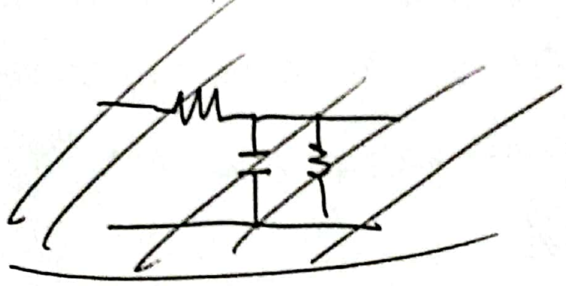
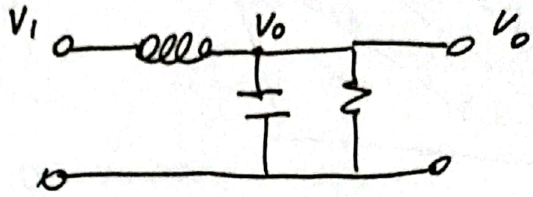
1 DE





Butterworth orden ②

$$\frac{\omega_o^2}{s^2+\frac{\omega_o}{Q}s+\omega_o^2} = \text{Butter orden ②}$$

$$\frac{1}{s^2+s\sqrt{2}+1}$$

$$Q=\frac{1}{\sqrt{2}}$$

nodos: $V_o\left(\frac{1}{sL}+\frac{sC}{1}+\frac{1}{R}\right)-V_1\frac{1}{sL}=0$

SLR

$$\frac{V_o}{V_1}=\frac{1/sL}{\frac{R+s^2CLR+sL}{sLR}} \quad sLR \quad =\frac{R/C}{s^2\frac{C}{C}+s\frac{L}{C}+\frac{R}{C}}=\frac{\frac{R}{C}}{s^2+s\frac{L}{C}+\frac{R}{C}}$$

$$\omega_o^2=\frac{R}{C}=1$$

$$\frac{\omega_o}{Q}=\frac{1}{Q}=\frac{L}{C} \Rightarrow Q=\frac{1}{L} \qquad L=\frac{1}{Q}=\sqrt{2} \qquad \frac{L}{1}=\frac{1}{Q}=\sqrt{2}$$

$\Omega_z=1k$ $\quad \Omega_w=2\pi 1k$

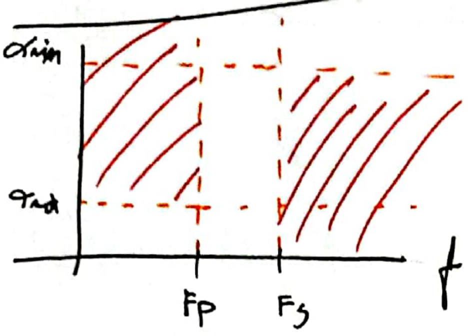
$$R=R^*\Omega_z=1\cdot 1000=1k$$

$$C=\frac{C^*}{\Omega_z\Omega_w}=\frac{1}{1k\cdot\Omega_w}=159\,mF$$

$$L^*=\sqrt{2} \Rightarrow L=\frac{L^*\Omega_z}{\Omega_w}=\frac{\sqrt{2}\cdot 1k}{2\pi 1k}=225\,mHy$$

②

$\cancel{H(L) = L^*}$



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

$\alpha_{min} = 20\ dB$

$f_p = 1k \rightarrow \omega_p = 2.\pi / k \quad \Omega_\omega = \omega_p$

$F_s = 2k \qquad \omega_p^* = 1$

$\omega_s^* = 2$

Maxima planicidad pero no Butter

Primero lo primero, encontramos ξ i m

$$|T(j\omega)|^2 = \frac{1}{1 + \xi^2 \omega^{2m}}$$

$$\boxed{\alpha_{dB} = 10 \log(1 + \xi^2 \omega^{2m})}$$

$$|T(\omega)|^2 = \cancel{\frac{1}{|T(0)|^2}} \qquad |T(\omega_p)|^2 = \frac{1}{1 + \xi^2}$$

$\omega = 1$

$$\alpha = \frac{1}{|T(1)|} \Rightarrow \alpha = 0,5 = 20 \log((1 + \xi^2)^{1/2}) = 10 \log(1 + \xi^2)$$

$$\xi^2 = 10^{0,5/10} - 1$$

$$\xi^2 = 0,122 \qquad \xi = 0,349$$

m	$\alpha(2)$ dB
2	4,70
3	9,44
4	~~14,94~~ 15,08
$\boxed{5}$	$\boxed{21,00}$ → esto cumple con la plantilla.

