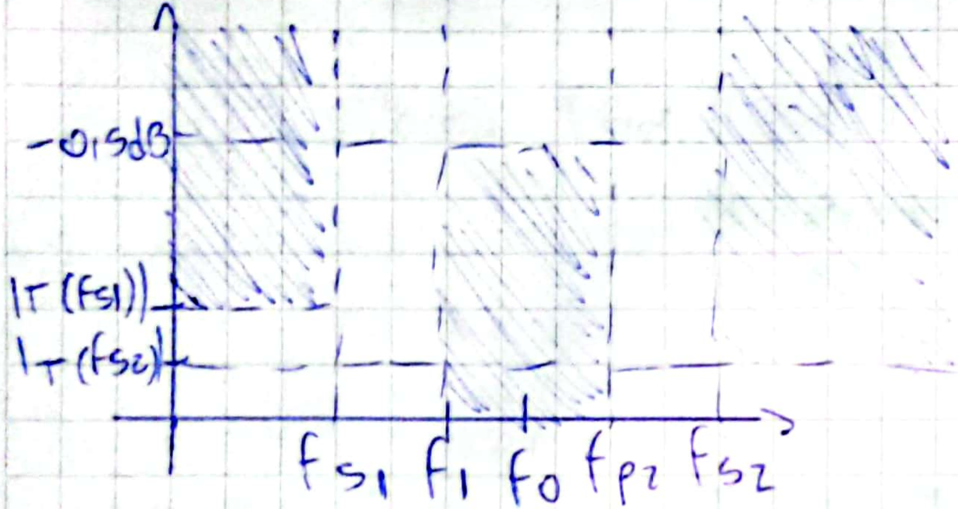
Tarea Semanal 4:



$W_0 = 2\pi \cdot 22KHz$

$Q = 5$

Chebyshev ripple 0,5dB

$|T(f_{S1})| = -16dB$ @ $f_{S1} = 17KHz$

$|T(f_{S2})| = -24dB$ @ $f_{S2} = 36KHz$

- Tomo $\alpha_{min} = 24$ dB, peor caso, condición más exigente:

$W_0 = 22KHz \cdot 2\pi \rightarrow f_0 = 22KHz$

$f_{p1}' = \frac{f_{p1}}{f_0}$; $Q = \frac{W_0}{BW} = 5 \Rightarrow BW = \frac{W_0}{Q} = 2\pi \cdot 4400Hz$

$BW = f_2 - f_1 = 4{,}4KHz$; $f_0^2 = f_1 \cdot f_2 = (f_2 - BW) \cdot f_2 = (22KHz)^2$

$f_1 = f_2 - BW$

$f_2^2 - BW \cdot f_2 - (22KHz)^2 = 0$

$f_2 = 24307{,}72 Hz \Rightarrow f_1 = 19907{,}72 Hz$

Escaneado con CamScanner

$$\left.\begin{array}{ll} f_{p1}' = 0{,}904 & f_{p2}' = 1{,}105 \\ f_{s1}' = 0{,}772 & f_{s2}' = 1{,}636 \end{array}\right\} \text{Frecuencias normalizadas}$$

