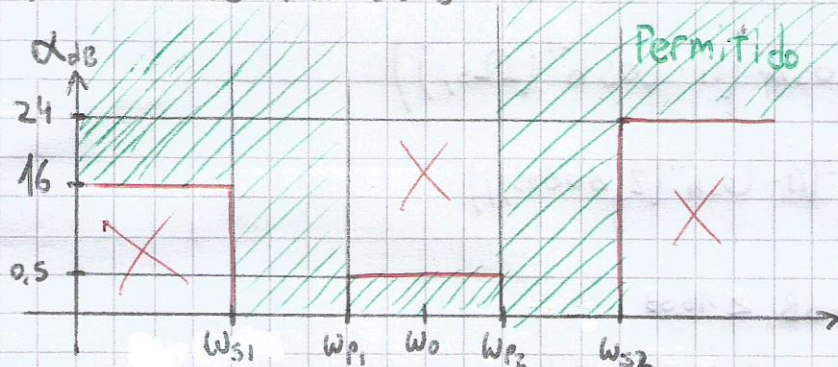


Diseño de Pasabanda:



$$\omega_0 = 2\pi \cdot 22 \text{ KHz}$$

$$Q = 5$$

$$\omega_{s1} = 2\pi \cdot 17 \text{ KHz}$$

$$\omega_{s2} = 2\pi \cdot 36 \text{ KHz}$$

Cálculo ω_{p1} y ω_{p2} Para hacer la Plantilla normalizada

• Normalizando $\omega_0 \rightarrow 1$ ($\Omega_w = \omega_w$)

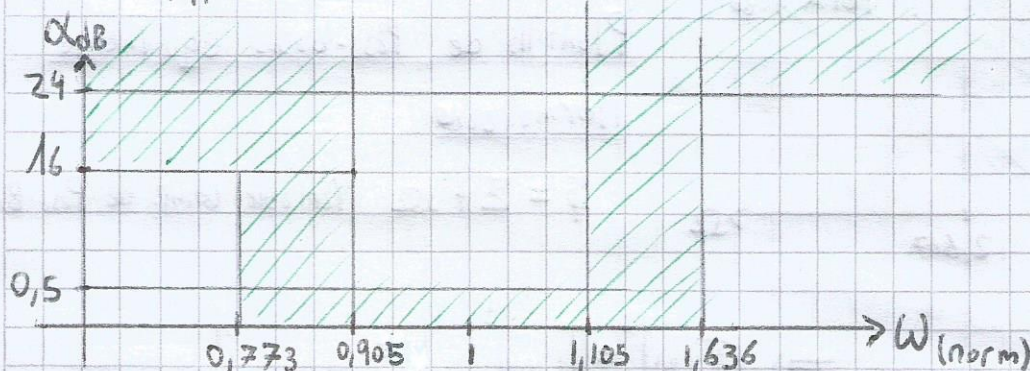
$$\begin{cases} \omega_{p1} \cdot \omega_{p2} = 1 \\ \omega_{p2} - \omega_{p1} = \frac{1}{Q} \end{cases} \Rightarrow \omega_{p2} = \frac{1}{\omega_{p1}} \Rightarrow \frac{1}{\omega_{p1}} - \omega_{p1} = \frac{1}{Q}$$

$$1 - \omega_{p1}^2 = \frac{\omega_{p1}}{Q} \Rightarrow \omega_{p1}^2 + \omega_{p1} \frac{1}{Q} - 1 = 0 \Rightarrow \omega_{p1} = -\frac{1}{2Q} \pm \sqrt{\frac{1}{4Q^2} + 1}$$

$$\omega_{p1} > 0 \Rightarrow \omega_{p1} = -\frac{1}{2Q} + \sqrt{\frac{1}{4Q^2} + 1} = 0,9049876 \quad (\text{Desnorm. } \omega_{p1} = 2\pi \cdot 19909,73 \text{ Hz})$$

$$\omega_{p2} = \frac{1}{\omega_{p1}} = 1,1049876 \quad (\text{Desnorm. } \omega_{p2} = 2\pi \cdot 24309,73 \text{ Hz})$$

Para luego Verif.
En simulación.



