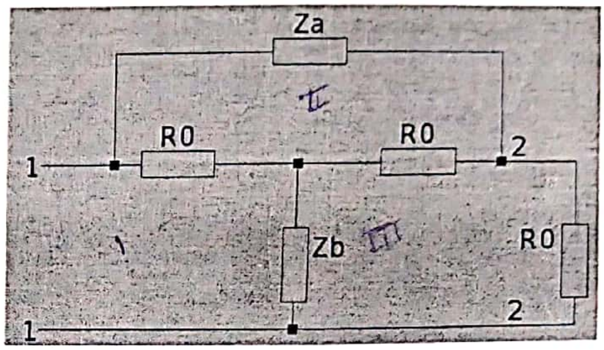
Universidad Tecnológica Nacional FRBA
Departamento de Ing. Electrónica — Teoría de los Circuitos II
Examen final — 01/08/2019

Alumno:
Legajo:

1) Dada la siguiente topología y sabiendo que $R_0{}^2 = Z_a . Z_b$ determinar:



a) **(1 Punto)** La transferencia de tensión en función de Ro, Za y Zb

b) **(1 Punto)** Los valores de Za y Zb para que la transferencia de tensión cargada sea:

$$H_{(s)} = \frac{s}{s^2 + s + 1}$$

2) Se desea diseñar una red pasiva en configuración π que permita adaptar a máxima transferencia de energía una carga resistiva de 300Ω a un generador cuya resistencia interna es de 50Ω. Se pide además que la red tenga atenuación nula a la frecuencia de operación de 1MHz. e introduzca un atraso de fase de 30° en dicha frecuencia

a) **(1 Punto)** Demostrar que la matriz T representa la matriz transmisión (A,B,C,D) en función de los parámetros imagen para cuadripolos pasivos adaptados. (Ecuaciones hiperbólicas del cuadripolo)

$$T = \begin{bmatrix} \sqrt{\frac{Z_{o1}}{Z_{o2}}} cosh\gamma & \sqrt{Z_{o1} Z_{o2}} senh\gamma \\ \frac{1}{\sqrt{Z_{o1} Z_{o2}}} senh\gamma & \sqrt{\frac{Z_{o2}}{Z_{o1}}} cosh\gamma \end{bmatrix}$$

b) **(1 Punto)** Determinar las admitancias de la red requerida en función de los parámetros imagen.

c) **(1 Punto)** Obtener los valores de los componentes de la red.

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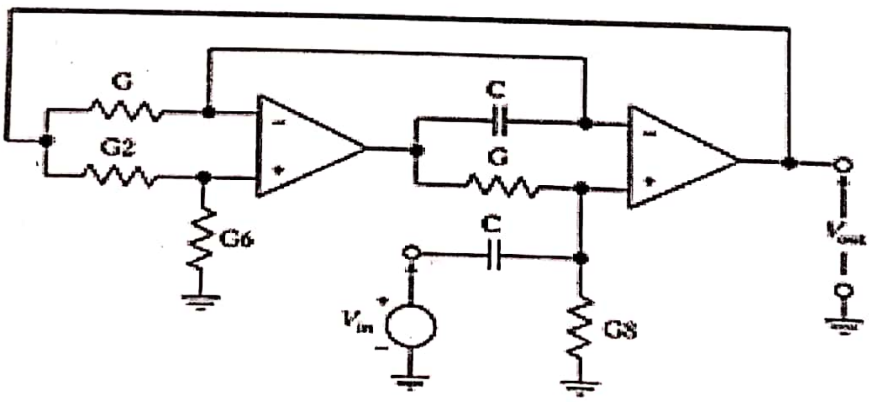
3) Diseñar un filtro de máxima planicidad en base a la plantilla: $\omega_p = 10k$rad/s, $\omega_s = 1k$rad/s, $\alpha_{MIN} = 30$dB y $\alpha_{MAX} = 1$dB.

a)(2 puntos) Obtenga la función transferencia normalizada del filtro pedido **mediante los conceptos de parte de función.**

b)(2 puntos) Implemente la función transferencia mediante el circuito de la figura asegurando que $|T(\omega)|_{\omega\to\infty} =$ 6dB.

c) (1 punto) Obtenga las sensibilidades S^Q_{G8} y S^Q_C.