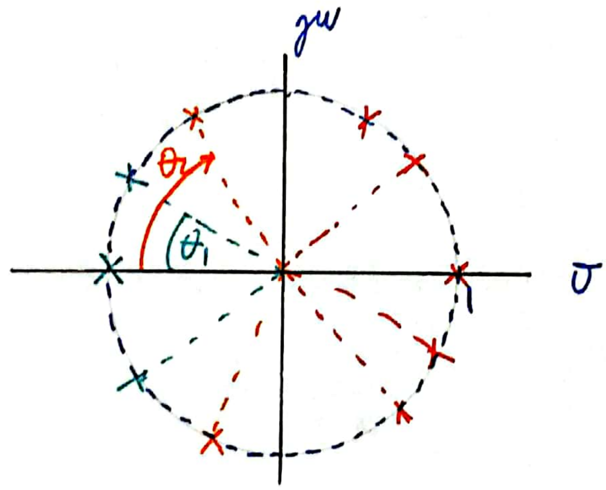
Ahora no me interesa, o varios por parte de fuchi 2de θ por Ω_B con queremos ser felices y llegar a algo varios por Ω_B

$$\Omega_B = \Omega_W \cdot \xi^{-1/n} = 2\pi \, 1k \cdot 0{,}349^{-1/5} = 2\pi \, 1k \cdot 1{,}23 = 7{,}75 \, k \frac{rad}{seg}$$

normalizado por Ω_B

$$|T(j\omega)|^2 = \frac{1}{1 + \omega^{2n}}$$

$$T(s) = \frac{1}{s+1} \cdot \frac{1}{s^2 + 2\cos(\theta_1)s + 1} \cdot \frac{1}{s^2 + 2\cos(\theta_2)s + 1}$$



$\frac{\pi}{5} = 36°$ $\theta_1 = \frac{\pi}{5}$ $\theta_2 = \frac{2}{5}\pi$

$$T(s) = \frac{1}{s+1} \cdot \frac{1}{s^2 + 1{,}61s + 1} \cdot \frac{1}{s^2 + 0{,}618s + 1}$$

$\frac{1}{Q_1} = 2\cos(\theta_1) \Rightarrow Q_1 = 0{,}618$

$\frac{1}{Q_2} = 2\cos(\theta_2) \Rightarrow Q_2 = 1{,}618$

3 DQ

$m_2 = \dfrac{1}{\frac{1}{Q} - 1} = -2{,}61$ y ahora (2)

$R, m \quad C = 1$

$\dfrac{1}{R\sqrt{m}} = 1 \Rightarrow \sqrt{m} = \dfrac{1}{R} \Rightarrow m = \sqrt{\dfrac{1}{R}}$

$Q = \dfrac{\sqrt{m}}{1 + 2m - km} = \dfrac{\sqrt{m}}{1 + 2m - m} = \dfrac{\sqrt{m}}{1+m}$

