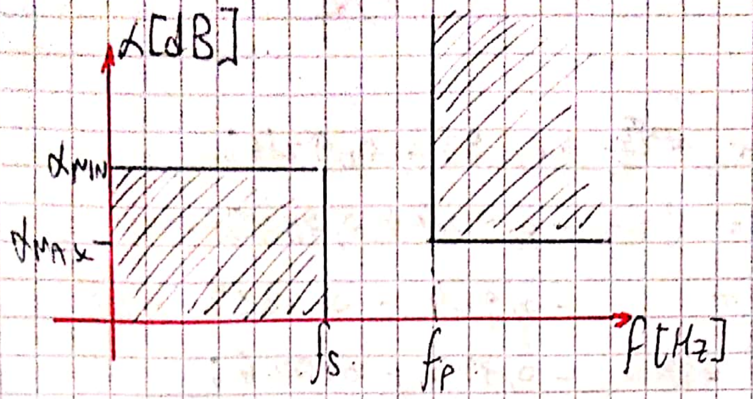
HOJA N°

FECHA



α_{MAX}	α_{MIN}	fp [Hz]	fs [Hz]
1	35	3500	1000

Me piden el anterior pasa altos. Para resolverlo voy a calcular el pasa bajos y luego transformar.

$$\alpha_{MAX} = 10 \log(1+\epsilon^2)$$

$$\boxed{\epsilon \cong 0,5}$$

$$\alpha_{MIN} = 10 \log(1+\epsilon^2 w_s^{2N}) \qquad w_s = \left(\frac{1000}{3500}\right)^{-1} \frac{rad}{s}$$

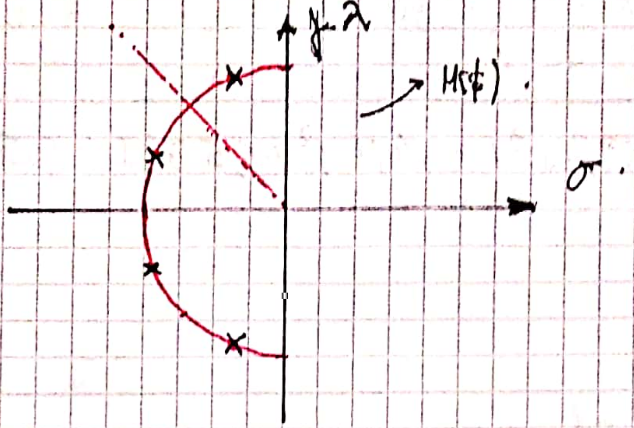
→ para un α_{MIN} de 37,5 tenemos un grado 4.

• Renormalizo para tener un filtro Butterworth

$$|H(\Omega)|^2 = \frac{1}{1+\Omega^{2N}} \qquad \Omega = w\sqrt[N]{\epsilon} = w\sqrt[4]{\epsilon}$$

NOTA

En el filtro de Butter de 4to orden tenemos 4 polos. en el semiplano izquierdo de módulo ① y con una separación de $\frac{1}{4}\pi$.



$$H(\$) = \frac{1}{\$^2 - 2\cos\left(\frac{5}{8}\pi\right)\$ + 1} \cdot \frac{1}{\$^2 - 2\cos\left(\frac{7}{8}\pi\right)\$ + 1}$$

$$H(\$) = \frac{1}{\$^2 + 0{,}765\$ + 1} \cdot \frac{1}{\$^2 + 1{,}848\$ + 1}$$

$$H(\$) = \frac{1}{\$^4 + 2{,}613\$^3 + \$^2(1 + 1{,}414 + 1) + \$(0{,}765 + 1{,}848) + 1}$$

$$H(\$) = \frac{1}{\$^4 + \$^3\, 2{,}613 + \$^2\, 3{,}414 + \$\, 2{,}613 + 1}$$

$$H(\$) = \frac{1}{(S\sqrt[4]{\varepsilon})^4 + (S\sqrt[4]{\varepsilon})^3\, 2{,}613 + (S\sqrt[4]{\varepsilon})^2\, 3{,}414 + (S\sqrt[4]{\varepsilon})\, 2{,}613 + 1}$$

$$H(P) = \frac{1}{0{,}5 \quad P^4 + P^3 \cdot 1{,}554 + P^2 \cdot 2{,}414 + P \cdot 2{,}197 + 1}$$

NOTA

Transformo PB → PA $\quad p = \frac{1}{s}$.

