

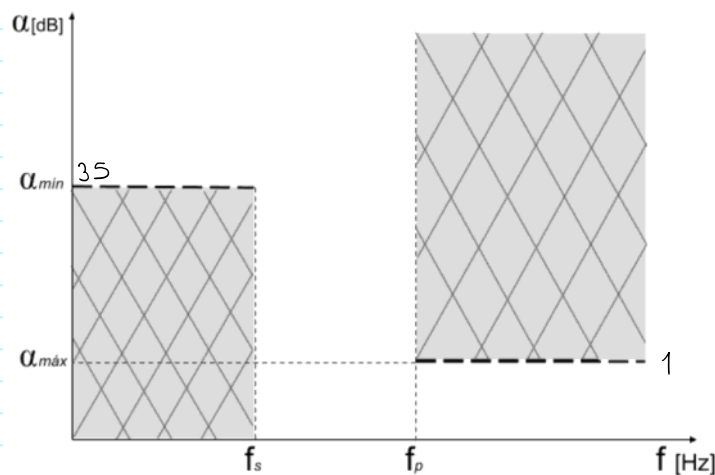
TS3 - Ejercicio 4

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

A partir de la siguiente plantilla, sabiendo que:

$\alpha_{\text{máx}}$ [dB]	$\alpha_{\text{mín}}$ [dB]	f_p [Hz]	f_s [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 $Z_N = 1K$, obtenga el valor de los componentes.
5. Active las bobinas utilizando una estructura con OPAMPs.



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

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

NORMALIZANDO EN FRECUENCIA

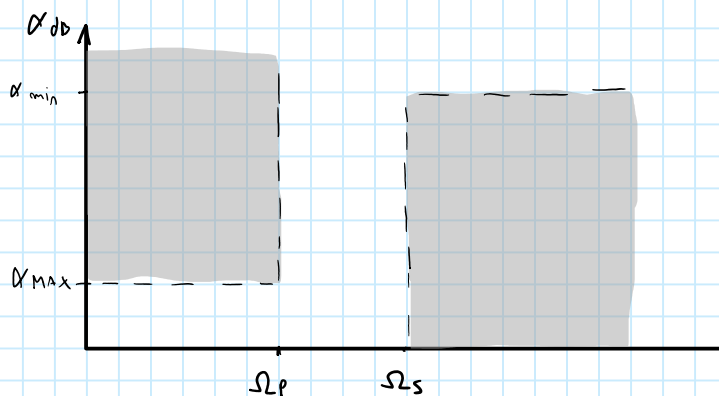
$$\omega_{pN} = 1 \quad \omega_{sN} = \frac{\omega_s}{\omega_p} = \frac{2\pi}{2\pi} \cdot \frac{1000}{3500} = \frac{2}{7}$$

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

Tengo una plantilla de un PASA ALTO \rightarrow Transformo en PASA BAJO

$$\Omega = \frac{-1}{\omega} \quad \text{y} \quad \Phi = \frac{1}{s}$$

$$\Omega_p = \frac{1}{\omega_{pN}} = 1 \quad \Omega_s = \frac{1}{\omega_{sN}} = \frac{7}{2} = 3,5$$



M: Prohibido

PLANTILLA PASA BAJO

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

MAXIMA PLANICIDAD

$$|T(j\omega)|^2 = \frac{1}{1 + \xi^2 \omega^{2m}} \xrightarrow[\text{como}]{\text{en muestreo}} |T(j\Omega_p)|^2 = \frac{1}{1 + \xi^2 \Omega_p^{2m}}$$

Pero lo quiero trabajar como BUTTER

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

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

$$\Omega_B = 1,184$$

Análisis de ξ

$$\xi^2 = 10^{\frac{\alpha_{\max}}{10}} - 1 = 10^{\frac{1}{10}} - 1 \rightarrow \xi^2 \cong 0,259 \rightarrow \xi \cong 0,50885$$