$0{,}618 = \dfrac{\sqrt{m}}{1+m}$

$Q^2 (1+m)^2 = \sqrt{m}^2$

$Q_2 (1 + 2m + m^2) = m$

no joda

vamo por $\dfrac{1}{RC} = \omega_0 = 1 \Rightarrow R = 1 \Rightarrow C = 1$

$Q = \dfrac{1}{3-k}$

Q $\dfrac{1}{Q} = 3 - k \Rightarrow \left(\dfrac{1}{Q} - 3\right)(-1) = K$

$R_{4a} = 0{,}38$

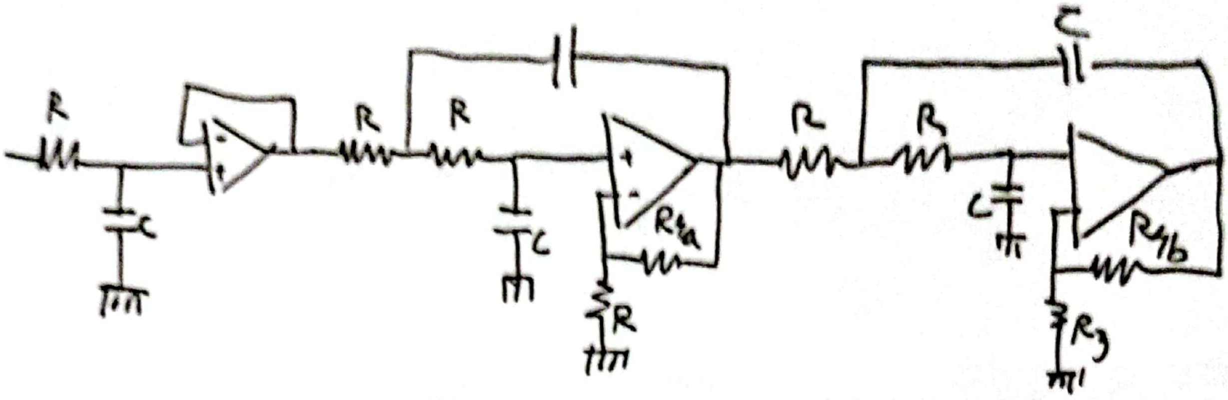
$Q_1 = 0{,}618 \quad K_1 = 1{,}38 = 1 + \dfrac{R_4}{R_3} \Rightarrow \dfrac{R_4}{R_3} = 0{,}38$

$R_3 = 1 \Rightarrow R_4 = 0{,}38$

$Q_2 = 1{,}618 \quad K_2 = 2{,}382 = 1 + \dfrac{R_4}{R_3} \Rightarrow R_4 = R_3 \cdot 1{,}382$

$R_{4_b} = 1{,}382$

O.K.



$R_{4a} = 0{,}38$

$R_{4b} = 1{,}382$

Ver ceros en ápice.

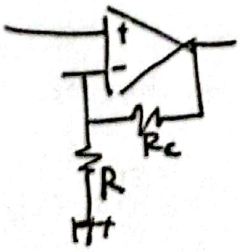
Pero ojo al piojo $\quad k_1 k_2 = 1{,}38 \cdot 2{,}38 = 3{,}28$

$k_1 k_2 \big|_{db} = 10{,}3\ db \quad$ nos faltan 10 db

20 db = 10 veces

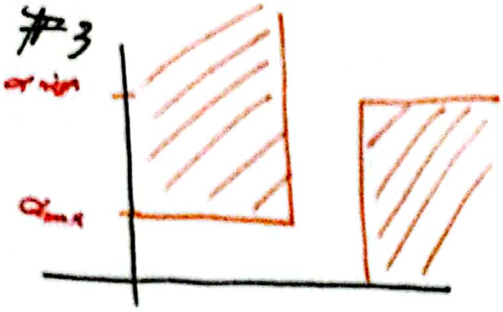
$k_T = 10 = k_1 k_2 k_3 \Rightarrow k_3 = 3{,}044$

Incorporamos antes del RC un amplificador.



~~R4~~ $k = 1 + \frac{R_c}{R} \Rightarrow 2{,}044\,R = R_c$

3



4 de

$\alpha_{max} = 0,4\ db$

$\alpha_{min} = 48\ db$

$F_s = 9,6K$

$F_p = 3,2K$ $\quad \omega_p = 2\pi\ 3,2K$

$\Omega_\omega = \omega_p$

$\omega_s = 3$

$$|T(j\omega)|^2 = \frac{1}{1 + \xi^2 C_n^2}$$

$$\alpha_{db} = 20 \log\left(\left(1 + \xi^2 C_n^2\right)^{1/2}\right) = 10 \log(1 + \xi^2 C_n^2(\omega))$$

$$C_n^2 = \cosh^2(n \cosh^{-1}(\omega))$$

$$\boxed{* \ \cosh^{-1}(\omega) = \ln(\omega + \sqrt{\omega^2 - 1}) \ \wedge \ \cosh(\omega) = \frac{e^{\omega} + e^{-\omega}}{2} \ *}$$