$$H(s) = \frac{1}{0{,}5\, s^{-4} + 1{,}554\, s^{-3} + 2{,}414\, s^{-2} + 2{,}197\, s^{-1} + 1}$$

$$H(s) = \frac{s^4}{s^4 + 2{,}197\, s^3 + 2{,}414\, s^2 + 1{,}554\, s + 0{,}5}$$

Si factorizo:

$$H(s) = \frac{s^4}{(s^2 + 0{,}643\, s + 0{,}707)(s^2 + 1{,}554\, s + 0{,}707)}$$

NOTA

Escaneado con CamScanner

HOJA N°

FECHA

~~El primer filtro debe tener la siguiente transferencia~~

$$\cancel{H_1(s) = \frac{s^2}{s^2 + s \cdot 0{,}643/(3500Hz\,2\pi) + \frac{0{,}707}{(3500Hz\,2\pi)^2}}}$$

Desnormalizamos en frecuencia. $s = 3500Hz\,2\pi\,S$.

$$H_1(s) = \frac{s^2}{s^2 + s\;0{,}643\,(3500Hz\,2\pi) + (3500Hz\,2\pi)^2 \cdot 0{,}707}$$

→ circuito pasivo:

$$H(s) = \frac{s^2}{s^2 + s\frac{R}{L} + \frac{1}{LC}}$$

→ Tomo $R_1 = 10\,K\Omega$ → $L_1 = 0{,}707\,Hy$ → ~~...~~

$C_1 = 4{,}136\,nF$.

Segundo circuito:

$$H_2(s) = \frac{s^2}{s^2 + 1{,}554\,s\,W_0 + 0{,}707 \cdot W_0^2}$$

→ Tomo $R_2 = 10K\Omega$ → $C_2 = 10\,nF$.

$L_2 = 0{,}292\,Hy$

NOTA

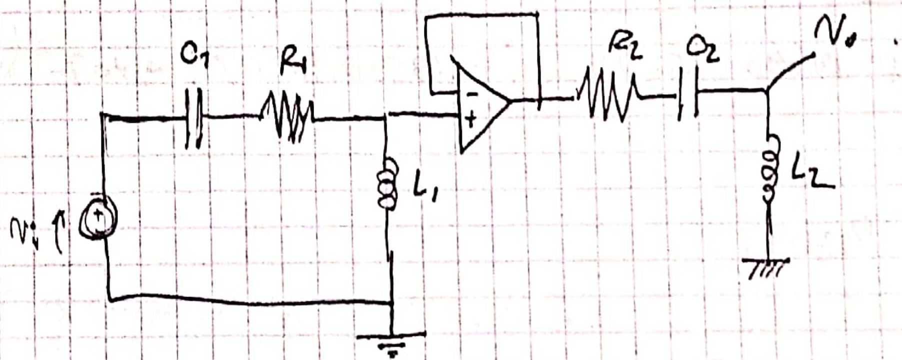
Recalculo par $Z_N = 1K$.

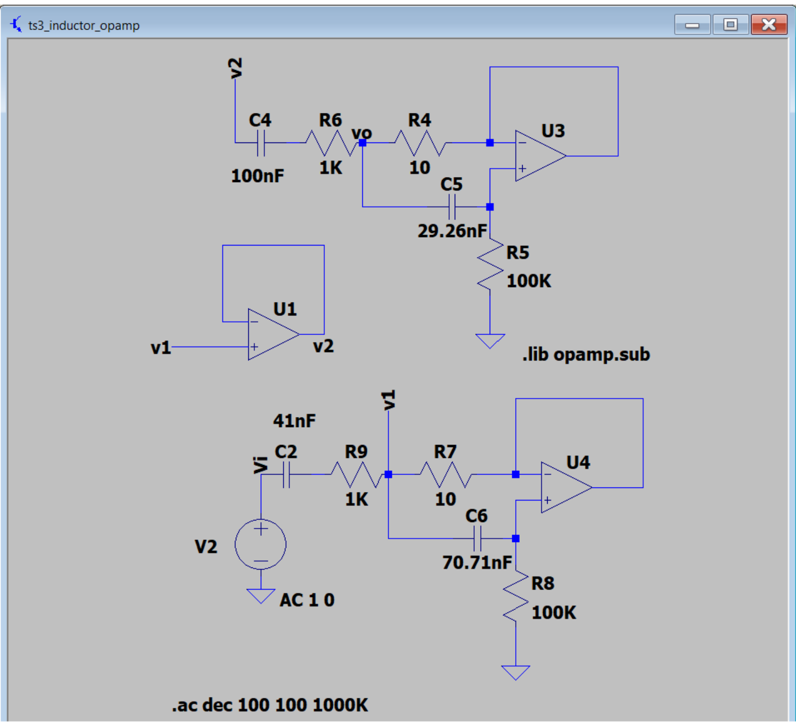
$$0{,}643\,\omega_0 = \frac{R_1}{L_1} \rightarrow L_1 = \frac{R_1}{0{,}643\,\omega_0} = 70{,}71\,mHy.$$

$$0{,}707 \cdot \omega_0^2 = \frac{1}{L_1 C_1} \rightarrow C_1 = \frac{1}{L_1\, 0{,}707\,\omega_0^2} = 41{,}356\,nF.$$