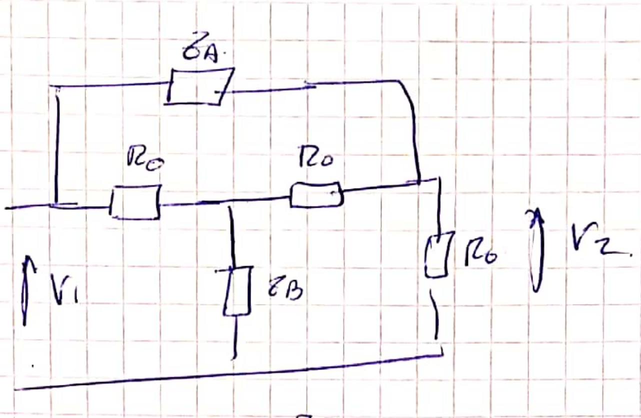


Criterio de aprobación : Sumatoria de ítems mayor o igual a 6 (SEIS)

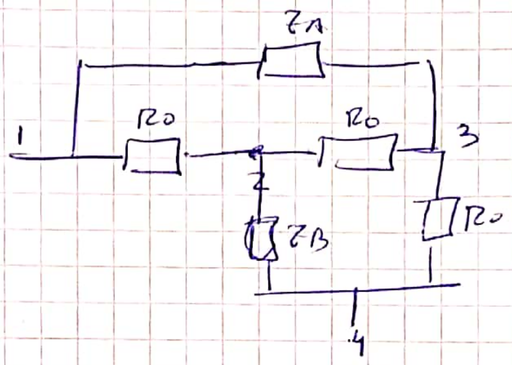
HOJA N°

FECHA

1)



α MAI



I

X MAI

$$
\begin{bmatrix}
\frac{1}{R_0}+\frac{1}{Z_A} & -\frac{1}{R_0} & -\frac{1}{Z_A} & 0 \\
-\frac{1}{R_0} & \left(\frac{2}{R_0}+\frac{1}{Z_B}\right) & -\frac{1}{R_0} & -\frac{1}{Z_B} \\
-\frac{1}{Z_A} & -\frac{1}{R_0} & \frac{2}{R_0}+\frac{1}{Z_A} & -\frac{1}{R_0} \\
0 & -\frac{1}{Z_B} & -\frac{1}{R_0} & \frac{1}{R_0}+\frac{1}{Z_B}
\end{bmatrix}
$$

$$
\frac{V_{34}}{V_{14}} = (-1)^{3+4+1+4} \frac{\left|Y^{34}_{14}\right|^{COL}_{FIL}}{\left|Y^{14}_{14}\right|^{COL}_{FIL}} = \frac{\begin{vmatrix} -\frac{1}{R_0} & \frac{2}{R_0}+\frac{1}{Z_B} \\ -\frac{1}{Z_A} & -\frac{1}{R_0} \end{vmatrix}}{\begin{vmatrix} \frac{2}{R_0}+\frac{1}{Z_B} & -\frac{1}{R_0} \\ -\frac{1}{R_0} & \frac{2}{R_0}+\frac{1}{Z_A} \end{vmatrix}}
$$

NOTA

HOJA N°

FECHA

$$T = \frac{V_{34}}{V_{14}} = \frac{\frac{1}{R_o^2} + \frac{1}{Z_A}\left(\frac{2}{R_o} + \frac{1}{Z_B}\right)}{\left(\frac{2}{R_o} + \frac{1}{Z_B}\right)\left(\frac{2}{R_o} + \frac{1}{Z_A}\right) - \frac{1}{R_o^2}}$$

$$T = \frac{\frac{1}{R_o^2} + \frac{2}{Z_A R_o} + \frac{1}{Z_A Z_B}\ R_o^2}{\frac{4}{R_o^2} + \frac{2}{R_o Z_A} + \frac{2}{R_o Z_B} + \cancel{\frac{1}{Z_A Z_B}}\ R_o^2 - \cancel{\frac{1}{R_o^2}}}$$

$$T = \frac{\frac{2}{R_o^2} + \frac{2}{Z_A R_o}}{\frac{4^{2}}{R_o^2} + \frac{2}{R_o Z_A} + \frac{2}{R_o Z_B}}$$

$$T = \frac{\frac{Z_A + R_o}{\cancel{R_o^2 Z_A}}}{\frac{2 Z_A Z_B + R_o Z_B + R_o Z_A}{\cancel{R_o^2 Z_A} Z_B}}$$

$$T = \frac{Z_A Z_B + R_o Z_B}{2 R_o^2 + R_o Z_B + R_o Z_A} = \frac{\cancel{R_o}\,(R_o + Z_B)}{\cancel{R_o}\,(2R_o + Z_B + Z_A)}$$