Cálculo de m mínimos

$$\alpha_{\min} = 35$$

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

Pruebo con $m = 3$

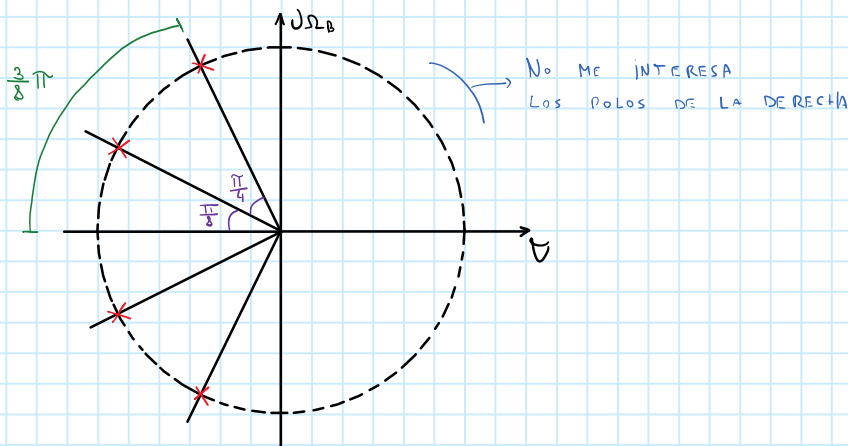
$$\alpha_3(\Omega_s) = 10 \log(1 + 0,259 \cdot (3,5)^{2 \cdot 3}) \rightarrow \alpha_3 = 26,79$$

Pruebo con $m = 4$

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

"BUTTER" de orden 4

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



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

Corrijo el Factor de Butter

$$\phi = \frac{s}{\Omega_B} \wedge \Omega_B = \underbrace{\Omega_p}_1 \phi^{-\frac{1}{m}} \rightarrow \phi = s \cdot \phi^{\frac{1}{m}}$$

$$T_{LP}(s) = \frac{1}{s^2 \phi^{\frac{1}{m}} + s \phi^{\frac{1}{m}} \cdot 2 \cdot \cos\left(\frac{\pi}{8}\right) + 1} \cdot \frac{1}{s^2 \phi^{\frac{1}{m}} + s \phi^{\frac{1}{m}} \cdot 2 \cdot \cos\left(\frac{3\pi}{8}\right) + 1}$$

$$PASA-BAJA \rightarrow PASA-ALTO \quad s = \frac{1}{s}$$

$$T_{HP}(s) = \frac{1}{\frac{\phi^{\frac{1}{m}}}{s^2} + \frac{1}{s} \phi^{\frac{1}{m}} \cdot 2 \cos\left(\frac{\pi}{8}\right) + 1} \cdot \frac{1}{\frac{\phi^{\frac{1}{m}}}{s^2} + \frac{1}{s} \phi^{\frac{1}{m}} \cdot 2 \cos\left(\frac{\pi}{4}\right) + 1}$$

$$T_{HP}(s) = \frac{s^2}{\phi^{\frac{1}{m}} + s \phi^{\frac{1}{m}} \cdot 2 \cos\left(\frac{\pi}{8}\right) + s^2} \cdot \frac{s^2}{\phi^{\frac{1}{m}} + s \phi^{\frac{1}{m}} \cdot 2 \cos\left(\frac{\pi}{4}\right) + s^2}$$

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

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

SOS₁:

$$K_1 = 1$$

$$\omega_o^2 \approx 0,7133 \rightarrow \omega_o \approx 0,8446$$

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

$$Q_1 \approx 0,5412$$

SOS₂:

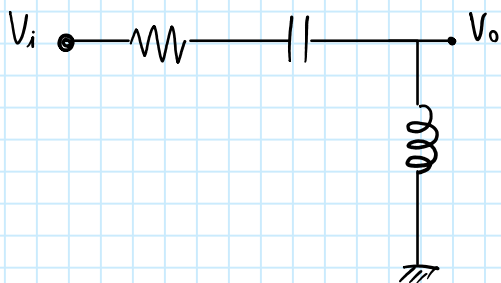
$$K_2 = 1$$

$$\omega_o^2 \approx 0,7133 \rightarrow \omega_o \approx 0,8446$$

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

$$Q_2 \approx 1,30657$$

IMPLEMENTO EN CIRCUITO PASIVO \rightarrow 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 $Z_N = 1K$, 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 me es tor en el radio unitario.