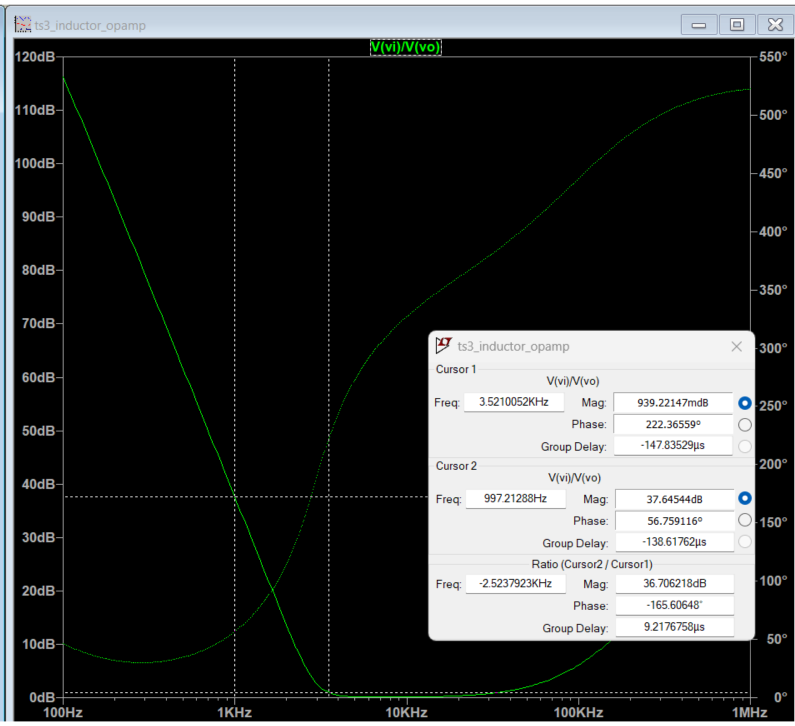
$$1{,}554\,\omega_0 = \frac{R_2}{L_2} \rightarrow L_2 = \frac{R_2}{1{,}554\,\omega_0} = 29{,}261\,mHy$$

$$0{,}707\,\omega_0^2 = \frac{1}{L_2 C_2} \rightarrow C_2 = \frac{1}{L_2 \cdot 0{,}707\,\omega_0^2} = 100\,nF$$

