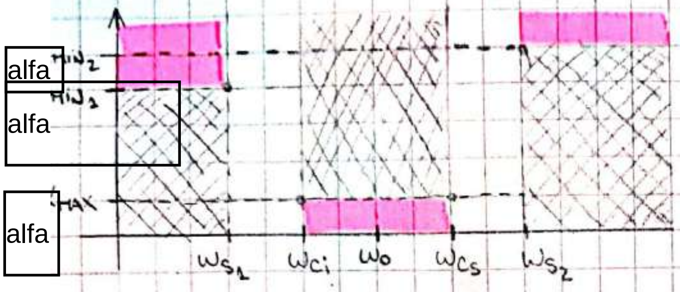
TAREA SEMANAL 4 bis 2

• Diseño filtro pasabanda



$\omega_0 = 2\pi \cdot 22\,kHz \qquad Q = 5$

$BW = \omega_0/Q = 8800\pi = 27{,}64\,k\,rad/s$

$\hookrightarrow 4{,}4\,kHz$

$\alpha_{MIN_1} = 16\,dB \qquad \alpha_{MIN_2} = 24\,dB$

$\alpha_{MAX} = 0{,}5\,dB$

$f_{s_1} = 17\,kHz \rightarrow \omega_{s_1} = 34\pi\,k\,rad/s$

$f_{s_2} = 36\,kHz \rightarrow \omega_{s_2} = 72\pi\,k\,rad/s$

$f_{ci} = 19{,}91\,kHz \Rightarrow \omega_{ci} = 39{,}82\pi\,k\,rad/s$

$f_{cs} = 24{,}31\,kHz \Rightarrow \omega_{cs} = 48{,}62\pi\,k\,rad/s$

1 Normalizo según ω_0 (f_0)

$\omega_{s_1N} = 0{,}773 \qquad \omega_{ciN} = 0{,}905 \qquad \omega_{0N} = 1$

$\omega_{s_2N} = 1{,}64 \qquad \omega_{csN} = 1{,}105$

2 Análisis de Ω_{s_1} ∧ Ω_{s_2}

→ Aplico $k(\omega) = Q \cdot \frac{(\omega^2 - 1)}{\omega}$ con $\omega_0 = 1$

$$\Omega_{s_1} = 5 \cdot \frac{(0{,}773^2 - 1)}{0{,}773} = -2{,}6$$

} Es la menor en módulo → más exigente

$$\Omega_{s_2} = 5 \cdot \frac{(1{,}64^2 - 1)}{1{,}64} = 5{,}15$$

3 Diseño Chebyshev

$$\varepsilon^2 = 10^{\alpha_{MAX}/10} - 1 \rightarrow \varepsilon^2 = 10^{0{,}5/10} - 1 = \boxed{0{,}122 = \varepsilon^2}$$

$$\alpha_{MIN} = 10 \cdot \log\left\{1 + \varepsilon^2 \cdot \cosh^2\left[m \cdot \underbrace{\cosh^{-1}(\Omega_s)}_{=1{,}61}\right]\right\}$$

con $\boxed{\alpha_{MIN} = 24\,dB}$ ↳ ⊕ exigente

$m = 2 \rightarrow \alpha_{MIN} = 13{,}04\,dB$

$m = 3 \rightarrow \alpha_{MIN} = 26{,}9\,dB > 24\,dB \rightarrow \boxed{m = 3}$

Aproximación de Cheby: $C_n(w) = 2w \cdot C_{n-1}(w) - C_{n-2}(w)$

$C_3(\Omega) = 2\Omega \cdot C_2(\Omega) - C_1(\Omega)$ $\quad C_1(\Omega) = \Omega$

$C_2(\Omega) = 2\Omega^2 - 1$

$C_3(\Omega) = 2\Omega \cdot (2\Omega^2 - 1) - \Omega$

$C_3(\Omega) = 4\Omega^3 - 2\Omega - \Omega = \boxed{4\Omega^3 - 3\Omega = C_3(\Omega)}$

Entonces:

$$|T_{LP}(\Omega)|^2 = \frac{1}{1 + \epsilon^2 \cdot C_3(\Omega)^2} = \frac{1}{1 + \epsilon^2 \cdot (16\Omega^6 - 24\Omega^4 + 9\Omega^2)}$$

$$|T_{LP}(\Omega)|^2 = \frac{1}{1 + \epsilon^2 16\Omega^6 - \epsilon^2 24\Omega^4 + \epsilon^2 9\Omega^2}$$ → reemplazo $\Omega = \frac{S}{j}$

$$|T_{LP}(S)|^2 = \frac{1}{1 - \epsilon^2 16 S^6 - \epsilon^2 24 S^4 - \epsilon^2 9 S^2} = \frac{1}{-S^6 - \frac{3}{2}S^4 - \frac{9}{16}S^2 + \frac{1}{16\epsilon^2}} \cdot \left(\frac{1}{16\epsilon^2}\right)$$

Partes de función:

$$|T_{LP}(S)|^2 = T_{LP}(S) \cdot T_{LP}(-S) = \frac{1/4\epsilon}{(S^3 + aS^2 + bS + c)} \cdot \frac{1/4\epsilon}{(-S^3 + aS^2 - bS + c)}$$

$-\frac{3}{2}S^4 = (-b + a^2 - b)\cancel{S^4} \rightarrow \boxed{-3/2 = a^2 - 2b}$ ① $\rightarrow \sqrt{2b - 3/2} = a$ $\quad \boxed{b = \frac{a^2}{2} + \frac{3}{4}}$

