TS3 - Ejercicio 4

lunes, 16 de mayo de 2022 10:35 p. m.

A partir de la siguiente plantilla, sabiendo que:

αmáx [dB]	αmín [dB]	fp [Hz]	fs [Hz]
1	35	3500	1000

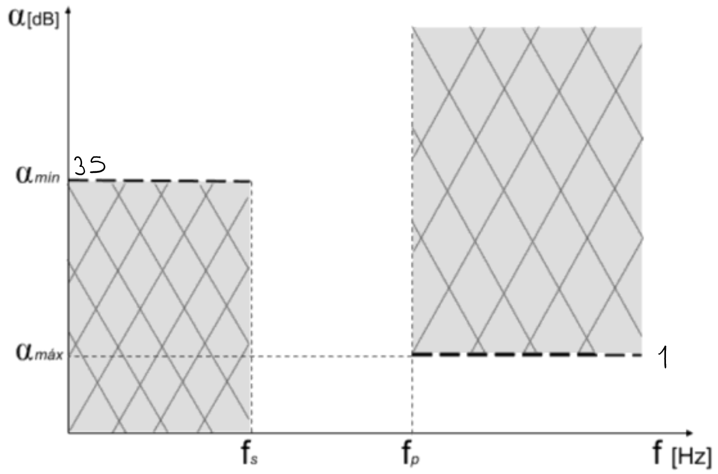
1. Obtener polos y ceros para máxima planicidad en la banda de paso.

2. ~~Comparar con los polos obtenidos en el ejercicio 3.3.~~ **(Este NO! para la TS3, si para el TP2)**

3. Implementar el circuito con estructuras pasivas adaptadas mediante buffers.

4. Utilizando una norma de impedancia ZN = 1K, obtenga el valor de los componentes.

5. Active las bobinas utilizando una estructura con OPAMPs.



$f_s = 1000\ Hz \rightarrow \omega_s = 2\pi\ 1000\ \frac{1}{s}$

$f_p = 3500\ Hz \rightarrow \omega_p = 2\pi \cdot 3500\ \frac{1}{s}$

NORMALIZANDO EN FRECUENCIA

$\omega_{p_N} = 1 \qquad \omega_{s_N} = \frac{\omega_s}{\omega_p} = \frac{\cancel{2\pi}}{\cancel{2\pi}} \cdot \frac{100\cancel{0}}{350\cancel{0}} = \frac{2}{7}$

$\Omega_w = \omega_p = 2\pi\, 3500$

Tengo una plantilla de un PASA ALTO ⟶ Transformo en PASA BAJO

$\Omega = \frac{-1}{\omega} \quad ; \quad \$ = \frac{1}{S}$

$\Omega_p = \frac{1}{\omega_{p_N}} = 1 \qquad \Omega_s = \frac{1}{\omega_{s_N}} = \frac{7}{2} = 3,5$

M: Prohibido

PLANTILLA PASA BAJO

Ahora trabajamos como un PASA BAJO. Luego volveremos a las condiciones originales

MAXIMA PLANICIDAD

$$|T(j\omega)|^2 = \frac{1}{1+\varepsilon^2\omega^{2m}} \xrightarrow[\text{caso}]{\text{en nuestro}} |T(j\Omega_p)|^2 = \frac{1}{1+\varepsilon^2\Omega_p^{2m}}$$

$$\frac{1}{s^2+\frac{\omega_0}{Q}+\omega_0}$$

Pero lo quiero trabajar como BUTTER

$$|T(j\Omega_p)|^2 = \frac{1}{1+(\underbrace{\Omega_p\,\varepsilon^{-1/m}}_{\Omega_B})^{2m}} \xrightarrow{B} |T(j\Omega_B)|^2 = \frac{1}{1+\Omega_B^{2m}}$$

donde $\Omega_B = \Omega_p \cdot \varepsilon^{-\frac{1}{m}}$

$\Omega_B = 1,184$

Analisis de ε

$$\varepsilon^2 = 10^{\frac{\alpha_{MAX}}{10}} - 1 = 10^{\frac{1}{10}} - 1 \longrightarrow \varepsilon^2 \cong 0,259 \longrightarrow \varepsilon \cong 0,50885$$