SOS₁

$$R = 1K \quad R_N = \frac{R}{\Omega_z} = 1 \text{ donde } \Omega_z = 1K$$

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

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

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

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

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

SOS₂

$$R = 1K \quad R_N = \frac{R}{\Omega_z} = 1 \text{ donde } \Omega_z = 1K$$

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

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

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

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

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

Desnormalizo

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

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

$$C_1 = 99,4815 \text{ nF}$$

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

$$L_1 = 29,1376 \text{ mH}$$

Desnormalizo

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

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

$$C_2 = 41,2068 \text{ nF}$$

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

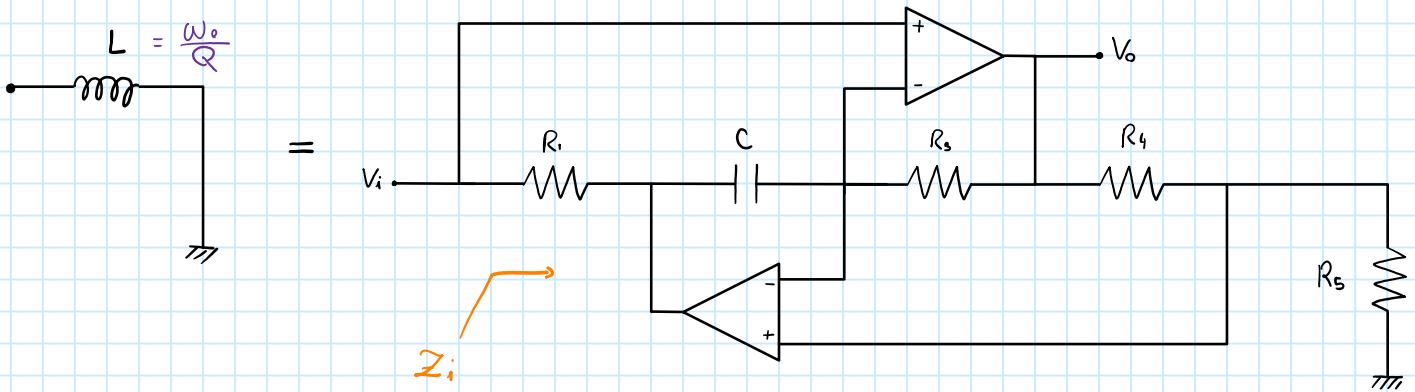
$$L_2 = 70,34512 \text{ mH}$$

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

⊕ Simulación numérica y circuital.

HECHO EN JUPYTER

Active las bobinas utilizando una estructura con OPAMPs.



$$Z_i = \frac{Z_1 \cdot Z_3 \cdot Z_5}{\underbrace{Z_2 \cdot Z_4}_{C_{ap}}}$$

$$\text{Si } Z_1 = Z_3 = Z_4 = Z_5 = R$$

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

Para SOS₁ adopt. $R = 100$

$$C_{G1} R^2 = \frac{Q_1}{W_0} \rightarrow C_{G1} = \frac{Q_1}{W_0 R^2} = \frac{0,5412}{0,8446 \cdot 100^2}$$

$$C_{G1} = 6,4078 \times 10^{-5}$$

DESNORMALIZADO

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

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

Para SOS₂ adopt. $R = 100$

$$C_{G2} R^2 = \frac{Q_2}{W_0} \rightarrow C_{G2} = \frac{Q_2}{W_0 R^2} = \frac{1,30657}{0,8446 \cdot 100^2}$$

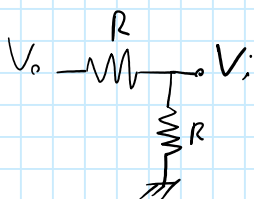
$$C_{G2} = 1,5697 \times 10^{-4}$$

DESNORMALIZADO

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

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

Analizando SALIDA del girador

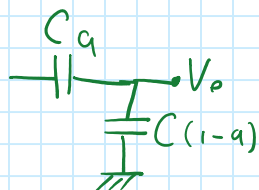


$$V_i = \frac{V_o \cdot R}{R+R} \Rightarrow V_o = 2 V_i$$

Por la configuración
gano 2 veces mi entrada

Tengo 2 giradores \rightarrow gano 4 veces \therefore Necesito atenuar $\times 4$ la salida

Uso DIVISOR CAPACITIVO



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

Adopto

$$C = 100 \mu F$$