Ejercicio ④

- Filtro Pass-Band.

$$\left.\begin{array}{l} f_{ci} = 1{,}6\,kHz \\ f_{cs} = 2{,}5\,kHz \end{array}\right\} \left.\begin{array}{l} f_0 = 2000\,Hz \\ B = 0{,}9 \end{array}\right\} Q = 2{,}22.$$

→ Filtro simétrico, transformo a $f_{cs} = 3{,}24\,kHz$

↳ $fc_{PB} = 2{,}166$

→ Tenemos un ripple de 3dB y es un filtro de máxima planicidad. por la tanto:

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

$$\alpha|_{dB} = 10 \log\left(1 + \Omega_s^{2N}\right) \rightarrow N = 3 \rightarrow \begin{array}{l} \alpha = 20{,}18 \\ \Omega = 2{,}166 \end{array}.$$

→ Nuestro prototipo es un filtro Butter de orden 3.

$$H(s) = \frac{1}{(s+1)\left[s^2 + 2\cos\left(\frac{\pi}{3}\right)s + 1\right]}.$$

→ Realizo la transformación a un pasabanda

$$S = k(s) = 2{,}22 \cdot \frac{(s^2+1)}{s}$$

$$H(s) = \frac{1}{\left(Q\frac{(s^2-1)}{s}+1\right)\left(Q^2\frac{(s^2+1)^2}{s^2} + AQ\frac{(s^2+1)}{s} + 1\right)}$$

$$H(s) = \frac{s \cdot s^2}{(Q(s^2+1)+s)(Q^2(s^2+1)^2 + AQs(s^2+1) + s^2)}$$

$$H(s) = \frac{s \cdot s^2}{(Qs^2+s+Q)(Q^2s^4+2Q^2s^2+Q^2+AQs^3+AQs+s^2)}$$

$$H(s) = \frac{s^3 \cdot 1/Q^3}{(s^2+s\cdot\frac{1}{Q}+1)(s^4+\frac{A}{Q}s^3+s^2(\frac{1}{Q^2}+2)+\frac{A}{Q}s+1)}$$

$$\frac{1}{Q^2}+2 = \frac{1+2Q^2}{Q^2}$$

$$H(s) = SOS_1 \cdot SOS_2 \cdot SOS_3 .$$

$$SOS_1 = \frac{s \cdot 1/Q}{s^2+s/Q+1}$$

$$SOS_2 = \frac{s \cdot 1/Q}{s^2+s(0{,}268)+1{,}476}$$

NOTA

$$SOS_3 = \frac{s \cdot 1/Q}{s^2 + s(0,182) + 0,677} = \frac{s \cdot 1/Q}{s^2 + s\frac{w_3}{q_3} + w_3^2}$$

$w_3 = 0,822 \qquad q_3 = 4,5208$

$$SOS_2 = \frac{s\ 1/Q}{s^2 + s\,0,268 + 1,476} = \frac{s\ 1/Q}{s^2 + s\frac{w_2}{q_2} + w_2^2}$$

$w_2 = 1,215 \qquad q_2 = 4,533$

$\therefore$ La transferencia normalizada es:

$$H(s) = \frac{1/Q^3 \cdot s^3}{\left(s^2 \frac{s}{Q} + 1\right)\left(s^2 + s\frac{w_3}{q_3} + w_3^2\right)\left(s^2 + s\frac{w_2}{q_2} + w_2^2\right)}$$

Siendo $Q = 2,22 \qquad w_2 = 1,215$

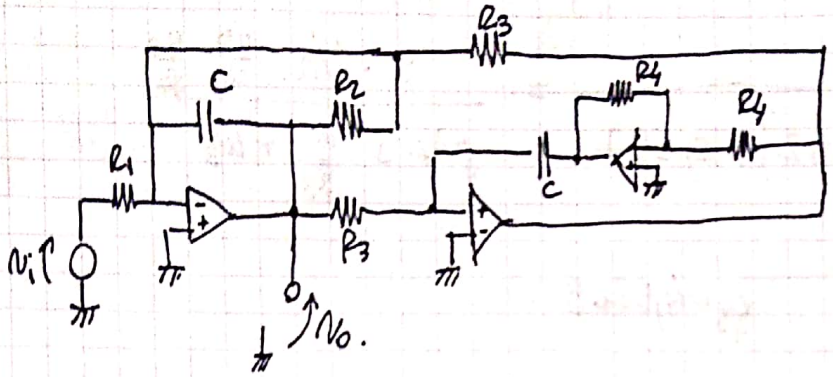
$q_2 = 4,533 \qquad w_3 = 0,822$

$q_3 \simeq q_2$

→ ⓑ Graficar diagrama de polos y ceros.