Para la Plantilla del Pasabandas equivalente debo elegir la Transición más existente \Rightarrow el α_{\min} con el Ω_s que da el mayor orden.

$$|\Omega_{s1}| = |\Omega_{p2}| = \left| Q \frac{1 - \omega_{p1,2}^2}{\omega_{p1,2}} \right| = 1 \quad (\text{Siempre})$$

$$|\Omega_{s1}| = \left| Q \frac{1 - \omega_{s1}^2}{\omega_{s1}} \right| = 2,60695 \quad |\Omega_{s2}| = \left| Q \frac{1 - \omega_{s2}^2}{\omega_{s2}} \right| = 5,126$$

Evalúo el orden Para cada Transición:

$$\xi^2 = 10^{\frac{\alpha_{\max}}{10}} - 1 = 0,122 \Rightarrow \xi = 0,349$$

• Transición 1: Ω_{s1} y $\alpha_{\min} = 16 \text{ dB}$

$$\alpha_{\min} = 10 \cdot \log(1 + \xi^2 \cdot \cosh^2(n \cdot \cosh^{-1}(\Omega_s)))$$

$$16 \text{ dB} = 10 \cdot \log(1 + \xi^2 \cdot \cosh^2(n \cdot \cosh^{-1}(2,60695)))$$

con $n_1 = 2 \rightarrow \alpha_{\min} = 13,085 \text{ dB} < 16 \text{ dB}$

con $n_1 = 3 \rightarrow \alpha_{\min} = 26,8667 \text{ dB} > 16 \text{ dB}$

• Transición 2: Ω_{s2} y $\alpha_{\min} = 24 \text{ dB}$

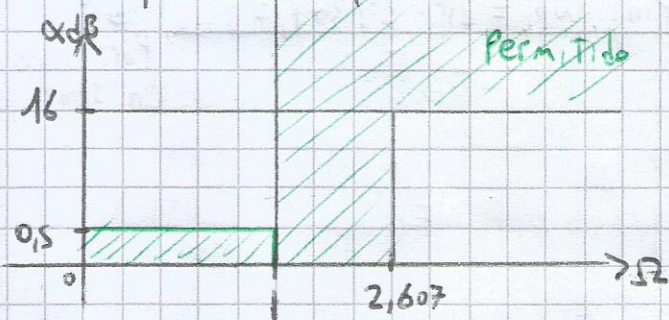
$$24 \text{ dB} = 10 \cdot \log(1 + \xi^2 \cdot \cosh^2(n_2 \cdot \cosh^{-1}(5,126)))$$

con $n_2 = 1 \rightarrow \alpha_{\min} = 6,24 \text{ dB} < 24 \text{ dB}$

con $n_2 = 2 \rightarrow \alpha_{\min} = 25,10 \text{ dB} > 24 \text{ dB}$

La Transición 1 es la más exigente porque requiere el mayor orden

∴ $n = 3$, $\Omega_s = \Omega_{s1}$, $\alpha_{\min} = 16 \text{ dB}$ ← (aunque se sabe que será 26,8667 dB)



Plantilla de Pass-bands equivalente
Normalized

$s = \Sigma + j\Omega$ Variable comp. de Pass-Bands

$$\circ \circ \quad |T(\Omega)|^2 = \frac{1}{1 + \xi^2 C_3^2(\Omega)} \Rightarrow |T(s)|^2 = |T(j\Omega)|^2 \Big|_{\Omega = \frac{s}{j}} = \frac{1}{1 + \xi^2 C_3^2(\frac{s}{j})}$$

• $C_n(\Omega) = 2\Omega C_{n-1}(\Omega) - C_{n-2}(\Omega)$; $C_0(\Omega) = 1$ y $C_1(\Omega) = \Omega$

