HOJA Nº

FECHA

Ejercicio #7 Filtro Pasabanda

$f_{ci} = 1600kHz$

$f_{cs} : 2500kHz$

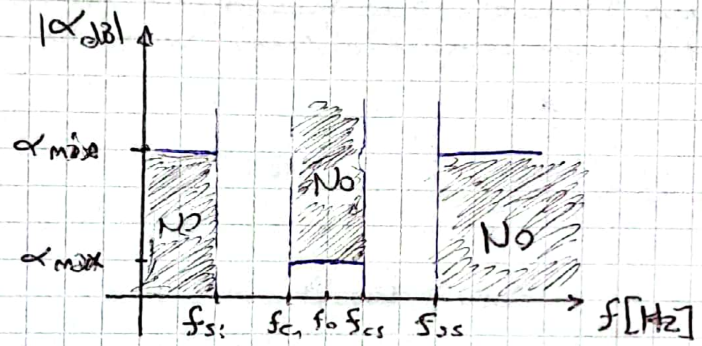
$\alpha_{max} = 3dB$

$K = 10dB$

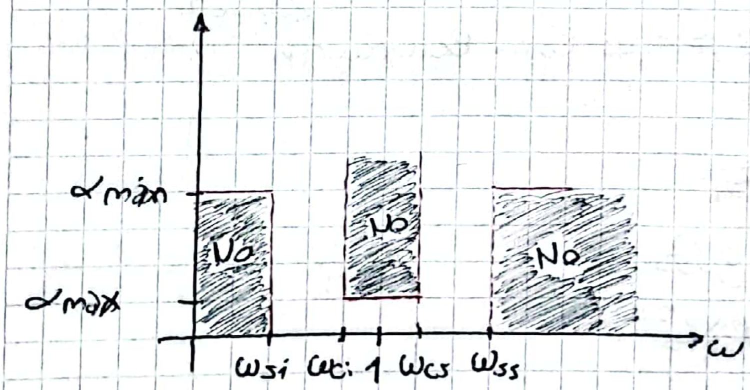
$\alpha_{min} = 20dB$ a $f_{si} = 1250kHz$ y $f_{ss} = 3200kHz$

Diseño la plantilla (Sin la ganancia)

$f_o = \sqrt{f_{c1} \cdot f_{c2}} = 2000kHz$



Normalizo la plantilla para que la misma sea $2\pi f_o$



$\omega_o = 1$

$\omega_{ci} = 0,8 = \frac{4}{5}$

$\omega_{cs} = 1,25 = \frac{5}{4}$

$\omega_{si} = 0,625 = \frac{5}{8}$

$\omega_{ss} = 1,6 = \frac{8}{5}$

$BW = 0,45 = \frac{9}{20}$

$Q = \frac{\omega_o}{BW} = \frac{20}{9} = 2,\hat{2}$

NOTA

Obtengo la plantilla para el pasabajo prototipo.

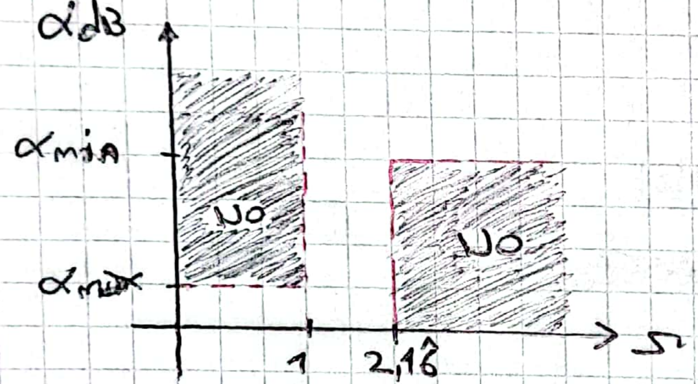
$$\Omega = \left| Q \cdot \frac{\omega^2 - 1}{\omega} \right| = \left| \frac{\omega^2 - 1}{\omega BW} \right|$$

$\Omega_p = 1$

$\Omega_{si} = 2,1\hat{6}$, $\Omega_{ss} = 2,1\hat{6}$

Si esto caso coinciden, uno tendría que quedarme con el menor ya que es lo que impone un requisito más exigente

La plantilla resulta



$\alpha_{min} = 20dB$

$\alpha_{max} = 3 dB$

$K = 10$ → Aplicado ganancia al final

Siendo $\alpha_{max} = 3dB \Rightarrow \varepsilon \simeq 1 \Rightarrow$ Es un Butterworth

Determino el orden del filtro:

$$\alpha_{min_{dB}} = 10 \log(1 + \Omega_s^{2n})$$

Para $n = 3$

$$\alpha_{min} = 20,109 \, dB$$

NOTA

Transferencia Butterworth para orden 3:

$$T_{LP}(\$) = \frac{1}{\$^3 + \$^2 .2 + \$ .2 + 1} = \frac{1}{(\$+1)(\$^2+\$+1)}$$