~~$\cosh^{-1}(1) = 0$~~ $\quad C_n(\omega = 1) = 1$

n	C_n^2	α
1	9	2,7 db
2	285,84	14,53 db
3	9 640	29,66 db
4		44,95
5		60,23 db

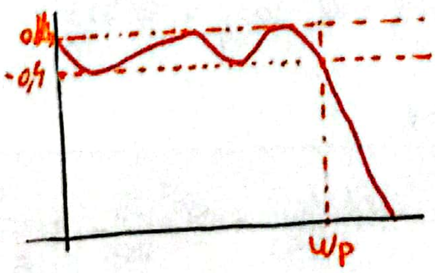
$$10^{\frac{0,4}{10}} = 1 + \xi^2$$

$$\xi^2 = 10^{0,4/10} - 1 = 0,096$$

$$\xi = 0,309$$

$$C_n^2\Big|_{n=1} = \cosh^2(1 \cosh^{-1}(3))$$

Para cumplir con la plantilla debe ser de orden 5



$$|T(jw)|^2 = \frac{1}{1+\xi^2 C_m^2(w)} \qquad C_m(w) = 2w\, C_{m-1}(w) - C_{m-2}(w)$$

¿ C_m ?

$C_0 = 1 \qquad C_1 = w$

$C_2 = 2w\,C_1 - C_0 = 2w^2 - 1$

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

$C_4 = 2w(4w^3 - 3w) - (2w^2-1) = 8w^4 - 6w^2 - 2w^2 + 1 = 8w^4 - 8w^2 + 1$

$C_5 = 2w(8w^4 - 8w^2 + 1) - (4w^3 - 3w)$

$C_5 = 16w^5 - 16w^3 + 2w - 4w^3 + 3w$

$C_5 = 16w^5 - 20w^3 + 5w$

$$|T(jw)|^2 = \frac{1}{1+\xi^2(16w^5 - 20w^3 + 5w)^2} = \frac{1}{1+\xi^2(16w^5 - 20w^3 + 5w)(16w^5 - 20w^3 + 5w)}$$

$(16w^5 - 20w^3 + 5w)^2 = 256w^{10} - 320w\,w^8 + 80w^6 - 320w^8 + 400w^6$

$-100w^4 + 80w^6 - 100w^4 + 25w^2$

$(16w^5 - 20w^3 + 5w)^2 = 256w^{10} - 640w^8 + 560w^6 - 200w^4 + 25w^2$

$$|T(jw)|^2 = \frac{1}{\xi^2 256w^{10} - w^8\xi^2 640 + w^6 560\xi^2 - w^4 200\xi^2 + w^2 25\xi^2 + 1}$$

$$|T(jw)|^2 = \frac{1/\xi^2 256}{w^{10} - w^8\frac{640}{256} + w^6\frac{560}{256} - w^4\frac{200}{256} + w^2\frac{25}{256} + \frac{1}{\xi^2 256}}$$

$$|T(j\omega)|^2 = \frac{a}{\omega^{10} - \omega^8 e + \omega^6 d - \omega^4 c + \omega^2 b + a}$$

$$a = \frac{1}{\xi^2 256}$$

$$b = \frac{25}{256} \qquad c = \frac{200}{256} = \frac{25}{32} \qquad d = \frac{35}{16} \qquad e = \frac{640}{256} = \frac{5}{2}$$

$$|T(j\omega)|^2\Big|_{\omega = \frac{s}{j}} = |T(s)|^2 = \frac{a}{-s^{10} - s^8 e - s^6 d - s^4 c - s^2 b + a}$$

$$\cancel{|T(s)|^2 = \frac{\alpha}{s^5 + s^4\theta + s^3\gamma + s^2\beta + \alpha} \cdot \frac{\alpha}{-s^5 + s^4\theta - s^3\gamma + s^2\beta + \alpha}}$$

$$|T(s)|^2 = \frac{\alpha}{s^5 + \theta s^4 + \gamma s^3 + \Delta s^2 + \beta s + \alpha} \cdot \frac{\alpha}{-s^5 + \theta s^4 - \gamma s^3 + \Delta s^2 - \beta s + \alpha}$$

