$f_p = 1500\,Hz \quad f_s = 3000\,Hz \quad \alpha_{min} = 12\,dB \quad \alpha_{max} = 1\,dB$

$\alpha(\omega=1) = 10\log(1+\xi^2) \rightarrow \xi^2 = 10^{\alpha/10} - 1 = 10^{0,1} - 1 = 0,259 \rightarrow \underline{\xi = 0,509}$

$n? \rightarrow \alpha(\omega = f_s/f_p) = 10\log(1+\xi^2\omega^{2n}) = 10\log(1+0,259\cdot 2^{2n}) \rightarrow n=1: \alpha=3,09$

$n=2: \alpha = 7,11$

$\underline{n=3: \alpha = 12,45}$

Para orden 3: $|T(\$)|^2\Big|_{\omega=\$/j} = \dfrac{1}{1+\xi^2(\$/j)^{2n}}$ $\quad (\$/j)^6 = -\$^6$ $\quad \Rightarrow |T(\omega=\$/j)|^2 = \dfrac{1}{1-\xi^2\$^6} = \dfrac{1/\xi^2}{1/\xi^2 - \$^6}$

Transf. MP$3: $T(\$) = \dfrac{a}{\$+a}\cdot\dfrac{c}{\$^2+b\$+c}$

$$T(\$)T(-\$) = \frac{a}{\$+a}\cdot\frac{a}{(-\$+a)}\cdot\frac{c}{\$^2+b\$+c}\cdot\frac{c}{\$^2-b\$+c} = \frac{a^2}{\$^2(-1)+\cancel{\$(a-a)}+a^2}\cdot\frac{c^2}{\$^4(1)+\cancel{\$^3(b-b)}+\$^2(2c-b^2)+\cancel{\$(bc-bc)}+c^2}$$

$$= \frac{a^2}{\$^2(-1)+a^2}\cdot\frac{c^2}{\$^4+\$^2(2c-b^2)+c^2} = \frac{a^2c^2}{\$^6(-1)+\$^4(a^2-(2c-b^2))+\$^2(a^2(2c-b^2)-c^2)+a^2c^2}$$

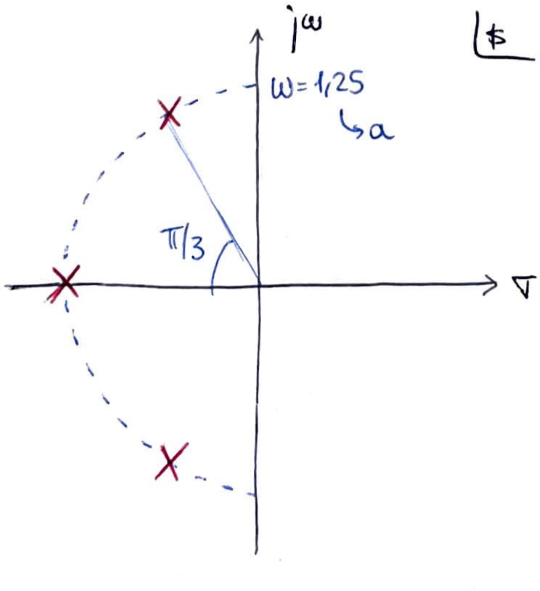
Igualando $T(\$)T(-\$) = |T(j\omega)|^2\Big|_{\omega=\$/j}$