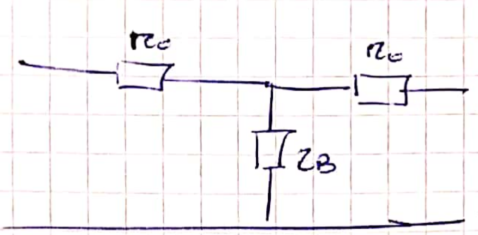
$$R_o^2 = Z_A Z_B \qquad \frac{R_o^2}{Z_B} = Z_A$$

$$T = \frac{R_o + Z_B}{2R_o + Z_B + \frac{R_o^2}{Z_B}} \cdot \frac{Z_B}{Z_B}$$

$$T = \frac{R_o Z_B + Z_B^2}{Z_B^2 + 2 R_o Z_B + R_o^2} = \frac{Z_B\,\cancel{(R_o + Z_B)}}{(R_o + Z_B)^{\cancel{2}}} = \frac{Z_B}{R_o + Z_B}$$

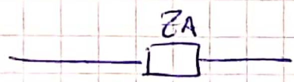
NOTA

X Interconex de cuadripolos:



$$[Z] = \begin{vmatrix} R_o+Z_B & Z_B \\ Z_B & R_o+Z_B \end{vmatrix} \qquad \Delta Z = (R_o+Z_B)^2 - Z_B^2 = R_o^2 + 2R_oZ_B$$

$$|Y| = \begin{vmatrix} \frac{Z_{22}}{\Delta Z} & -\frac{Z_{12}}{\Delta Z} \\ -\frac{Z_{21}}{\Delta Z} & \frac{Z_{11}}{\Delta Z} \end{vmatrix} = \begin{vmatrix} \frac{R_o+Z_B}{R_o^2+2R_oZ_B} & \frac{-Z_B}{R_o^2+2R_oZ_B} \\ \frac{-Z_B}{R_o^2+2R_oZ_B} & \frac{R_o+Z_B}{R_o^2+2R_oZ_B} \end{vmatrix}$$



$$|Y| = \begin{vmatrix} \frac{1}{Z_A} & -\frac{1}{Z_A} \\ -\frac{1}{Z_A} & \frac{1}{Z_A} \end{vmatrix}$$

$$\oplus \Rightarrow \begin{vmatrix} \frac{R_o+Z_B}{\Delta Z}+\frac{1}{Z_A} & \frac{-Z_B}{\Delta Z}-\frac{1}{Z_A} \\ -\frac{Z_B}{\Delta Z}-\frac{1}{Z_A} & \frac{R_o+Z_B}{\Delta Z}+\frac{1}{Z_A} \end{vmatrix}$$

$$\frac{-Y_{21}}{Y_{22}+Y_L} \Rightarrow \frac{\frac{Z_B}{\Delta Z}+\frac{1}{Z_A}}{\frac{R_o+Z_B}{\Delta Z}+\frac{1}{Z_A}+\frac{1}{R_o}}$$

$Y_L = \frac{1}{R_o}$

HOJA N°

FECHA

$$t = \frac{(Z_B + Z_A + \Delta Z)R_0}{Z_A R_0 (R_0 + Z_B) + \Delta Z R_0 + \Delta Z Z_A}$$

$$t = \frac{R_0^3 + R_0^3 + 2R_0^2 Z_B}{Z_A R_0^2 + Z_A R_0 Z_B + R_0^3 + 2R_0^2 Z_B + R_0^2 Z_A + 2R_0 Z_B Z_A}$$

$$t = \frac{2R_0^3 + 2R_0^2 Z_B}{Z_A R_0^2 + R_0^3 + R_0^3 + 2Z_B R_0^2 + Z_A R_0^2 + 2R_0^3}$$

$$t = \frac{\cancel{R_0^2}\,(2R_0 + 2Z_B)}{\cancel{R_0^2}\,(Z_A + 4R_0 + 2Z_B + Z_A)}$$

$$t = \frac{\cancel{2}\,(R_0 + Z_B)}{\cancel{2}\,(2R_0 + Z_A + Z_B)}$$

Si, $R_0^2 = Z_A \cdot Z_B$

$$Z_A = \frac{R_0^2}{Z_B}$$

$$t = \frac{R_0 + Z_B}{2R_0 + \frac{R_0^2}{Z_B} + Z_B} = \frac{Z_B \cdot (R_0 + Z_B)}{Z_B^2 + 2R_0 Z_B + R_0^2} = \frac{Z_B\,\cancel{(R_0 + Z_B)}}{(R_0 + Z_B)^{\cancel{2}}}$$

$$\boxed{t = \frac{Z_B}{R_0 + Z_B}}$$

HOJA Nº

FECHA

1.2)