(Ver apartado de calculo) (HOJA 6 DE)

$$-e = \theta^2 - 2\gamma$$

$$-d = 2(\Delta\theta - \beta) - \gamma^2$$

$$-c = 2(\alpha\theta - \beta\gamma) + \Delta^2$$

$$-b = 2\alpha\Delta - \beta^2$$

$$a = \alpha^2 \Rightarrow \alpha = \sqrt{\frac{1}{\xi^2 256}} = \boxed{\frac{1}{\xi 16}}$$

$$\cancel{(-\phi^5-\theta\phi^4-\gamma\phi^3-\beta\phi^2+\alpha)(\phi^5-\phi^4\theta+\gamma\phi^3-\beta\phi^2+\alpha)}$$

$$(\phi^5+\theta\phi^4+\gamma\phi^3+\Delta\phi^2+\beta\phi+\alpha)(-\phi^5+\theta\phi^4-\gamma\phi^3+\Delta\phi^2-\beta\phi+\alpha)$$

$$-\phi^{10} = -\phi^{10}$$

$$0\phi^9 = \phi^9(\theta-\theta) = 0$$

$$-e\phi^8 = \phi^8(-\gamma+\theta^2-\gamma) \Rightarrow -e = \theta^2 - 2\gamma$$

$$0\phi^7 = \phi^7(\Delta - \theta\gamma + \gamma\theta - \Delta) = 0$$

$$-d\phi^6 = \phi^6(-\beta + \theta\Delta - \gamma^2 + \theta\Delta - \beta) \Rightarrow -d = 2(\Delta\theta - \beta) - \gamma^2$$

$$0\phi^5 = \phi^5(\alpha - \beta\theta + \Delta\gamma - \Delta\gamma + \beta\theta - \alpha) = 0$$

$$-c\phi^4 = \phi^4(\alpha\theta - \beta\gamma + \Delta^2 - \beta\gamma + \alpha\theta) \Rightarrow -c = 2(\alpha\theta - \beta\gamma) + \Delta^2$$

$$0\phi^3 = \phi^3(\alpha\gamma - \beta\Delta + \beta\Delta - \alpha\gamma) = 0$$

$$-b\phi^2 = \phi^2(\alpha\Delta - \beta^2 + \alpha\Delta) \Rightarrow -b = 2\alpha\Delta - \beta^2$$

$$0\phi = \phi(\beta\alpha - \alpha\beta) = 0$$

$$a = \alpha^2$$

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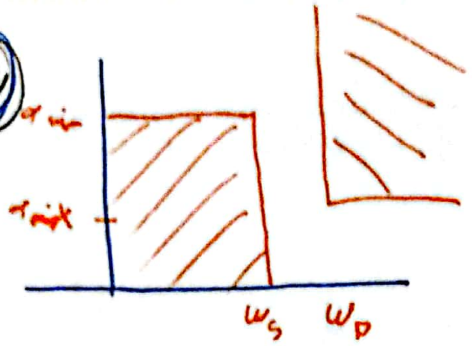
#4



$\omega_p = 2\pi\, 3500$ $\quad\quad \Omega_w = \omega_p$

$\omega_p = 1$ $\quad\quad \Omega_p = 1$

$\omega_s = 0{,}285$ $\quad\quad \Omega_s = \dfrac{1}{\omega_s} = 3{,}5$

$\alpha = 10 \log (1 + \xi^2 w^{2m})$

en $\omega = \omega_p \Rightarrow \alpha = 1\,db \Rightarrow 10^{1/10} - 1 = \xi^2 = 0{,}258$

