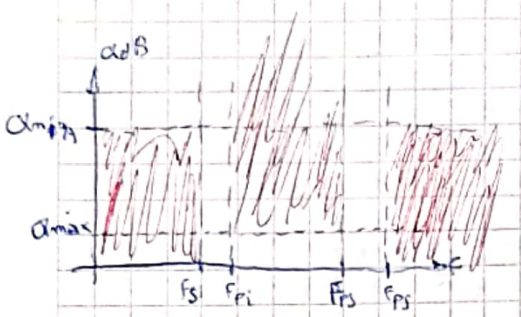
Tarea Semanal 4 bis

Filtro pasabanda 3 dB Máxima planicidad

$F_{pi} = 1{,}6\,kHz$ $F_{ps} = 2{,}5\,kHz$ $K = 10dB$

$F_{si} = 1{,}25\,kHz$ $F_{ss} = 3{,}2\,kHz$

$\alpha_{min} = 20dB$ $\alpha_{max} = 3dB$

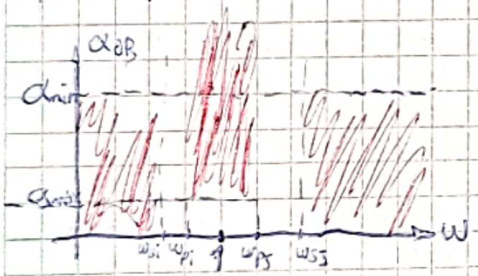


$f_0 = \sqrt{F_{pi} \cdot F_{ps}} = 2\,kHz \rightarrow \Omega_w = 2\pi f_0$; $f_0' = \sqrt{F_{si} \cdot F_{ss}} = 2\,kHz$

$w_{0_{BP}} = 12\,566{,}37\ rad/s$; $\Delta w = 2\pi \cdot (F_{ps} - F_{pi}) = 5654{,}87\ rad/s \Rightarrow Q_{BP} = \frac{w_0}{\Delta w} = 2{,}22$

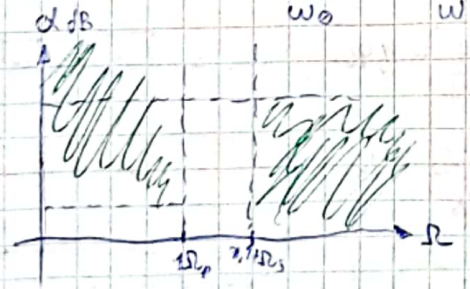
$w_0' \rightarrow 1$

$w_{ps}' \rightarrow 1{,}25$; $w_{pi}' \rightarrow 0{,}8$; $w_{si}' \rightarrow 0{,}625$; $w_{ss}' \rightarrow 1{,}6$



Mi núcleo de transformación será:

$$\frac{Q}{w_0} \cdot \frac{(w_0^2 - w^2)}{w} \Rightarrow \Omega_0 = 0 \; ; \; \Omega_{pi} = 1 \; ; \; \Omega_{si} = 2{,}17$$



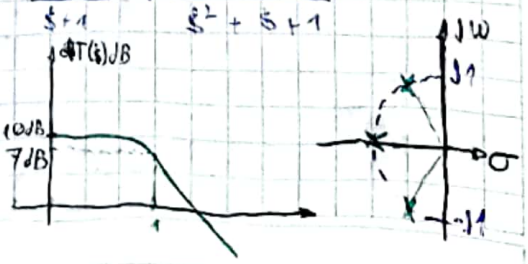
$\alpha_{max} = 3dB \rightarrow \varepsilon = 10^{\alpha_{max}/10} - 1 = 1 \rightarrow$ butterworth