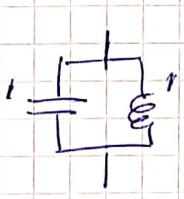
$$T = \frac{Z_B}{Z_B + R_0} \Rightarrow \frac{1}{1 + \frac{R_0}{Z_B}} = \frac{s}{s^2 + s + 1}$$

$$\frac{1}{s + \frac{1}{s} + 1}$$

$$\frac{R_0}{Z_B} = s + \frac{1}{s}$$

$\underline{\text{Si } R_0 = 1}$

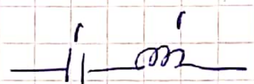
$\frac{1}{Z_B} = Y_B = s + \frac{1}{s}$



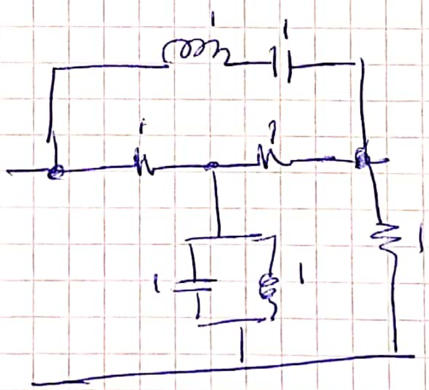
$= Z_B$

$R_0^2 = Z_A \cdot Z_B$

$Z_A = \frac{R_0^2}{Z_B}$ $\quad Z_A = \frac{1}{Z_B} = s + \frac{1}{s} \Rightarrow$



Circuito final



NOTA

2.1)

$$V_1 = A\, V_2 + B(-I_2)$$

$$\frac{V_1}{V_2} = A + \frac{B}{Z_{o2}}$$

$$\frac{V_1}{V_2} = A + B\sqrt{\frac{CA}{DB}}$$

$$\frac{V_1}{V_2} = \sqrt{\frac{A}{D}}\left[\sqrt{A^2}\sqrt{\frac{D}{A}} + \sqrt{B^2}\sqrt{\frac{C}{B}}\right]$$

$$\frac{V_1}{V_2} = \sqrt{\frac{A}{D}}\left[\sqrt{AD} + \sqrt{BC}\right]$$

$$I_1 = C\, V_2 + D(-I_2)$$

$$\frac{I_1}{-I_2} = C\overset{Z_{o2}}{\frac{V_2}{(-I_2)}} + D$$

$$\frac{I_1}{-I_2} = C\sqrt{\frac{DB}{CA}} + D$$

$$\frac{I_1}{-I_2} = \sqrt{\frac{D}{A}}\left[\sqrt{C^2}\sqrt{\frac{B}{C}} + \sqrt{D^2}\sqrt{\frac{A}{D}}\right]$$

$$\frac{I_1}{-I_2} = \sqrt{\frac{D}{A}}\left[\sqrt{BC} + \sqrt{AD}\right]$$

$$\overset{P_1}{\underbrace{\frac{V_1}{V_2}}_{e^{\gamma}} \cdot \underbrace{\frac{I_1}{-I_2}}_{e^{\gamma}}}\; {}_{\sim P_2} = \left[\sqrt{BC} + \sqrt{AD}\right]^2 = e^{2\gamma} = \left[e^{\gamma}\right]^2$$

$$e^{\gamma} = \sqrt{BC} + \sqrt{AD}$$

$$e^{\gamma} = \operatorname{senh}\gamma + \cosh\gamma \qquad e^{-\gamma} = \cosh\gamma - \operatorname{senh}\gamma$$

$$e^{\gamma} = \sqrt{BC} + \sqrt{AD}$$

$$e^{-\gamma} = \frac{1}{\sqrt{AD}+\sqrt{BC}} \cdot \frac{\sqrt{AD}-\sqrt{BC}}{\sqrt{AD}-\sqrt{BC}} = \frac{\sqrt{AD}-\sqrt{BC}}{\Delta T}$$

$\Delta T = 1$

$$\begin{cases} \sqrt{AD} = \cosh\gamma & (1) \\ \sqrt{BC} = \operatorname{senh}\gamma & (2) \\ Z_{01} = \sqrt{\frac{AB}{CD}} & (3) \\ Z_{02} = \sqrt{\frac{DB}{CA}} & (4) \end{cases}$$

3x4 $\quad Z_{01} \cdot Z_{02} = \sqrt{\frac{AB}{CD}} \cdot \sqrt{\frac{DB}{CA}} = \frac{B}{C}$

en 2 $\quad \operatorname{senh}\gamma = C\sqrt{Z_{01} \cdot Z_{02}}$

$$\boxed{\frac{\operatorname{senh}\gamma}{\sqrt{Z_{01} \cdot Z_{02}}} = C}$$

en 2 $\quad \operatorname{senh}\gamma = B\frac{1}{\sqrt{Z_{01} \cdot Z_{02}}}$

$$\boxed{\sqrt{Z_{01} \cdot Z_{02}} \cdot \operatorname{senh}\gamma = B}$$

$\frac{3}{4}$ $\quad \frac{Z_{01}}{Z_{02}} = \frac{\sqrt{\frac{AB}{CD}}}{\sqrt{\frac{DB}{CA}}} = \frac{A}{D}$