Aplico el núcleo de transformación:

$$T_{BP}(S) = \frac{1}{Q\left(\frac{S^2+1}{S}\right)+1} \cdot \frac{1}{\left[\frac{Q(S^2+1)}{S}\right]^2 + \frac{Q(S^2+1)}{S} + 1}$$

$$T_{BP}(S) = \frac{1}{Q} \frac{S}{S^2+S\frac{1}{Q}+1} \cdot \frac{S^2}{Q^2(s^2+1)^2 + Q(S^3+S) + S^2}$$

$$T_{BP}(S) = \frac{1}{Q} \frac{S}{S^2+S.\frac{1}{Q}+1} \quad \frac{S^2}{(S^2+1)^2 + \frac{1}{Q}(S^3+S) + \frac{S^2}{Q^2}} \quad \frac{1}{Q^2}$$

$$T_{BP}(S) = \frac{1}{Q} \frac{S}{S^2+S\frac{1}{Q}+1} \cdot \frac{1}{Q^2} \frac{S^2}{(S^4+2S^2+1)+S^3.\frac{1}{Q}+S.\frac{1}{Q}+S^2.\frac{1}{Q^2}}$$

$$T_{BP}(S) = \frac{1}{Q} \frac{S}{S^2+S\frac{1}{Q}+1} \cdot \frac{1}{Q^2} \frac{S^2}{S^4+S^3.\frac{1}{Q}+S^2\left(2+\frac{1}{Q^2}\right)+S\frac{1}{Q}+1}$$

$$T_{BP}(S) = \frac{1}{Q^3} \frac{S^3}{S^6+S^5\frac{1}{Q}+S^4\left(2+\frac{1}{Q^2}\right)+S^3\frac{1}{Q}+S^2+S^5\frac{1}{Q}+S^4\frac{1}{Q^2}+S^3\frac{1}{Q}\left(2+\frac{1}{Q^2}\right)+S^2\frac{1}{Q^2}+\frac{S}{Q} + S^4+S^3\frac{1}{Q}+S^2\left(2+\frac{1}{Q^2}\right)+S\frac{1}{Q}+1}$$

$$T_{BP}(S) = \frac{S^3/Q^3}{S^6+S^5\frac{2}{Q}+S^4\left(2+\frac{2}{Q^2}\right)+S^3\frac{1}{Q}\left(3+\frac{1}{Q^2}\right)+S^2\left(1+\frac{1}{Q^2}\right)+}$$

$$T_{BP}(S) = \frac{S^3/Q^3}{S^6 + S^5 \frac{2}{Q} + S^4\left(2 + \frac{1}{Q^2} + \frac{1}{Q^2} + 1\right) + S^3\left(\frac{1}{Q} + \frac{1}{Q}\left(2 + \frac{1}{Q^2}\right) + \frac{1}{Q}\right) + S^2\left(1 + \frac{1}{Q^2} + 2 + \frac{1}{Q^2}\right) + S\left(\frac{1}{Q} + \frac{1}{Q}\right) + 1}$$

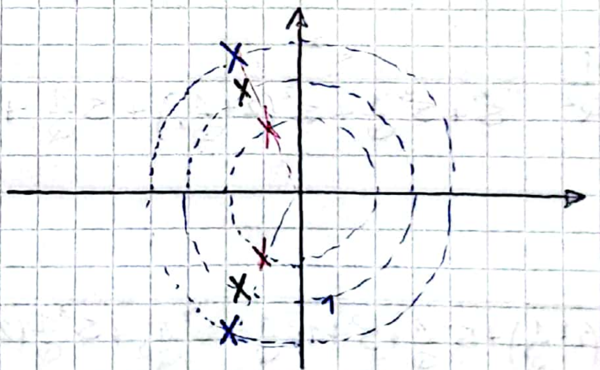
→ Multiplico por K (ganancia solicitada)

$$\boxed{T_{BP}(S) = \frac{K \; S^3/Q^3}{S^6 + S^5 \frac{2}{Q} + S^4\left(3 + \frac{2}{Q^2}\right) + S^3\left(\frac{1}{Q}\left(4 + \frac{1}{Q^2}\right)\right) + S^2\left(3 + \frac{2}{Q^2}\right) + S\frac{2}{Q} + 1}}$$

$$K = 10^{\left(\frac{K_{dB}}{20}\right)} \triangleq 3{,}162$$

2 Para obtener los polos, factorizo con la ayuda de python

$$T_{BP}(S) = \frac{K}{Q^3} \frac{1}{\left(S^2 + S\frac{1}{2{,}22} + 1\right)\left(S^2 + S\frac{0{,}823}{4{,}53} + (0{,}823)^2\right)\cdot\left(S^2 + S\frac{1{,}22}{4{,}53} + (1{,}22)^2\right)}$$



c