$10dB = 20\log(k) \Rightarrow k = 3{,}16$

$\alpha_{min} = 10\log(1 + \varepsilon^2 \Omega_s^{2n}) \rightarrow n = 3$

$$T_{LP}(s) = K \frac{1}{s+1} \cdot \frac{1}{s^2 + s2\cos\pi/3 + 1} = K \frac{1}{s+1} \cdot \frac{1}{s^2 + s + 1}$$

$$T_{LP}(s) = \frac{3{,}16}{s^3 + 2s^2 + 2s + 1}$$



$\omega_0/\Delta\omega = 2{,}22$

$$T_{BP}(s) = T_{LP}(\$)\Big|_{\$ = \frac{Q}{\omega_0}\cdot\frac{s^2+\omega_0^2}{s}}$$

$$T_{BP}(s) = \frac{3{,}16}{\left(\frac{Q}{\omega_0}\frac{s^2+\omega_0^2}{s}\right)+1} \cdot \frac{1}{\left(\frac{Q}{\omega_0}\frac{s^2+\omega_0^2}{s}\right)^2 + \frac{Q}{\omega_0}\frac{s^2+\omega_0^2}{s}+1}$$

$$= \frac{3{,}16\cdot s}{\frac{Q}{\omega_0}s^2+s+\omega_0^2}\cdot\frac{Q}{\omega_0}\cdot \frac{1}{\frac{Q^2}{\omega_0^2}\frac{s^4+2s^2\omega_0^2+\omega_0^4}{s^2}+\frac{Q}{\omega_0}\frac{s^2+\omega_0^2}{s}+1}$$

$$= 3{,}16\cdot \frac{s\,\omega_0/Q}{s^2+s\frac{\omega_0}{Q}+\omega_0^2}\cdot \frac{1}{(*)}$$

$$(*) = (s^2+\omega_0^2)^2 + s\frac{\omega_0}{Q}\cdot(s^2+\omega_0^2)+s^2\frac{\omega_0^2}{Q^2}$$

$$(*) = s^4+2s^2\omega_0^2+\omega_0^4+s^3\frac{\omega_0}{Q}+\frac{s\omega_0^3}{Q}+s^2\frac{\omega_0^2}{Q^2}$$

$$= s^4+s^3\frac{\omega_0}{Q}+s^2\left(2\omega_0^2+\frac{\omega_0^2}{Q^2}\right)+s\frac{\omega_0^3}{Q}+\omega_0^4 = \cancel{(s^2+as+a)(s^2+bs+a)}$$

$$s^4+s^3\frac{1}{2{,}22}+s^2\left(2+\left(\frac{1}{2{,}22}\right)^2\right)+s\frac{1^3}{2{,}22}+1=0$$

$s_{1,2} = -0{,}09 \pm j\,0{,}818$

$s_{3,4} = -0{,}134 \pm j\,1{,}207$

$s_{5,6} = -0{,}225 \pm j\,0{,}97$

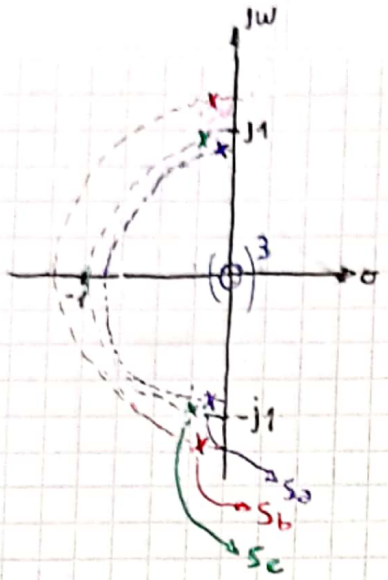
$s_{1,2} = s_a \Rightarrow Q_a = \frac{1}{2\cos\varphi_a} = 4{,}56 \quad \varphi_a = tj^{-1}\frac{0{,}818}{0{,}09} = 1{,}461 \quad ; \quad \omega_{0a} = \sqrt{0{,}09^2+0{,}818^2} = 0{,}823$