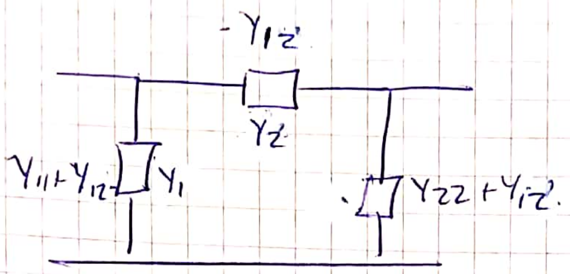
en 1 $\quad \cosh\gamma = D\sqrt{\frac{Z_{01}}{Z_{02}}}$

$$\boxed{\sqrt{\frac{Z_{02}}{Z_{01}}} \cdot \cosh\gamma = D}$$

en 1 $\quad \cosh\gamma = A\sqrt{\frac{Z_{02}}{Z_{01}}}$

$$\boxed{\sqrt{\frac{Z_{01}}{Z_{02}}} \cosh\gamma = A}$$

2.2



$Y_{21} = Y_{12}$ pasivo (reciproco)

$$Y \Rightarrow \begin{vmatrix} Y_1+Y_2 & -Y_2 \\ -Y_2 & Y_3+Y_2 \end{vmatrix} \xrightarrow{T} \begin{vmatrix} -\frac{Y_{22}}{Y_{21}} & -\frac{1}{Y_{21}} \\ -\frac{\Delta Y}{Y_{21}} & -\frac{Y_{11}}{Y_{21}} \end{vmatrix}$$

$$T_\pi = \begin{vmatrix} \frac{Y_3+Y_2}{Y_2} & \frac{1}{Y_2} \\ \frac{Y_1Y_3 + Y_1+Y_3}{Y_2} & \frac{Y_1+Y_2}{Y_2} \end{vmatrix}$$

$$\Delta Y = (Y_1+Y_2)(Y_3+Y_2) - Y_2^2$$

$$\Delta Y = Y_1Y_3 + Y_1Y_2 + Y_2Y_3$$

$$T_\pi = \begin{vmatrix} \frac{Y_3}{Y_2}+1 & \frac{1}{Y_2} \\ \frac{Y_1Y_3}{Y_2}+Y_1+Y_3 & \frac{Y_1}{Y_2}+1 \end{vmatrix}$$

$B = 30°$ $\quad \gamma = j30°$

T imagen $\quad \frac{Z_{01}}{Z_{02}} = \frac{50\,\Omega}{300\,\Omega}$

$$\begin{vmatrix} 0{,}35 & j61{,}23 \\ j4{,}08\,10^{-3} & 2{,}12 \end{vmatrix}$$

$$\cosh(j30°) = \frac{e^{j30°} + e^{-j30°}}{2}$$

$$\cosh(j30) = \cos(30°)$$

$$\operatorname{senh}(j30°) = \frac{e^{j30} - e^{-j30}}{2}$$

$$\operatorname{senh}(j30°) = j\operatorname{sen}(30°)$$

$Y_2 = \frac{1}{j61,23}$ S $\quad Z_2 = j61,23\,\Omega \quad Z_L = jwL = j61,23$

$L_2 = \frac{61,23}{2\pi \cdot 1\,10^6} = 9,74\,\mu Hy$

$0,35 = \frac{Y_3}{Y_2} + 1$

$-0,65 \cdot Y_2 = Y_3$

$-0,65 \cdot \left(\frac{-j}{61,23}\right) = Y_3 \quad Y_3 = j0,01$

$Z_3 = -j100$

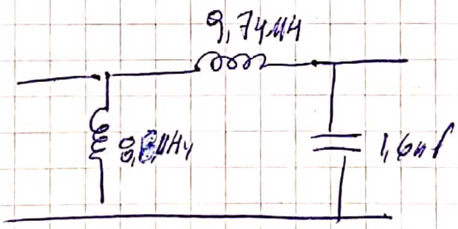
$Z_3 = -\frac{j}{wC_3} = -j100 \cdot \quad C_3 = \frac{1}{2\pi\,1\,10^6 \times 100}$