$\xi = 0{,}508$

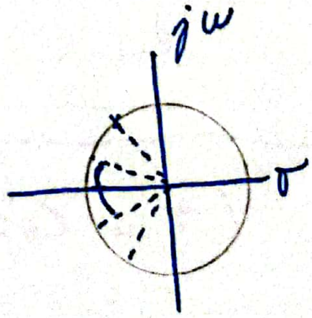
en $\omega = \omega_s$ $\quad \alpha = 35\,db$

m	α
2	15,98 db
3	26,76 db
$\boxed{4}$	$\boxed{37{,}64\ db}$
5	

llevando un máximo planitud de orden 4

$$|T(j\omega)|^2 = \frac{1}{1+\xi^2 \omega^8}\Bigg|_{\omega = \frac{s}{j}} = \frac{1}{1+\xi^2 s^8}$$

aplicando $\Omega_B = \dfrac{1}{\omega_p}\, \xi^{-1/m}$ $\quad\quad |T(s)|^2 = \dfrac{1}{1+s^4}$



$$T(s) = \frac{1}{s^2 + s\frac{1}{Q_1} + 1} \cdot \frac{}{s^2 + s\,2\cos(\theta_2) + 1}$$

$\dfrac{1}{Q} = 2\cos\theta_1$ $\quad\quad \theta_1 = \dfrac{\pi}{8}$

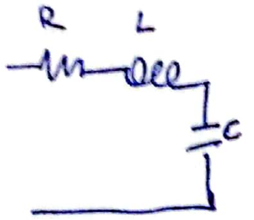
$\theta_2 = \dfrac{3}{8}\pi$

$$T_{1_{LP}}(s) = \frac{1}{s^2 + s\,1{,}84 + 1} \qquad T_{2_{LP}}(s) = \frac{1}{s^2 + s\,0{,}765 + 1}$$

$$T_{1_{HP}} = \frac{1}{\left(\frac{1}{s}\right)^2 + \frac{1}{s}1{,}84 + 1} = \frac{1}{\frac{1}{s^2} + \frac{1{,}84}{s} + 1}\,\frac{s^2}{s^2} = \frac{s^2}{s^2 + s\,1{,}84 + 1}$$

$$T_{1_{LP}}(s)\Big|_{s=\frac{1}{s}} = T_{1_{HP}}$$

$$T_{2_{HP}} = \frac{s^2}{s^2 + s\,0{,}765 + 1}$$



$$\cancel{\frac{1}{sC}}\ \frac{V_1}{\frac{1}{sC} + sL + R} \cdot \frac{1}{sC} = V_0$$

$$\frac{V_0}{V_1} = \frac{1}{s^2LC + sCR + 1} = \frac{\frac{1}{LC}}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$

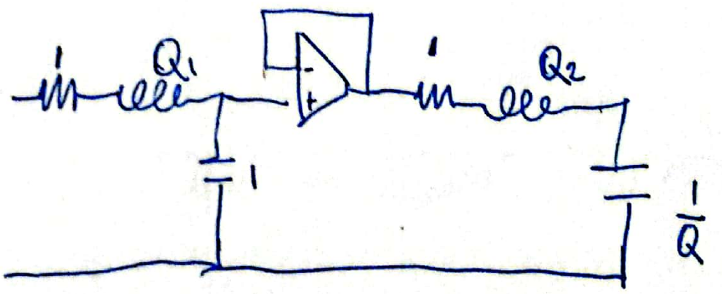
$$\frac{1}{LC} = \cancel{= \omega_0^2 \Rightarrow L = C = 1}$$

$$\cancel{R = \frac{1}{Q} = 2\cos(\theta_1)}$$

$$R = 1 \Rightarrow \frac{1}{L} = \frac{\omega_0}{Q} \qquad \omega_0^2 = \frac{1}{LC}$$

$$L = Q$$

$$\omega_0^2 = \frac{1}{QC} =$$



(T e coporte, ato a un LP NO SIRVE)

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era por acá

$$\frac{V_1}{sL + R + \frac{1}{sC}} \cdot sL = V_0 \Rightarrow \frac{V_0}{V_1} = \frac{s^2 LC}{s^2 LC + sCR + 1} = \frac{s^2}{s + s\frac{R}{L} + \frac{1}{LC}}$$