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

$C_3(\Omega) = 2\Omega \cdot (2\Omega^2 - 1) - \Omega = 4\Omega^3 - 2\Omega - \Omega = 4\Omega^3 - 3\Omega \Rightarrow C_3(\frac{s}{j}) = 4s^3 \cdot j - 3s_j$

$$|T(s)|^2 = \frac{1}{1 + \xi^2 (4s^3 + 3s)^2}$$

$C_3(\frac{s}{j}) = j(4s^3 + 3s)$

$$|T(s)|^2 = \frac{1}{1 - \xi^2 (16s^6 + 2 \cdot 4s^3 \cdot 3s + 9s^2)}$$

$$\text{Polos: } 1 - \xi^2 (16s^6 + 24s^4 + 9s^2) = 0$$

$$16s^6 + 24s^4 + 9s^2 - \frac{1}{\xi^2} = 0$$

$$s^6 + \frac{3}{2}s^4 + \frac{9}{16}s^2 - \frac{1}{16\xi^2} = 0$$

$$s = \begin{cases} \pm 0,626456 & (2 \text{ Polos Reales}) \\ \pm 0,313228 \pm j1,02193 & (4 \text{ Polos Complejos}) \end{cases}$$

$$|T(s)|^2 = T(s) \cdot T(-s) = \frac{T(-s)}{4\xi} \cdot \frac{1}{s+0,626456} \cdot \frac{1}{(s+0,313228+j1,02193)(s+0,313228-j1,02193)}$$

$$|T(s)|^2 = \frac{1}{4\xi} \cdot \frac{1}{s+0,626456} \cdot \frac{1}{\underbrace{s^2 + s \cdot 2 \cdot 0,313 + 0,313^2 + 1,02^2}_{T(s)}} \cdot T(-s)$$

$$T(s) = \frac{1}{4\xi} \cdot \frac{1}{s+0,626456} \cdot \frac{1}{s^2 + s \cdot 0,626456 + 1,142452705} \quad \begin{array}{l} \text{Pase bndes} \\ 3^\circ \text{ orden} \end{array}$$

$$s = K(s) = Q \cdot \frac{s^2+1}{s} \quad (s \text{ Variable Comp. de Pase bndes ; } s = \sigma + j\omega)$$

$$\text{Pase bndes: } T(s) = \frac{1}{4\xi} \cdot \frac{1}{Q \cdot \frac{s^2+1}{s} + 0,626} \cdot \frac{1}{Q^2 \frac{(s^2+1)^2}{s^2} + Q \frac{(s^2+1)}{s} 0,626 + 1,14}$$

$$T(s) = \frac{1}{4\xi} \cdot \frac{s}{Qs^2 + Q + s \cdot 0,626} \cdot \frac{s^2}{Q^2(s^2+1)^2 + sQ(s^2+1)0,626 + s^2 \cdot 1,14}$$

$$T(s) = \frac{1}{4\xi} \cdot \frac{s \cdot \frac{1}{Q}}{s^2 + s \frac{0,626}{Q} + 1} \cdot \frac{s^2}{Q^2 s^4 + 2Q^2 s^2 + Q^2 + Qs^3 0,626 + Q \cdot s \cdot 0,626 + s^2 \cdot 1,14}$$

$$T(s) = \frac{1}{45} \cdot \frac{\frac{1}{0,626}}{s^2 + s \frac{0,626}{Q} + 1} \cdot \frac{s^2 \frac{1}{Q^2}}{s^4 + s^3 \frac{0,626}{Q} + s^2 \left(\frac{1,14}{Q^2} + 2 \right) + s \frac{0,626}{Q} + 1}$$

$$T(s) = \frac{1}{45 \cdot 0,626} \cdot \frac{s \cdot 0,12529}{s^2 + s \cdot 0,12529 + 1} \cdot \frac{s^2 \cdot \frac{1}{25} \cdot \frac{0,069}{0,069} \cdot \frac{0,056}{0,056}}{(s^2 + s \cdot 0,069 + 1,226)(s^2 + s \cdot 0,056 + 0,815)}$$