$C_3 = 1,6\,nf$

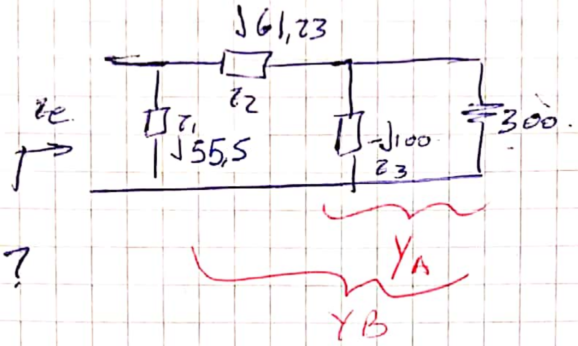
$2,12 = \frac{Y_1}{Y_2} + 1$

$1,12\left(\frac{-j}{61,23}\right) = Y_1 = -j0,018$ S

$Z_1 = j55,5\,\Omega \quad L_1 = \frac{55,5}{2\pi \times 1\,10^6} = 8,8\,\mu Hy$



verificacion



@ 1 MHz

$Ze = 50\,\Omega\,?$

$$Y_A = \frac{1}{300} + J\frac{1}{100}$$

$$Y_A = \frac{1 + J3}{300}$$

$$Z_A = \frac{300}{1+J3} \cdot \frac{1-J3}{1-J3} = \frac{30\cancel{0}(1-J3)}{1\cancel{0}} = 30 - J90$$

$$Z_B = Z_A + Z_2 = 30 - J90 + J61{,}23 = 30 - J28{,}77$$

$$Y_B = \frac{1}{30 - J28{,}77} \cdot \frac{30 + J28{,}77}{30 + J28{,}77} = \frac{30 + J28{,}77}{1727{,}71} = 0{,}017 + J0{,}016$$

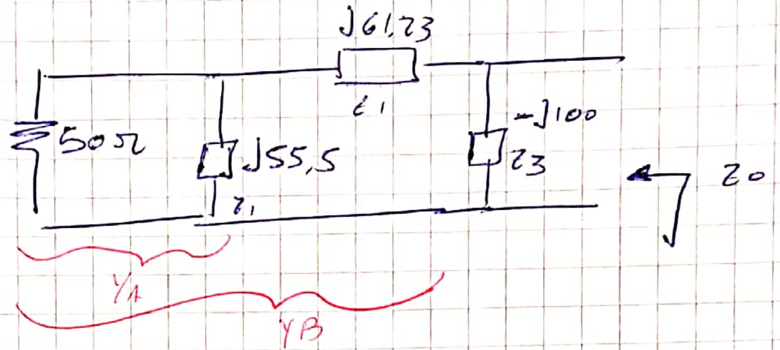
$$Y_e = Y_1 + Y_B = 0{,}017 + J0{,}016 - \frac{J}{55{,}5} \Rightarrow 0{,}017 - J0{,}001$$

$$Ze = \frac{1}{0{,}017 - J0{,}001} \cdot \frac{0{,}017 + J0{,}001}{0{,}017 + J0{,}001} \Rightarrow \frac{0{,}017 + J0{,}001}{2{,}9\,10^{-4}}$$

$$Ze = \underbrace{58{,}62\,\Omega + J\,3{,}44\,\Omega}$$

hay diferencia pero es por decimales ajustados

$Z_0 = 300\Omega$?



$Y_A = \frac{1}{50} - \frac{J1}{55,5} = \frac{1}{50} - J0,01 \quad S$

$Z_A = \frac{1}{Y_A} = 27,59 + J24,86 \quad \Omega$.

$Z_B = Z_A + Z_1 = 27,59 + J86,09 \quad \Omega$.

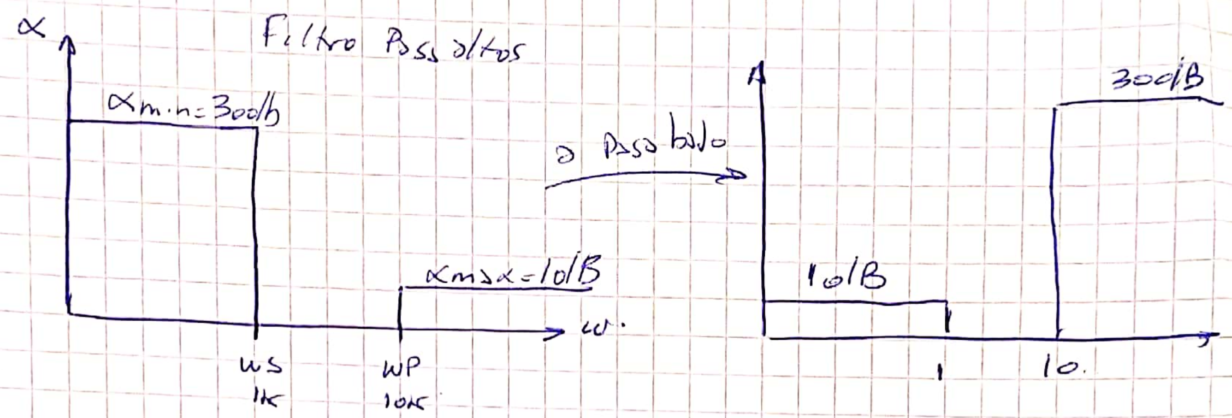
$Y_B = \frac{1}{Z_B} = 3,37 - J0,01 \quad S$