$L = Q \quad \omega_0^2 = 1 = \frac{1}{LC} = \frac{1}{QC} = C = \frac{1}{Q}$

$\Omega_z = 1k$

$R_1 = R_2 = R^* \Omega_z = 1k$

$C_1 = \frac{C_1^*}{\Omega_z \Omega_B}$ $\quad \cancel{\Omega_B = \frac{1}{2\pi 3500} \cdot 0{,}508^{1/4}}$ $\quad \Omega_B = \frac{1}{\omega_p \xi^{+1/4}}$

$\cancel{\Omega_B = \frac{1}{2\pi 3500\ 0{,}508^{1/4}}}$ $\quad \omega_B = \omega_p \xi^{+1/4}$

$C_1 = \cancel{\frac{1/Q}{1k}}$ $\cancel{2\pi\ 3500\ 0{,}508^{1/4}}$

$\cancel{C_1 = 10\ C^?}$ ~~esto perfecto.~~

$C_1 = \frac{1/Q_1}{1k\ 2\pi\ 3500 \cdot 0{,}508^{1/4}} = \cancel{34{,}67\,mF} = \boxed{C_1 = 99{,}10\ mF}$

$C_2 = \frac{1/Q_2}{1k\ 2\pi\ 3500\ 0{,}508^{1/4}} = \boxed{C_2 = 41{,}20\,m}$

$L = L^* \frac{R_z}{\sqrt{\omega_B}} \cdot Q \frac{R_z}{\sqrt{\omega_B}}$ $\quad \frac{R_z}{\omega_B} = 53,86m.$