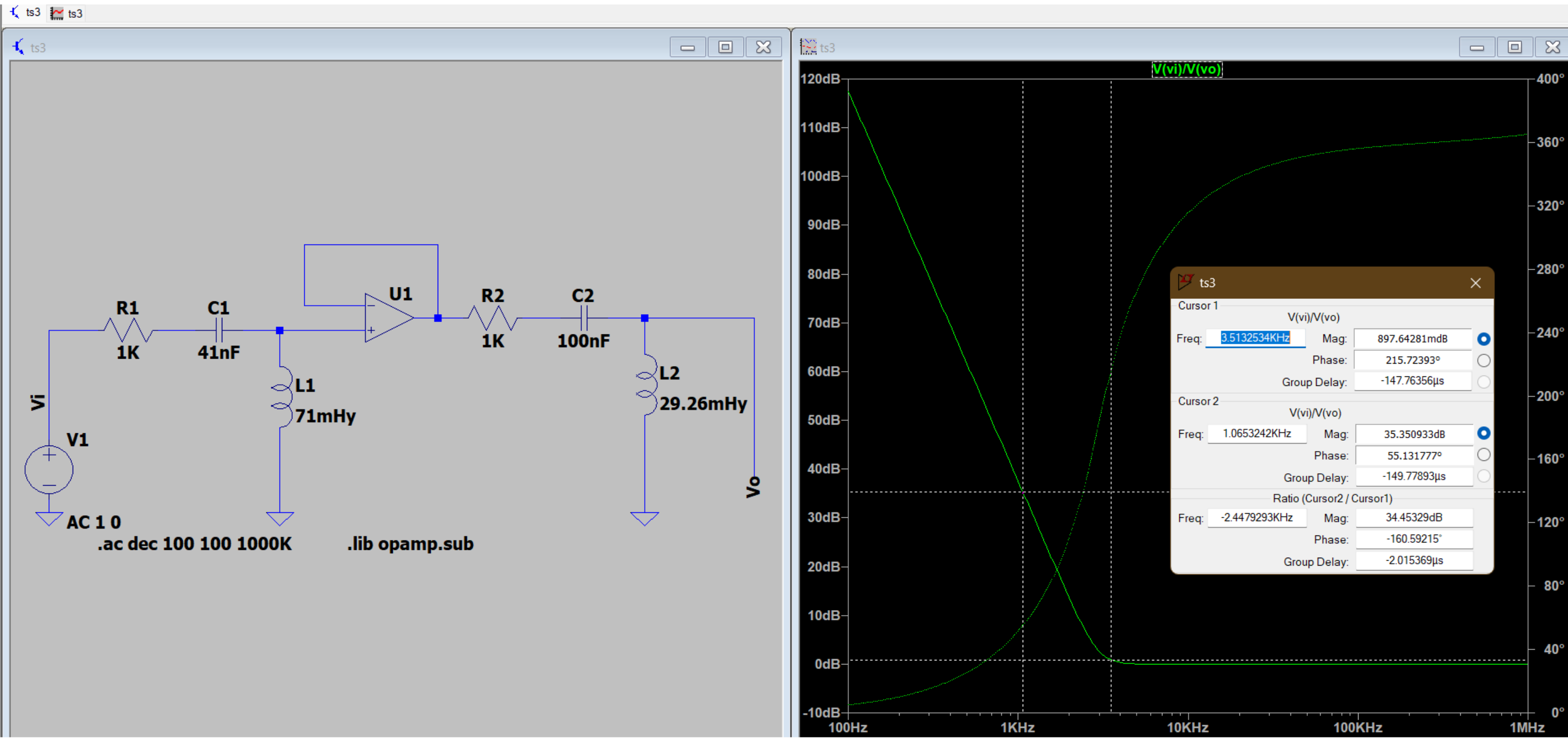




ts3_inductor_opamp
v2
C4
R6
vo
R4
U3
100nF
1K
10
C5
29.26nF
R5
100K
U1
v1
v2
.lib opamp.sub
v1
41nF
C2
R9
R7
U4
Vi
1K
10
C6
V2
70.71nF
R8
AC 1 0
100K
.ac dec 100 100 1000K



ts3_inductor_opamp
V(vi)/V(vo)
120dB
110dB
100dB
90dB
80dB
70dB
60dB
50dB
40dB
30dB
20dB
10dB
0dB
550°
500°
450°
400°
350°
300°
250°
200°
150°
100°
50°
0°
100Hz
1KHz
10KHz
100KHz
1MHz
ts3_inductor_opamp
Cursor 1
V(vi)/V(vo)
Freq: 3.5210052KHz
Mag: 939.22147mdB
Phase: 222.36559°
Group Delay: -147.83529µs
Cursor 2
V(vi)/V(vo)
Freq: 997.21288Hz
Mag: 37.64544dB
Phase: 56.759116°
Group Delay: -138.61762µs
Ratio (Cursor2 / Cursor1)
Freq: -2.5237923KHz
Mag: 36.706218dB
Phase: -165.60648°
Group Delay: 9.2176758µs


ts3
ts3
R1
1K
C1
41nF
U1
R2
1K
C2
100nF
L1
71mHy
L2
29.26mHy
Vi
V1
Vo
AC 1 0
.ac dec 100 100 1000K
.lib opamp.sub
V(vi)/V(vo)
120dB
110dB
100dB
90dB
80dB
70dB
60dB
50dB
40dB
30dB
20dB
10dB
0dB
-10dB
400°
360°
320°
280°
240°
200°
160°
120°
80°
40°
0°
100Hz
1KHz
10KHz
100KHz
1MHz
Cursor 1
V(vi)/V(vo)
Freq: 3.5132534KHz
Mag: 897.64281mdB
Phase: 215.72393°
Group Delay: -147.76356µs
Cursor 2
V(vi)/V(vo)
Freq: 1.0653242KHz
Mag: 35.350933dB
Phase: 55.131777°
Group Delay: -149.77893µs
Ratio (Cursor2 / Cursor1)
Freq: -2.4479293KHz
Mag: 34.45329dB
Phase: -160.59215°
Group Delay: -2.015369µs