$Y_0 = Y_B + Y_3 = 3,37 \, 10^{-3} - 5,32 \, 10^{-4} \quad S$

$Z_0 = (288 + J45)\ \Omega$

3.1]

Plantilla Propuesta:



Máx Planicidad

$$|T(j\omega)|^2 = \frac{1}{1+\varepsilon^2\omega^{2N}}$$

$$10^{-1/20} = \left.\frac{1}{\sqrt{1+\varepsilon^2}}\right|_{\omega=1}$$

$$10^{-\frac{1}{10}} + 10^{-1/10}\,\varepsilon^2 = 1$$

$$\sqrt{\frac{1-10^{-1/10}}{10^{-1/10}}} = \varepsilon \Rightarrow 0,5$$

$$10^{-3/2} = \frac{1}{\sqrt{1+(0,5)^2\,10^{2N}}}$$

$$10^{-3} + 10^{-3}\cdot\frac{1}{4}\cdot 10^{2N} = 1$$

$$\frac{1}{10^{-3}\frac{1}{4}} - 10^{-3} = 10^{2N}$$

$$N = \frac{1}{2}\log\left(\frac{1}{10^{-3}\frac{1}{4}} - 10^{-3}\right) = 1,8$$

$N = 2$

Trabajo con Butter de 2do orden después desnormalizo en los componentes

$$\omega_B = \varepsilon^{-1/n}\, \omega_P = 1414{,}21$$

$$T(s) \cdot T(-s) = |T(j\omega)|^2 \Big|_{j\omega = s}$$

$$|T(j\omega)|^2 = \frac{1}{1+\omega^4}$$

$$|T(j\omega)|^2 \Big|_{\omega = \frac{s}{j}} = \frac{1}{1+s^4} = \frac{1}{s^4+1}$$

$$|T(j\omega)|^2 = \underbrace{\frac{1}{s^2+\sqrt{2}\,s+1}}_{T(s)} \cdot \underbrace{\frac{1}{s^2-\sqrt{2}\,s+1}}_{T(-s)}$$

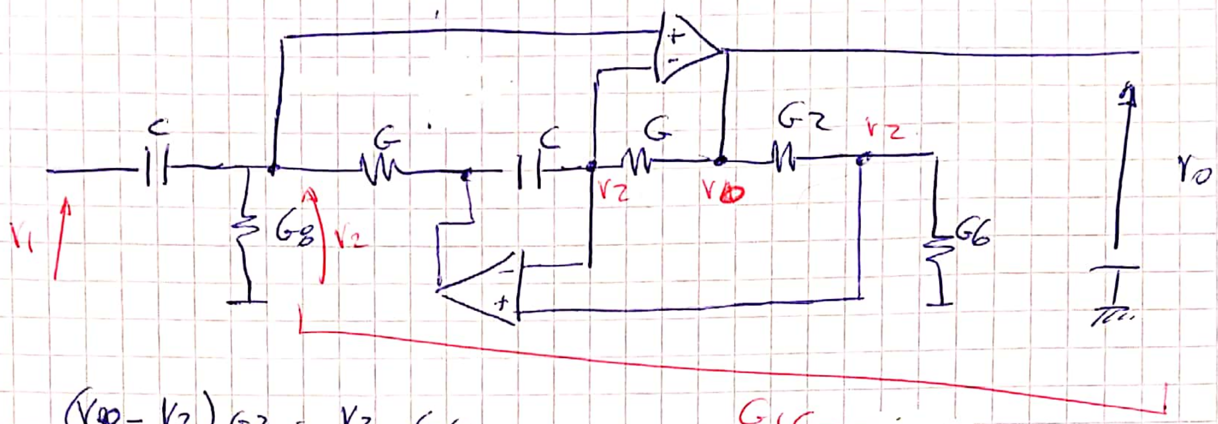
$$T(s) = \frac{1}{s^2+\sqrt{2}\,s+1}$$

a pasa alto $s = \frac{1}{S}$

$$T\left(\frac{1}{S}\right) = \frac{1}{\left(\frac{1}{S}\right)^2+\sqrt{2}\,\frac{1}{S}+1} = \frac{S^2}{S^2+\sqrt{2}\,S+1}$$