$-\frac{9}{16}S^2 = (a \cdot c - b^2 + ac)S^2 \rightarrow \boxed{-\frac{9}{16} = 2a \cdot c - b^2}$ ②

$\frac{1}{16\epsilon^2} = c^2 \rightarrow \boxed{c = \frac{1}{4\epsilon}}$ ③ $\rightarrow c = 0{,}716$

①, ③ → ②

$-\frac{9}{16} = 2 \cdot a \cdot 0{,}716 - \left(\frac{a^2}{2} + \frac{3}{4}\right)^2$

$-\cancel{\frac{9}{16}} = 1{,}432\,a - \frac{1}{4}a^4 - \frac{3}{4}a^2 - \cancel{\frac{9}{16}}$ $\quad \boxed{a_1 = 1{,}2529}$, $\left.\begin{matrix} a_2 \\ a_3 \end{matrix}\right\} \in \mathbb{I}m$

Entonces: $b = \frac{(1{,}2529)^2}{2} + \frac{3}{4} \rightarrow \boxed{b = 1{,}535}$

Entonces, $T_{LP}(\$) = \dfrac{0{,}716}{\$^3 + \$^2\, 1{,}2529 + \$\, 1{,}535 + 0{,}716}$

Factorizando, el polo real está en $\sigma = -0{,}626$.

Reescribo $T_{LP}(\$)$:

$$T_{LP}(\$) = \frac{0{,}626}{\$ + 0{,}626} \cdot \frac{\omega_{o_2}^2}{\$^2 + \$\,\frac{\omega_{o_2}}{Q_0} + \omega_{o_2}^2}$$

$\omega_{o_2}^2 \cdot 0{,}626 = 0{,}716$

$\hookrightarrow \omega_{o_2}^2 = 1{,}144 \ \wedge \ \omega_{o_2} = 1{,}069$

$\$ \cdot \left(\omega_{o_2}^2 + \dfrac{0{,}626 \cdot \omega_{o_2}}{Q_0} \right) = 1{,}535$

$\dfrac{0{,}626 \cdot 1{,}069}{1{,}535 - 1{,}144} = Q_0 \rightarrow \boxed{Q_0 = 1{,}71}$

Entonces,

$$T_{LP}(\$) = \frac{0{,}626}{\$ + 0{,}626} \cdot \frac{1{,}144}{\$^2 + \$\,\frac{1{,}069}{1{,}71} + 1{,}144}$$

$$T_{LP}(\$) = \frac{\omega_{o_1}}{\$ + \omega_{o_1}} \cdot \frac{\omega_{o_2}^2}{\$^2 + \$\,\frac{\omega_{o_2}}{Q_0} + \omega_{o_2}^2}$$

(4) Aplico $K(s) = Q\,\dfrac{(s^2+1)}{s}$ → este Q es el Q del pasobanda

$$T_{BP}(s) = \frac{k_0 \; s\,\frac{\omega_{o_1}}{Q}}{s^2 + s\,\frac{\omega_{o_1}}{Q} + 1} \cdot \frac{k_1 \; s\,\omega_{o_2}/Q'}{s^2 + s\,\frac{\omega_{o_2}}{Q'} + 1} \cdot \frac{k_2 \cdot s\,\omega_{o_3}/Q'}{s^2 + s\,\omega_{o_3}/Q' + 1}$$

Sabiendo que → $\omega_{o_2} \cdot \omega_{o_3} = 1$ → $\boxed{\omega_{o_3} = \dfrac{1}{\omega_{o_2}}}$

↳ Q' es el f. de select. de ambos SOS

NOTA: Esta ω_{o_2} es $\neq$ a la del prototipo Pasabajo

De Python:

$T_{BP}(s) =$

$$T_{BP}(s) = \frac{S\,0{,}1512}{S^2 + S\,0{,}1252 + 1} \cdot \frac{S\,0{,}1411}{S^2 + S\,0{,}0686 + 1{,}227} \cdot \frac{S\,0{,}2683}{S^2 + S\,0{,}05615 + 0{,}8153}$$

- $0{,}1512 = k_0 \cdot 0{,}1252 \rightarrow \boxed{k_0 = 1{,}207}$
- $0{,}1411 = k_1 \cdot \frac{w_{o2}}{Q'}$ $\qquad w_{o2}^2 = 1{,}227 \rightarrow \boxed{w_{o2} = 1{,}1077}$

$$w_{o3} = \frac{1}{w_{o2}} = \boxed{0{,}903 = w_{o3}}$$

$$0{,}0686 = \frac{w_{o2}}{Q'} \rightarrow \boxed{Q' = 16{,}1}$$

Entonces: $0{,}1411 = k_1 \cdot \frac{w_{o2}}{Q'} \rightarrow \boxed{k_1 = 2{,}051}$

$$0{,}2683 = k_2 \cdot \frac{1}{Q'\,w_{o2}} \rightarrow \boxed{k_2 = 4{,}784}$$

Entonces:

$$T_{BP}(s) = \frac{1{,}207 \cdot S\,0{,}626/5}{S^2 + S\,\frac{0{,}626}{5} + 1} \cdot \frac{2{,}051 \cdot S\,\frac{1{,}1077}{16{,}1}}{S^2 + S\,\frac{1{,}1077}{16{,}1} + (1{,}1077)^2} \cdot \frac{4{,}784 \cdot S\,\frac{0{,}903}{16{,}1}}{S^2 + S\,\frac{0{,}903}{16{,}1} + (0{,}903)^2}$$