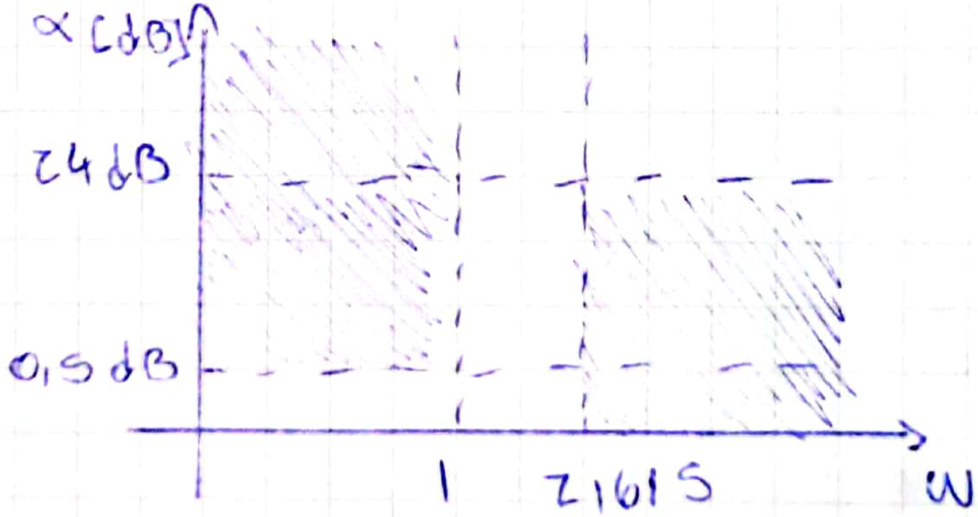
- Tomo Ω_s como la menor de f_{s1}' y f_{s2}':

$$\Omega = \left(\frac{w^2 - w_0^2}{w}\right) Q \Rightarrow \Omega_{s1} = \left(\frac{0{,}772^2 - 1}{0{,}772}\right) Q = -0{,}523 \cdot Q = -2{,}615$$

$$\Omega_{s2} = \left(\frac{1{,}636^2 - 1}{1{,}636}\right) Q = 1{,}024 \cdot Q = 5{,}12$$

Tomo la que impone un requisito más exigente.

$$\Omega_s = 2{,}615$$



- Busco transferencia para Chebyshev:

$$\varepsilon^2 = 10^{\alpha max/10} - 1 = 0{,}122$$

$$1 + \varepsilon^2 \cdot \{\cosh^2[n \cdot \operatorname{arccosh}(w_s)]\} \geq \alpha_{min}^2 \text{ (veces)}$$

$$\alpha_{min} = 24\,dB = 15{,}849 \; ; \; \alpha_{min}^2 = 251{,}18$$

$$n = 2 \rightarrow 20{,}6 < 251{,}18$$

$$n = 3 \rightarrow 495{,}771 > 251{,}18 \checkmark \text{ Orden 3}$$

$$\downarrow$$

$$\alpha_{min} = 26{,}95\,dB$$

- Busco polinomio de Cheby:

$$C_0 = 1 \; ; \; C_1 = w \; ; \; C_n = 2w \cdot C_{n-1} - C_{n-2}$$

$$C_2 = 2w^2 - 1 \; ; \; C_3 = 2w(2w^2 - 1) - w = 4w^3 - 3w$$

$$|T(jw)|^2 = \frac{1}{1 + \varepsilon^2 \cdot (4w^3 - 3w)^2} = \frac{1}{1 + \varepsilon^2 \cdot (16w^6 - 38w^4 + 9w^2)}$$

$$|T(jw)|^2 = \frac{1}{16\varepsilon^2 \cdot w^6 - 24\varepsilon^2 \cdot w^4 + 9\varepsilon^2 w^2 + 1} = T(s) \cdot T(-s)$$

$$|T(j\omega)|^2\Big|_{\omega=\frac{s}{j}} = |T(s)|^2 = \frac{1}{-16\varepsilon^2 s^6 - 24\varepsilon^2 s^4 - 9\varepsilon^2 s^2 + 1} = \frac{1}{as^3+bs^2+cs+d} \cdot \frac{1}{-as^3+bs^2-cs+d}$$

① $-a^2 = -16\varepsilon^2$ ② $-2ac + b^2 = -24\varepsilon^2$ ③ $2bd - c^2 = -9\varepsilon^2$

④ $d^2 = 1 \rightarrow d = 1$

de ① $a^2 = 16\varepsilon^2 \rightarrow a = 4\varepsilon = 1{,}397$, $\varepsilon^2 = 0{,}122$

$$\begin{cases} b^2 = -24\varepsilon^2 + 2ac \; ; \\ c^2 = 2bd + 9\varepsilon^2 \; ; \end{cases} \qquad \begin{cases} ① \; 2ac - b^2 = 24\varepsilon^2 \\ ② \; c^2 - 2bd = 9\varepsilon^2 \end{cases}$$