3).B)

Redibujando el circuito



GIC
Inductor activo

$$(V_0 - V_2)\, G_2 = V_2 \cdot G_6$$

$$V_0\, G_2 = V_2 \,(G_6 + G_2)$$

$$\frac{V_0}{V_2} = \left(\frac{G_6}{G_2} + 1\right)$$

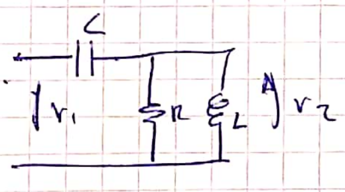
$$Z_{GIC} = \frac{s C\, G_2}{G\, G\, G_6}$$

$$Z_{GIC} = \frac{s C\, G_2}{G^2\, G_6}$$

$$\boxed{T(s) = \frac{s^2}{s^2 + \sqrt{2}\, s + 1}}$$

$\frac{G_2}{G_6} + 1$ fija el nivel en ∞

Piden $|T(\omega)|\Big|_{\omega \to \infty} = 6\,dB$



$$T(s) = \frac{V_2}{V_1} = \frac{\frac{R \cdot sL}{R + sL}}{\frac{1}{sC} + \frac{R \cdot sL}{R + sL}} = \frac{s^2 RLC}{R + sL + s^2 RLC}$$

$$T(s) = RLC\, \frac{s^2}{s^2 + \frac{s}{RC} + \frac{1}{LC}}$$

$$\frac{1}{RC} = \sqrt{2}$$

$$\frac{1}{LC} = 1$$

$6\,dB \simeq 2$

$$\frac{G_2}{G_6} = 1$$

$$\boxed{G_2 = G_6}$$

Si $L = 1H$ $C = 1F$

$$\frac{1}{G_8} = R = \frac{1}{\sqrt{2}} = 0{,}707\,\Omega$$

$$L_{Activa} = 1Hy = \frac{C}{G^2}\left(\frac{G2}{G6}\right) = \frac{C}{G^2} \Rightarrow \quad C = G^2$$

1

$G = 1\,S$

Desnormalizando en frec

$C = \frac{1F}{\omega B} = 707\,\mu F$ utilizo $RN = 10k$ para valores "normales"

$C_{final} = \frac{1F}{\omega B\,RN} = 70,7\,nF$

$\frac{1}{G8_{final}} = 7,07\,k\Omega$ $\qquad G2 = G6 = 1$

$\frac{1}{G2_{final}} = 10\,k\Omega$

$\frac{1}{G6_{final}} = 10\,k\Omega$

$\frac{1}{G_{final}} = 10\,k\Omega$

3.3)

$$S^{Q}_{G_8} : \frac{s^2}{s^2 + \frac{\omega_0 s}{Q} + \omega_0^2} \qquad \omega_0 = \frac{1}{\sqrt{LC}}$$

$$\frac{\omega_0}{Q} = \frac{1}{R_8 C} = \frac{G_8}{C}$$

$$Q = \frac{\omega_0 C}{G_8} = \frac{\sqrt{C^2}}{\sqrt{LC}\cdot G_8} = \sqrt{\frac{C}{L}}\cdot\frac{1}{G_8}$$

$$S^{Q}_{G_8} = \frac{\partial Q}{\partial G_8}\cdot\frac{G_8}{Q} =$$

$$\frac{G_8}{Q}\frac{\partial Q}{\partial G_8} = -\sqrt{\frac{C}{L}}\cdot\frac{1}{G_8^2}\cdot\frac{\cancel{G_8}}{Q}$$

$$S^{Q}_{G_8} = -\cancel{\sqrt{\frac{C}{L}}}\cdot\cancel{\frac{1}{G_8}}\cdot\cancel{G_8}\cdot\cancel{\sqrt{\frac{L}{C}}} = -1$$

$$S^{Q}_{C} = \frac{\partial Q}{\partial C}\cdot\frac{C}{Q} = \frac{1}{2}\frac{1}{G_8\sqrt{L}\sqrt{C}}\cdot\frac{\sqrt{C^2}}{Q}$$

$$S^{Q}_{C} = \frac{1}{2}\frac{1}{\cancel{G_8}}\cancel{\sqrt{\frac{C}{L}}}\cdot\cancel{G_8}\cdot\cancel{\sqrt{\frac{L}{C}}} = \frac{1}{2}$$

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