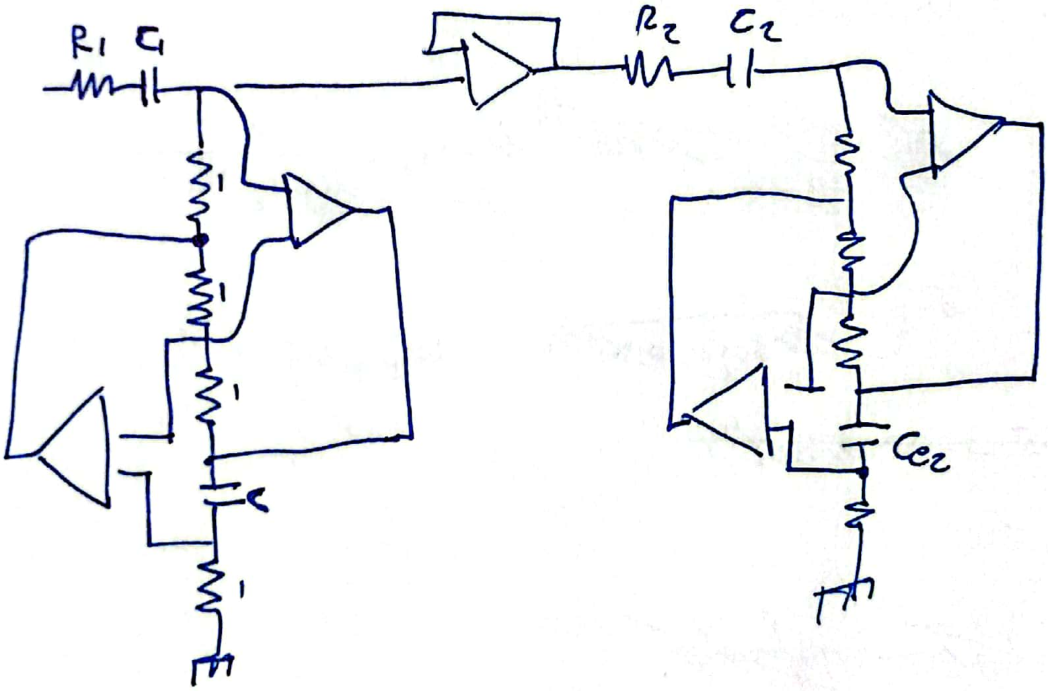
$L_1 = 29,27mH$

$L_2 = 70,4m$

Ahora con un GIC

$$Ze = \frac{Y_2 Y_4}{Y_1 Y_3 Y_5} = \frac{Z_1 Z_3 Z_5}{Z_2 Z_4}$$

$Ze = sL \Rightarrow Z_2 \vee Z_4 = \frac{1}{sC}$



$Ze = \frac{sCe_1}{\quad} = sL_1 = sQ_1$

$Ce_1^* = Q_1$

$Ce_1 = \frac{Ce_1^*}{\sqrt{\omega_B}\, R_z} = 292,73m$ $\quad Ce_2 = 704mF$

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#5

$F_p = 9,6\,k$

$F_s = 3,2k$

$\alpha_{max} = 0,4 db$

$\alpha_{min} = 48 db$

$\omega_p = 2\pi\, 9,6\,k$ $\qquad \omega_s = 2\pi\, 3,2k$

$\Omega_p = \frac{1}{2\pi\, 9,6k} = \Omega_\omega = 1 \qquad \Omega_s = \frac{2\pi\, 9,6\,k}{2\pi\, 3,2k} = 3$

$\alpha = 10 \log(1 + \xi_1^2 \omega_c^{2n})$ $\qquad \alpha = 10 \log(1 + \xi_1^2 C_n^2)$

Butter

$C_n^2 = \cosh^2(n \cdot \operatorname{arccosh}(\omega))$

en $\omega = 1$ $\quad C_n(1) = 1$

$10^{\frac{0,4}{10}} - 1 = \varepsilon^2 = 0,096 \qquad \varepsilon = 0,309$

m	α_B	α_C
2	9,43	14,53
3	18,51	29,66
4	27,99	44,95
5	37,53	60
6	47,07	
7	56,61	

El ejercicio 4 se resuelve con una transferencia de polos planicidad; todos los polos están a un círculo (Radio 1 para butter), en cheby se encuentran a una elipse.

$C_m(w) = \cosh(n \operatorname{arccosh}(w))$

$\cosh x = \frac{e^x + e^{-x}}{2}$

$C_1(3) = \cosh(n\ 1{,}76)$

$\cosh^{-1} x = \ln(x + \sqrt{x^2 - 1})$

$\cosh^{-1}(3) = \ln(3 + \sqrt{9-1}) = 1{,}76$

$C_1(3) = 3$

$C_2(3) = 16{,}9$

$C_4(3) = 570{,}7$

$C_5(3) = 3317$

$C_6(3) =$

$C_3(3) = 98{,}18$

Cheby

$\alpha = 10 \log(1 + \xi^2 C_n^2)$

$\alpha_{n=2} = 14{,}53\ db$

$\alpha_{n=3} = 29{,}66\ db$

$\alpha_{n=4} = 44{,}95\ db$

$\alpha_{n=5} = 60\ db$

Butter

$\alpha = 10 \log(1 + \xi^2 3^{2n})$

$\alpha_{n=2} = 9{,}83$

$\alpha_{n=3} = 18{,}51$

$\alpha_{n=4} = 27{,}99$

$\alpha_{n=5} = 37{,}53$

$\alpha_{n=6} = 47{,}07$

$\alpha_{n=7} = 56{,}61\ db$

~~Con lo calculado en tp2-ejs.ipynb la transferencia del cheby normalizada es~~

$$\cancel{\frac{1}{s + 0{,}386} \cdot \frac{1{,}06}{s^2 + s\frac{1{,}03}{19{,}3} + 1{,}06} \cdot \frac{0{,}494}{s^2 + s\frac{0{,}703}{1{,}13} + 0{,}494}}$$

~~Falta aplicar núcleo de transformación y después a fase mínima para llegar al Hp.~~

10 dl

$$\frac{1}{s+0{,}386} \cdot \frac{1}{s^2+\frac{s\,1}{4{,}3}+1} \cdot \frac{1}{s^2+\frac{1}{1{,}13}s+1}$$

LP2HP

$$\frac{s}{1+0{,}386s} = \frac{\frac{1}{0{,}386}s}{\frac{1}{0{,}386}+s}$$

$$\frac{s^2}{s^2+s\frac{1}{4{,}3}+1} \cdot \frac{s^2}{s^2+\frac{1}{1{,}13}s+1}$$