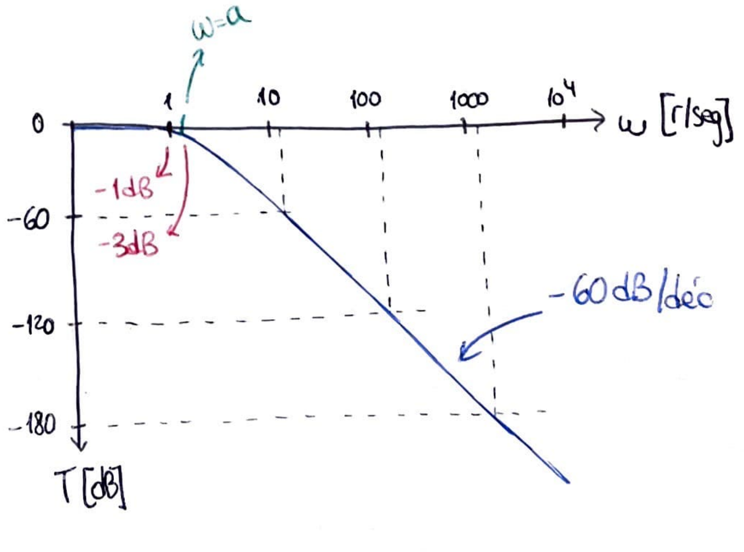
- $\$^6: -1=-1$
- $\$^4: 0 = a^2-(2c-b^2) \rightarrow a^2=(2c-b^2) \rightarrow c^2=(2c-b^2)^2 \rightarrow c=(2c-b^2) \rightarrow \underline{b^2=c}$
- $\$^2: 0=a^2(2c-b^2)-c^2 \rightarrow c^2 = a^2(2c-b^2)$ $\quad a^2=(2c-b^2)=(2c-c)=c \rightarrow \underline{a^2=c}$
- $\$^0: \underline{a^2c^2 = 1/\xi^2}$ $\quad \Rightarrow a^2=b^2$

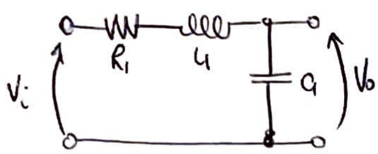
$\hookrightarrow c\cdot c^2 = 1/\xi^2 \rightarrow c = \xi^{-2/3} = 0,509^{-2/3} = \underline{1,5686}$

$a=b=c^{1/2} = (\xi^{-2/3})^{1/2} = \xi^{-1/3} = \underline{1,2525}$

$\Rightarrow \boxed{T(\$) = \dfrac{1,25}{\$+1,25}\cdot\dfrac{1,57}{\$^2+1,25\$+1,57}}$ $\quad \dfrac{a}{\$+a}\cdot\dfrac{c}{\$^2+b\$+c} = \dfrac{ac}{\$^3+\$^2(b+a)+\$(c+ab)+ac}$

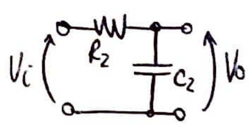






$$\frac{V_o}{V_i} = \frac{1/sC_1}{R_1 + sL_1 + 1/sC_1} = \frac{\frac{1}{L_1C_1}}{s^2 + s\frac{R_1}{L_1} + \frac{1}{L_1C_1}} = \frac{c}{s^2+bs+c}$$

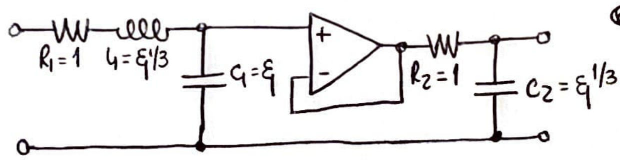
Si fijo $\{R_1 = 1\} \rightarrow \frac{R_1}{L_1} = b \rightarrow \left\{L_1 = \frac{1}{b} = \xi^{1/3}\right\}$ $\quad c = \frac{1}{L_1C_1} \rightarrow \left\{C_1 = \frac{1}{cL_1} = \xi^{2/3}\cdot\xi^{-1/3} = \xi^{1/3}\right\}$



$$\frac{V_o}{V_i} = \frac{1/sC_2}{R_2 + 1/sC_2} = \frac{1/R_2C_2}{s + 1/R_2C_2} = \frac{a}{s+a}$$

Si fijo $\{R_2 = 1\} \rightarrow a = \frac{1}{R_2C_2} \rightarrow \left\{C_2 = \frac{1}{a} = \xi^{1/3}\right\}$

$\Rightarrow$ Implementación:



Si solo se dispusiera de capacitores de 100nF:

$$\frac{c}{s^2+bs+c} = \frac{1/L_1C_1}{s^2 + sR_1/L_1 + 1/L_1C_1} \rightarrow \frac{1}{L_1C_1} = c \rightarrow \left\{L_1 = \frac{1}{c\cdot\cancel{C_1}}\right\} \qquad \frac{R_1}{L_1} = b \rightarrow \left\{R_1 = b\cdot L_1 = \frac{b}{c\cdot\cancel{C_1}}\right\}$$

$\frac{1}{c} = \xi^{2/3}$ $\qquad \frac{b}{c} = \frac{\xi^{-1/3}}{\xi^{-2/3}} = \xi^{1/3}$