① $2ac = 24\varepsilon^2 + b^2 \rightarrow c = \dfrac{24\varepsilon^2 + b^2}{2a} = \dfrac{24\varepsilon^2 + b^2}{8\varepsilon}$

en ② $\left(\dfrac{24\varepsilon^2 + b^2}{8\varepsilon}\right)^2 - 2bd = 9\varepsilon^2$

$$\frac{(24\varepsilon^2)^2 + 2\cdot 24\varepsilon^2 b^2 + b^4}{(8\varepsilon)^2} - 2b = 9\varepsilon^2$$

$$\frac{576\varepsilon^4}{64\varepsilon^2} + \frac{48\varepsilon^2}{64\varepsilon^2}\cdot b^2 + \frac{b^4}{64\varepsilon^2} - 2b = 9\varepsilon^2$$

$$9\varepsilon^2 + \frac{3}{4}b^2 + \frac{b^4}{64\varepsilon^2} - 2b = \cancel{9\varepsilon^2}$$

$$\frac{1}{64\varepsilon^2}\,b^4 + \frac{3}{4}\,b^2 - 2b = 0$$

$$\frac{1}{64\varepsilon^2}\,b^3 + \frac{3}{4}\,b - 2 = 0 \longrightarrow b = 1{,}75$$

$$c = 2{,}14$$

$$T_{LP}(s) = \frac{1}{1{,}397\cdot s^3 + 1{,}75\,s^2 + 2{,}14\,s + 1} = \frac{0{,}715}{s^3 + 1{,}252\,s^2 + 1{,}531\,s + 0{,}715}$$

- Obtengo transferencia pasabanda:

$$T_{BP}(s) = T_{LP}\left(Q\cdot\frac{s^2+1}{s}\right) = \frac{0{,}715}{\left(Q\cdot\frac{s^2+1}{s}\right)^3 + 1{,}252\cdot\left(Q\,\frac{s^2+1}{s}\right)^2 + 1{,}531\cdot\left(Q\,\frac{s^2+1}{s}\right) + 0{,}715}$$

$$T_{BP}(s) = \frac{0{,}715}{\frac{Q\,(s^2+1)^3}{s^3} + 1{,}252\cdot\frac{Q\cdot(s^2+1)^2}{s^2} + 1{,}531\cdot\frac{Q\cdot(s^2+1)}{s} + 0{,}715}$$

$$T_{BP}(s) = \frac{0{,}715\cdot s^3}{Q\,(s^2+1)^3 + 1{,}252\cdot Q\,(s^2+1)^2\cdot s + 1{,}531\cdot Q\,(s^2+1)\cdot s^2 + 0{,}715\cdot s^3}$$

Escaneado con CamScanner

$$T_{Bp}(\$) = \frac{1}{Q} \cdot \frac{0{,}715 \cdot \$^3}{\$^6 + 3\$^4 + 3\$^2 + 1 + 1{,}252 \cdot (\$^4 + 2\$^2 + 1) \cdot \$ + 1{,}531 \cdot (\$^2 + 1) \cdot \$^2 + \frac{0{,}715}{Q} \cdot \$^3}$$

$$T_{Bp}(\$) = \frac{1}{Q} \cdot \frac{0{,}715\ \$^3}{\$^6 + 3\$^4 + 3\$^2 + 1 + 1{,}252\,(\$^5 + 2\$^3 + \$) + 1{,}531\,(\$^4 + \$^2) + \frac{0{,}715}{Q}\ \$^3}$$

$$T_{Bp}(\$) = \frac{0{,}715/Q \cdot \$^3}{\$^6 + 1{,}252 \cdot \$^5 + 4{,}531 \cdot \$^4 + \left(2{,}504 + \frac{0{,}715}{Q}\right) \cdot \$^3 + 4{,}531\,\$^2 + 1{,}252\$ + 1}$$