ⓒ Graficar transferencia (módulo y fase) del filtro pedido.

(d) Sintetizar el filtro utilizando estructura Actebog-Rosenberg.



$$\frac{Vo(s)}{Vi(s)} = H(s) = \frac{-s\,G_1/C}{s^2 + s\,\frac{G_2}{C} + \frac{G_3^2}{C^2}} = -\frac{G_1}{G_2}\,\frac{s\,G_2/C}{s^2 + s\,\frac{G_2}{C} + \frac{G_3^2}{C^2}}$$

$$H(s) = -\frac{G_1}{G_2}\,\frac{s\,G_2/C}{s^2 + s\,\frac{G_2}{C} + \frac{G_3^2}{C^2}} = \frac{k\,s\,\omega_0/Q}{s^2 + s\,\omega_0/Q + \omega_0^2}$$

$$k = -\frac{G_1}{G_2} \qquad \omega_0 = \frac{G_3}{C} \qquad Q = \frac{G_3}{G_2}$$

- Sintetizo cada uno de los filtros por separado.

$$SOS_1 = \frac{s\,1/Q}{s^2 + s/Q + 1} \rightarrow \frac{s\,\frac{2\pi\,2kHz}{2,2}}{s^2 + s\,\frac{2\pi\,2kHz}{2,2} + (2\pi\,2kHz)^2}$$

$$\omega_0 = \frac{G_3}{C} = 2\pi\,2kHz \rightarrow \boxed{G_3 = 80} \quad \boxed{C = 1\mu F}$$

$$Q = \frac{G_3}{G_2} = 2,22 \rightarrow \boxed{R_2 = 17\Omega}$$

$$k = -\frac{G_1}{G_2} \rightarrow R_1 = 17\Omega$$

$$\rightarrow G \cdot H_2 = \frac{S \cdot 1/Q}{S^2 + S\frac{\omega_2}{Q_2} + \omega_2^2} \Rightarrow \frac{S \cdot \omega_0/Q}{S^2 + S\frac{\omega_2\omega_0}{Q_2} + (\omega_0\omega_2)^2}$$

$$G \cdot \frac{\frac{\omega_0\omega_2}{Q_2} \cdot \left(\frac{Q_2}{\omega_2 Q}\right) \rightarrow k}{S^2 + S\left(\frac{\omega_2\omega_0}{Q_2}\right) + (\omega_0\omega_2)^2}$$

$\frac{\omega_0}{Q_i}$; $\rightarrow \omega_0$.

Luego busco los valores de los componentes.

$$\omega_0\omega_2 = 2\pi \cdot 2kHz \cdot 1{,}215 = \frac{G_3}{C} \rightarrow \boxed{C = 1\mu F}$$

$$\boxed{R_3 = 65{,}5\Omega}$$

$$Q_2 = 4{,}533 = \frac{R_2}{R_3} \rightarrow \boxed{R_2 = 2 \cdot 96{,}97}$$

$$\frac{Q_2}{\omega_2 Q} = \frac{4{,}533}{1{,}285 \cdot 2{,}22} = -\frac{R_2}{R_1} = 1{,}680.$$

$$\boxed{R_1 = 176\Omega}.$$

$$G_{OS_3} = \frac{S \frac{\omega_0 \omega_3}{\beta_3} \frac{\beta_3}{\omega_3 Q}}{S^2 + S \frac{\omega_3 \omega_0}{\beta_3} + \gamma(\omega_3 \omega_0)^2}$$

$\omega_0 \omega_3 = 2\pi 2kHz \cdot 0{,}822 = \frac{1}{R_3 C} \rightarrow$ **C = 1 μF**

$R_3 \cong 97\Omega$

$\beta_3 = 4{,}52 = \frac{R_2}{R_3} \rightarrow$ **$R_2 \cong 440\Omega$**

$\frac{\beta_3}{\omega_3 Q} = \frac{4{,}52}{0{,}322 \cdot 2{,}22} = K = -\frac{R_2}{R_1} \Rightarrow$ **$R_1 = 177\Omega$**

NOTA