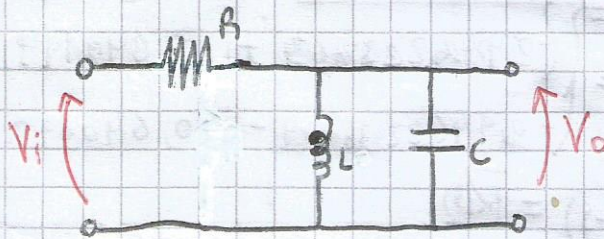
$$T(s) = 11,766 \cdot \underbrace{\frac{s \cdot 0,12529}{s^2 + s \cdot 0,12529 + 1}}_{T_1} \cdot \underbrace{\frac{s \cdot 0,069}{s^2 + s \cdot 0,069 + 1,226}}_{T_2} \cdot \underbrace{\frac{s \cdot 0,056}{s^2 + s \cdot 0,056 + 0,815}}_{T_3}$$

Pasa banda de :
3° orden (pasivos)

Pasa banda
de 6° orden

Diseño de Circuito

• Secciones pasivas:



$$V_o = V_i \cdot \frac{1}{\frac{1}{sL} + sC} \cdot \frac{1}{R + \frac{1}{\frac{1}{sL} + sC}} \Rightarrow \frac{V_o}{V_i} = \frac{\frac{1}{sL} + sC}{R(\frac{1}{sL} + sC) + 1} = \frac{1}{sRC + \frac{R}{sL} + 1} = \frac{s}{s^2 RC + s + \frac{R}{L}}$$

$$\frac{V_o}{V_i} = \frac{s \frac{1}{RC}}{s^2 + s \frac{1}{RC} + \frac{1}{LC}}$$

• Para T_1 :

$$\frac{1}{L_1 C_1} = 1$$

$$\frac{1}{R_1 C_1} = 0,1252912$$

Suponiendo $R_1 = 10 \text{ K}\Omega$

$$C_1 = \frac{1}{10 \text{ K}\Omega \cdot 0,1252912} = 798,14 \cdot 10^{-6} \text{ F}$$

$$L_1 = \frac{1}{C_1} = 1252,912 \text{ H}$$

$$L_1 = \frac{L_1}{\Omega_w} = 9,06396 \text{ mH}$$

$$C_1 = \frac{C_1}{\Omega_w} = 5,7740014 \text{ nF}$$

• Para T_2 :

$$\frac{1}{L_2 C_2} = 1,226462737$$

$$\text{Sup. } R_2 = 10 \text{ K}\Omega \rightarrow C_2 = \frac{1}{R_2 \cdot 0,069} = 1,4489 \text{ mF}$$

$$L_2 = \frac{1}{1,226 \cdot C_2} = 562,7354 \text{ H}$$

$$L_2 = 4,0710055 \text{ mH} \quad C_2 = 10,4818721 \text{ nF}$$

• P2D T3:

$$\frac{1}{L_3 C_3} = 0,815355696$$

$$\frac{1}{R_3 C_3} = 0,0562738$$

$$\text{Sup. } R_3 = 10 \text{ K}\Omega \Rightarrow C_3 = \frac{1}{R_3 \cdot 0,056} = 1,777025 \text{ mF}$$

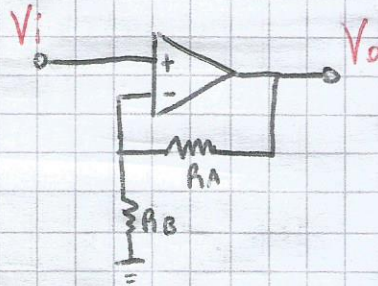
$$L_3 = \frac{1}{0,815 \cdot C_3} = 690,174856 \text{ mH}$$

$$L_3 = 4,992942723 \text{ mH} ; C_3 = 12,85556617 \text{ nF}$$

• Etapas de Ganancia

Ganancia Positiva de $K = 11,76608089$

• No Inversor



$$V_i = V_o \cdot \frac{R_B}{R_A + R_B}$$

$$\frac{V_o}{V_i} = \frac{R_A}{R_B} + 1 = 11,766$$

$$\frac{R_A}{R_B} = 10,766$$

$$R_A = 107,6608089 \text{ K}\Omega$$

$$R_B = 10 \text{ K}\Omega$$