Calculo de m minimo

$\alpha_{min} = 35$

$$\boxed{\alpha(\Omega_s) = 10\log(1+\varepsilon^2\Omega_s^{2m})}$$

Pruebo con $m = 3$

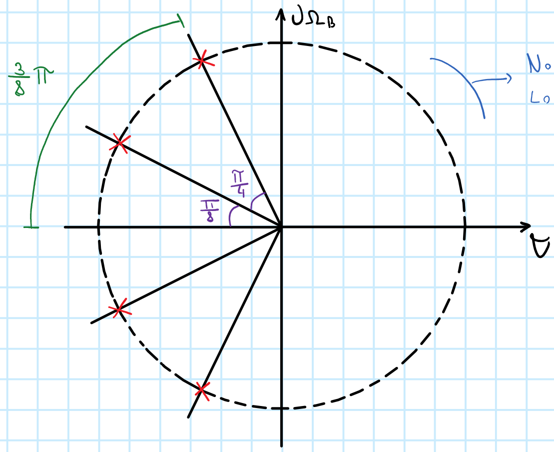
$$\alpha_3(\Omega_s) = 10\log(1+0,259\cdot(3,5)^{2\cdot 3}) \rightarrow \cancel{\alpha_3 \cong 26,79}$$

Pruebo con $\boxed{m = 4}$

$$\alpha_4(\Omega_s) = 10\log(1+0,259\cdot(3,5)^{2\cdot 4}) \rightarrow \boxed{\alpha_4 = 37,66}$$

"BUTTER" de orden 4

$$T_{B4}(s) = \frac{1}{s^2+s\cdot 2\cdot\cos\left(\frac{\pi}{8}\right)+1}\cdot\frac{1}{s^2+s\cdot 2\cdot\cos\left(\frac{3\pi}{8}\right)+1} \qquad \Omega_B = 1$$



NO ME INTERESA LOS POLOS DE LA DERECHA

$$T_{B4}(\$) = \frac{1}{\$^2 + \$.2.\cos\left(\frac{\pi}{8}\right) + 1} \cdot \frac{1}{\$^2 + \$.2.\cos\left(\frac{3\pi}{8}\right) + 1} \qquad \Omega_B = 1$$

$$T_{HP\,B4}(\$) = \frac{\$^2}{\$^2 + \$.2.\cos\left(\frac{\pi}{8}\right) + 1} \cdot \frac{\$^2}{\$^2 + \$.2.\cos\left(\frac{3\pi}{8}\right) + 1}$$

Corrijo el Factor de Butter

$$\frac{\omega_0}{Q} \rightarrow \frac{\omega_0\,\omega_B}{Q} \quad \wedge \quad \omega_0^2 \longrightarrow (\omega_0\,\omega_B)^2 \qquad \text{donde} \quad \omega_B = \frac{1}{\Omega_B} = \frac{1}{\underbrace{\Omega_p}_{1} \cdot \epsilon^{-\frac{1}{n}}}$$

$$T_{HP\,B4}(\$) = \frac{\$^2}{\$^2 + \$.2.\cos\left(\frac{\pi}{8}\right)\omega_B + \omega_B^2} \cdot \frac{\$^2}{\$^2 + \$.2.\cos\left(\frac{3\pi}{8}\right)\omega_B + \omega_B}$$

$$T_{HP\,B4}(\$) = \frac{\$^2}{\$^2 + \$.2.\cos\left(\frac{\pi}{8}\right)\frac{1}{\epsilon^{-\frac{1}{n}}} + \left(\frac{1}{\epsilon^{-\frac{1}{n}}}\right)^2} \cdot \frac{\$^2}{\$^2 + \$.2.\cos\left(\frac{3\pi}{8}\right)\frac{1}{\epsilon^{-\frac{1}{n}}} + \left(\frac{1}{\epsilon^{-\frac{1}{n}}}\right)^2}$$

$$T_{HP}(\$) = \frac{\$^2}{\$^2 + \$.1,5606 + 0,7133} \cdot \frac{\$^2}{\$^2 + \$.0,646425 + 0,7133}$$

3. Implementar el circuito con estructuras pasivas adaptadas mediante buffers.

SOS_1:

$K = 1$

$\omega_0^2 \approx 0,7133 \longrightarrow \omega_0 \approx 0,8446$

$\frac{0,8446}{Q_1} = 1,5606 \rightarrow Q_1 \approx \frac{0,8446}{1,5606}$

$Q_1 \approx 0,5412$

SOS_2:

