2} + I_{T_1} = \frac{V_1}{R_1} + \frac{V_1 - V_2}{R_2} + I_{T_1} \\ I_2 + I_{R_2} = I_{T_2} + I_{R_3} \longrightarrow I_2 + \frac{V_1 - V_2}{R_2} = I_{T_2} + \frac{V_2}{R_3} \\ I_{T_1} = \frac{1}{a} I_{T_2} \quad ; \; a=1 \Rightarrow I_{T_1} = I_{T_2} = I_T \end{cases}$$

$$\begin{cases} I_1 = (G_1 + G_2) V_1 - G_2 V_2 + I_T \\ I_T = G_2 V_1 - (G_2 + G_3) V_2 + I_2 \end{cases}$$

$$I_1 = (G_1 + G_2) V_1 - G_2 V_2 + G_2 V_1 - (G_2 + G_3) V_2 + I_2$$

$$\begin{cases} I_1 = (G_1 + 2G_2) V_1 - (2G_2 + G_3) V_2 + I_2 \\ V_1 = -a V_2 \quad ; \; a = 1 \Rightarrow V_1 = -V_2 \end{cases}$$

$$I_1 - I_2 = (G_1 + 4G_2 + G_3) V_1$$

$$Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0} = \frac{1}{G_1+4G_2+G_3} = \frac{3}{10}$$

$$Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0} = -\frac{1}{G_1+4G_2+G_3} = -\frac{3}{10}$$

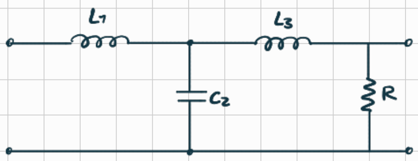
$$Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0} = -\frac{1}{G_1+4G_2+G_3} = -\frac{3}{10}$$

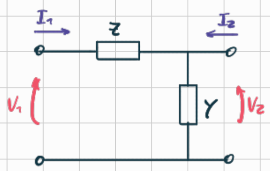
$$Z_{22} = \left.\frac{V_2}{I_2}\right|_{I_1=0} = \frac{1}{G_1+4G_2+G_3} = \frac{3}{10}$$

$Z_{12} = Z_{21} \longrightarrow$ pasiva

$$Z = \begin{pmatrix} 3/10 & -3/10 \\ -3/10 & 3/10 \end{pmatrix}$$

Ejercicio #2

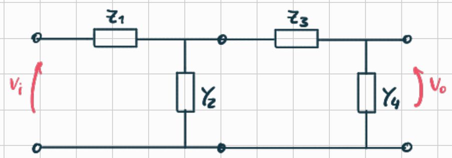




$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0} = ZY+1 \qquad B = \left.\frac{V_1}{(-I_2)}\right|_{V_2=0} = Z$$

$$C = \left.\frac{I_1}{V_2}\right|_{(-I_2)=0} = Y \qquad D = \left.\frac{I_1}{(-I_2)}\right|_{V_2=0} = 1$$

$$T_1 = \begin{pmatrix} ZY+1 & Z \\ Y & 1 \end{pmatrix}$$



$$T = \begin{pmatrix} Z_1Y_2+1 & Z_1 \\ Y_2 & 1 \end{pmatrix}\begin{pmatrix} Z_3Y_4+1 & Z_3 \\ Y_4 & 1 \end{pmatrix} = \begin{pmatrix} \overset{A}{Y_4Z_1+(Y_2Z_1+1)(Y_4Z_3+1)} & Z_1+Z_3(Y_2Z_1+1) \\ Y_2(Y_4Z_3+1)+Y_4 & Y_2Z_3+1 \end{pmatrix}$$

$$\frac{V_o}{V_i} = \frac{1}{A} = \frac{1}{Y_4Z_1+(Y_2Z_1+1)(Y_4Z_3+1)}$$

* Siendo: $Z_1 = sL_1$, $Y_2 = sC_2$; $Z_3 = sL_3$; $Y_4 = \frac{1}{R}$

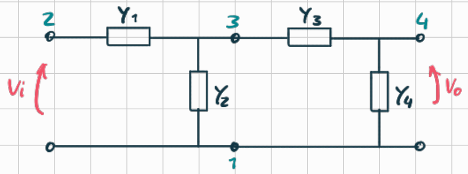
$$\frac{V_o}{V_i} = \frac{R}{C_2L_1L_3s^3 + RC_2L_1s^2 + (L_1+L_2)s + R} = \frac{R}{C_2L_1L_3}\;\frac{1}{s^3 + \frac{R}{L_3}s^2 + \frac{L_1+L_3}{C_2L_1L_3}s + \frac{R}{C_2L_1L_3}}$$

* Reemplazando por sus respectivos valores:

$$L_1 = \frac{3}{2} \;;\; L_3 = \frac{1}{2} \;;\; C_2 = \frac{4}{3} \;;\; R = 1$$

$$\frac{V_o}{V_i} = \frac{1}{s^3+2s^2+2s+1}$$ ⟵ pasa bajos de orden 3

* Obtención de MAI



$$Y_{MAI} = \begin{pmatrix} Y_2+Y_4 & 0 & -Y_2 & -Y_4 \\ 0 & Y_1 & -Y_1 & 0 \\ -Y_2 & -Y_1 & Y_1+Y_2+Y_3 & -Y_3 \\ -Y_4 & 0 & -Y_3 & Y_3+Y_4 \end{pmatrix}$$

* Transferencia de Tensión $\frac{V_o}{V_i}$ mediante MAI

$$\frac{V_o}{V_i} = A^{14}_{12} = \frac{V_{41}}{V_{21}} = sg(2-1)\, sg(4-1)\, \frac{Y^{21}_{41}}{Y^{21}_{21}}$$

$$Y^{21}_{41} = Y_1 Y_3$$

$$Y^{21}_{21} = \left(Y_1+Y_2+Y_3\right)\left(Y_3+Y_4\right) - Y_3^2$$

$$\frac{V_o}{V_i} = \frac{Y_1 Y_3}{(Y_1+Y_2+Y_3)(Y_3+Y_4) - Y_3^2}$$

* Siendo: $Y_1 = \frac{1}{sL_1}$; $Y_2 = sC_2$; $Y_3 = \frac{1}{sL_3}$; $Y_4 = \frac{1}{R}$

$$\frac{V_o}{V_i} = \frac{R}{C_2L_1L_3\, s^3 + RC_2L_1\, s^2 + (L_1+L_2)\, s + R} = \frac{R}{C_2L_1L_3}\quad \frac{1}{s^3 + \frac{R}{L_3}\, s^2 + \frac{L_1+L_3}{C_2L_1L_3}\, s + \frac{R}{C_2L_1L_3}}$$

* Reemplazando valores:

$$\frac{V_o}{V_i} = \frac{1}{s^3+2s^2+2s+1}$$