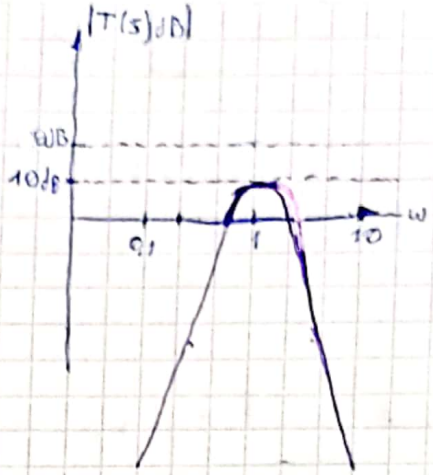
$s_{3,4} = s_b \Rightarrow Q_b = \frac{1}{2\cos\varphi_b} = 4{,}52 \quad ; \quad \varphi_b = tj^{-1}\frac{1{,}207}{0{,}134} = 1{,}46 \quad ; \quad \omega_{0b} = \sqrt{0{,}134^2+1{,}207^2} = 1{,}214$

$s_{5,6} = s_c \Rightarrow Q_c = \frac{1}{2\cos\varphi_c} = 2{,}185 \quad ; \quad \varphi_c = tj^{-1}\frac{0{,}97}{0{,}225} = 1{,}34 \quad ; \quad \omega_{0c} = \sqrt{0{,}225^2+0{,}97^2} = 0{,}945$

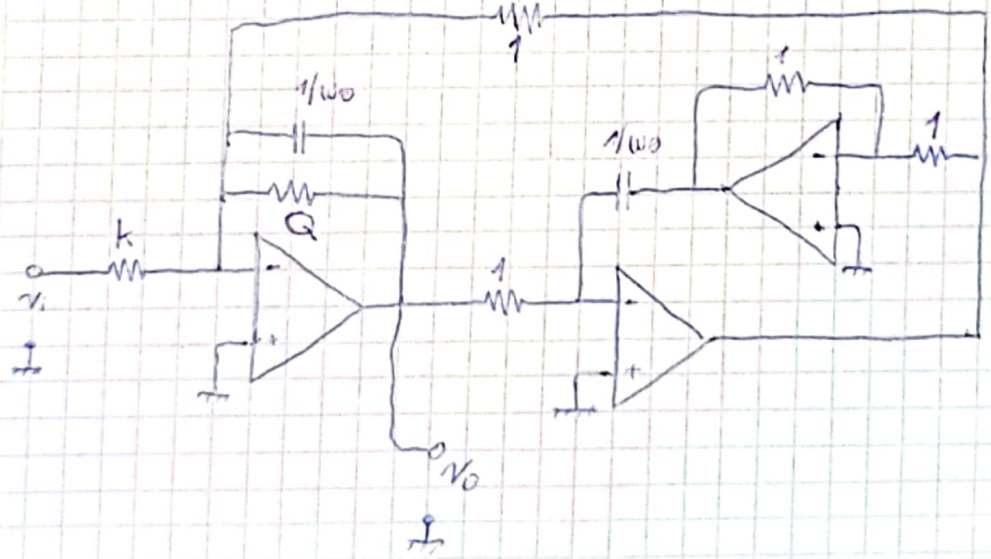
$$T(s) = 3{,}16\cdot\frac{s\frac{\omega_{0a}}{Q_a}}{s^2+s\frac{\omega_{0a}}{Q_a}+\omega_{0a}^2}\cdot\frac{s\frac{\omega_{0b}}{Q_b}}{s^2+s\frac{\omega_{0b}}{Q_b}+\omega_{0b}^2}\cdot\frac{s\frac{\omega_{0c}}{Q_c}}{s^2+s\frac{\omega_{0c}}{Q_c}+\omega_{0c}}$$

$$\left[T(s) = 3{,}16\cdot\frac{s\cdot 0{,}18}{s^2+s\cdot 0{,}18+0{,}677}\cdot\frac{s\,0{,}27}{s^2+s\,0{,}27+1{,}47}\cdot\frac{s\,0{,}455}{s^2+s\cdot 0{,}455+0{,}991}\right]$$





Implementación con estructuras Ackerberg-Mosberg



Normalizando $R_2 = R_3$ resultaba

La transferencia de este circuito resulta ser:

$$T_{AM}(s) = K \cdot \frac{s\frac{\omega_0}{Q}}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2}$$

por lo que se utilizaron 3 de estas en cascada para representar la transferencia del filtro obtenido. Se realiza en simulación

cada par de polos de