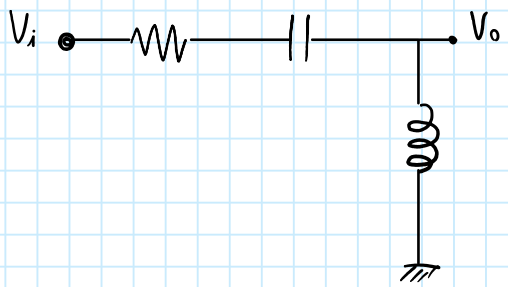
$K_2 = 1$

$\omega^2 \approx 7133 \longrightarrow \omega_0 \approx 0\ 8446$

$\frac{0,8446}{Q_2} \approx 0,646425 \rightarrow Q_2 \approx \frac{0,8446}{0,646425}$

$Q_2 \cong 1,30657$

IMPLEMENTO EN CIRCUITO PASIVO $\longrightarrow$ RLC Pasa-Alto



$$\frac{V_o}{V_i}(s) = \frac{s^2}{s^2 + s\frac{R}{L} + \frac{1}{LC}}$$

Utilizando una norma de impedancia ZN = 1K, obtenga el valor de los componentes.

💎 Obtener los valores de la red normalizados en frecuencia e impedancia.

Normalizo en Impedancia. No en frecuencia ya que no estoy en el radio unitario.

SOS$_1$

$R = 1K \qquad R_N = \frac{R}{\Omega_Z} = 1$ donde $\Omega_Z = 1K$

$\omega_0^2 = \frac{1}{L_{1N} C_{1N}} \rightarrow C_{1N} = \frac{1}{L_{1N}\,\omega_0^2}$ (1)

$\frac{\omega_0}{Q_1} = \frac{R_N}{L_N} \rightarrow L_N = \frac{Q_1}{\omega_0}$ (2)

2 → (1)

$\frac{1}{\frac{Q_1}{\cancel{\omega_0}} \cdot \omega_0^{\cancel{2}}} \rightarrow C_{1N} = \frac{1}{Q_1 \cdot \omega_0} = \frac{1}{0{,}5412 \cdot 0{,}8446}$

$\therefore C_{1N} = 2{,}187712$

$L_{1N} = \frac{0{,}5412}{0{,}8446} = 0{,}640777$

Desnormalizo

$R = R_N \cdot \Omega_Z = 1K\Omega$

$C_1 = \frac{C_{1N}}{\Omega_Z \, \Omega_\omega} = \frac{2{,}187712}{1K \cdot 2\pi \cdot 3500}$ [F]

$C_1 = 99{,}4815$ nF

$L_1 = \frac{L_{1N}\,\Omega_Z}{\Omega_\omega} = \frac{0{,}640777 \cdot 1K}{2\pi \cdot 3500}$ [H]

$L_1 = 29{,}1376$ mH

SOS$_2$

$R = 1K \qquad R_N = \frac{R}{\Omega_Z} = 1$ donde $\Omega_Z = 1K$

$\omega_0^2 = \frac{1}{L_{2N} C_{2N}} \rightarrow C_{2N} = \frac{1}{L_{2N}\,\omega_0^2}$ (1)

$\frac{\omega_0}{Q_2} = \frac{R_N}{L_{2N}} \rightarrow L_{2N} = \frac{Q_2}{\omega_0}$ (2)

(2) → (1)

$\frac{1}{\frac{Q_2}{\cancel{\omega_0}} \cdot \omega_0^{\cancel{2}}} \rightarrow C_{2N} = \frac{1}{Q_2 \cdot \omega_0} = \frac{1}{1{,}30657 \cdot 0{,}8446}$

$\therefore C_{2N} = 0{,}906184$

$L_{2N} = \frac{1{,}30657}{0{,}8446} = 1{,}54697$

Desnormalizo

$R = R_N \cdot \Omega_Z = 1K\Omega$

$C_2 = \frac{C_{2N}}{\Omega_Z \, \Omega_\omega} = \frac{0{,}906184}{1K \cdot 2\pi \cdot 3500}$ [F]

$C_2 = 41{,}2068$ nF

$L_2 = \frac{L_{2N}\,\Omega_Z}{\Omega_\omega} = \frac{1{,}54697 \cdot 1K}{2\pi \cdot 3500}$ [H]

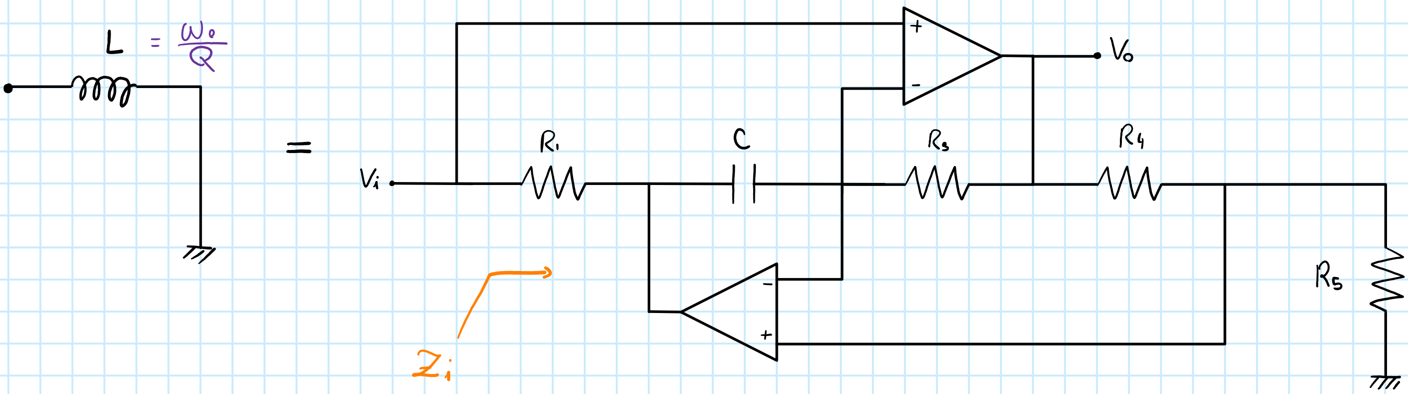
$L_2 = 70{,}34512$ mH

Al ser $Q_2 > Q_1 \rightarrow$ SOS$_2$ Estara a la entrada del circuito

⚽ Simulación **numérica y circuital.**

HECHO EN JUPYTER

Active las bobinas utilizando una estructura con OPAMPs.



$$Z_i = \frac{Z_1 \cdot Z_3\, Z_5}{Z_2 \cdot Z_4}$$ Cap

Si $Z_1 = Z_3 = Z_4 = Z_5 = R$

$$Z_i = S\,\boxed{C R^2} \rightarrow L_{eq}$$

Para SOS_1 adopto $R = 100$

$$C_{G1} R^2 = \frac{Q_1}{\omega_0} \rightarrow C_{G1N} = \frac{Q_1}{\omega_0 R^2} = \frac{0{,}5412}{0{,}8446 \cdot 100^2}$$

$$C_{G1N} = 6{,}4078 \times 10^{-5}$$

DESNORMALIZO

$$C_{G1} = \frac{C_{G1N}}{\Omega_w} \cdot \Omega_Z = \frac{6{,}4078 \times 10^{-5}}{2\pi \cdot 3500} \cdot 1K$$

$$C_{G1} = 2{,}9134 \ \mu F$$

Para SOS_1 adopto $R = 100$

$$C_{G2N} R^2 = \frac{Q_2}{\omega_0} \rightarrow C_{G2N} = \frac{Q_2}{\omega_0 R} = \frac{1{,}30657}{0{,}8446 \cdot 100^2}$$

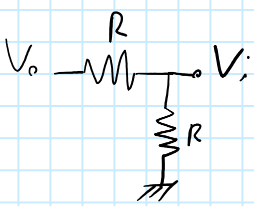
$$C_{G2N} = 1{,}5697 \times 10^{-4}$$

DESNORMALIZO

$$C_{G2} = \frac{C_{G2N} \cdot \Omega_Z}{\Omega_w} = \frac{1{,}5697 \times 10^{-4} \cdot 1K}{2\pi \cdot 3500}$$

$$C_{G2} = 7{,}03451 \ \mu F$$

Analizando SALIDA del girador

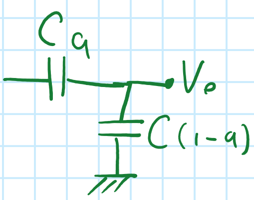


$$V_i = \frac{V_o \cancel{R}}{\cancel{R}+\cancel{R}} \Rightarrow V_o = 2\,V_i$$

Por la configuracion gano 2 veces mi entrada

Tengo 2 giradores $\longrightarrow$ gano 4 veces $\therefore$ Necesito atenuar x4 la salida

Uso Divisor Capacitivo



$a = \frac{1}{4}$

Adopto

$C = 100 \ nF$