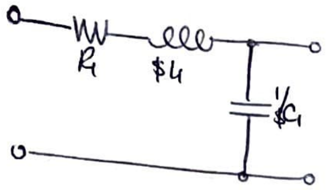
$$\frac{a}{s+a} = \frac{1/R_2C_2}{s + 1/R_2C_2} \rightarrow R_2C_2 = \frac{1}{a} \rightarrow \left\{R_2 = \frac{1}{a\cancel{C_2}}\right\}$$

$\hookrightarrow \frac{1}{a} = \xi^{1/3}$

Desnormalización: $R = R_N\,\Omega_z \quad L = L_N\,\Omega_z/\Omega_w \quad C = C_N/(\Omega_z\Omega_w)$

Sabemos que $\Omega_w = \omega_p = 2\pi f_p = 9424{,}78\,r/s \rightarrow 100nF = 1/(9424{,}78\,r/s \cdot \Omega_z) \rightarrow \Omega_z = 1061{,}03\,\Omega$

$R_1 = \xi^{1/3}\cdot\Omega_z = 847{,}16\,\Omega$ $\qquad R_2 = \xi^{1/3}\cdot\Omega_z = 847{,}16\,\Omega$ $\qquad L_1 = \xi^{2/3}\cdot\Omega_z/\Omega_w = 0{,}072\ Hy = 72mHy$



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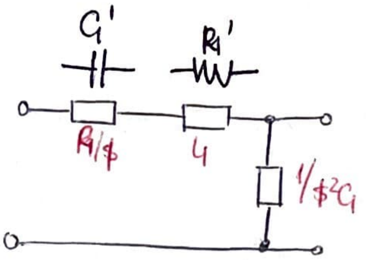


→ Implementado como un GIC

$$Z_{GIC} = \frac{Z_1 Z_3 Z_5}{Z_2 Z_4}$$

$$Z_1 Z_3 = \frac{1}{s^2 C} \qquad \frac{Z_5}{Z_2 Z_4} = 1$$

$$Z_1 = \frac{1}{s\sqrt{C}} = Z_3 \qquad Z_2 = Z_4 = 1$$

Los valores ~~...~~ normalizados utilizados anteriormente:

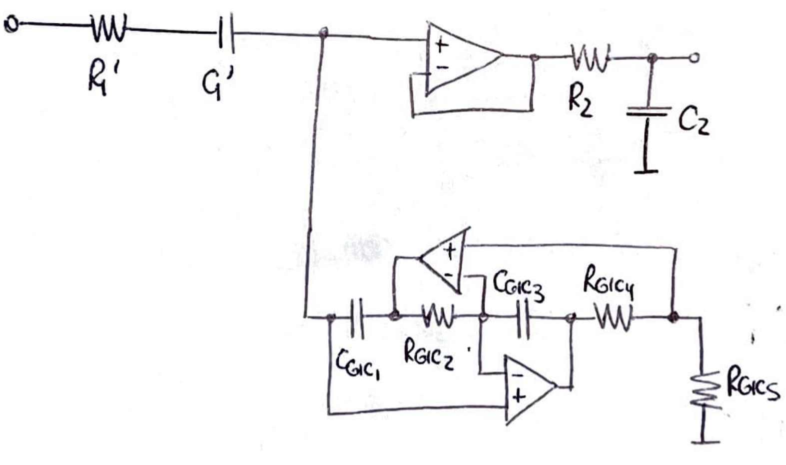
$$\{R_1 = 1;\ C_1 = \xi^{1/3};\ L_1 = \xi^{1/3}\}$$

$$\boxed{\begin{array}{l} \Omega_z = 1k\Omega \\ \Omega_w = 2\pi \cdot 1{,}5kHz \end{array}}$$

$$R_1' = L_N \cdot \Omega_z = 798{,}43\,\Omega \qquad C_1' = \frac{1}{R_N} \cdot \frac{1}{\Omega_w \cdot \Omega_z} = 106{,}1\,nF$$

$$C_{GIC1} = \sqrt{C_N} \cdot \frac{1}{\Omega_w \Omega_z} = \xi^{1/6} \cdot \frac{1}{\Omega_w \Omega_z} = 94{,}809\,nF = C_{GIC2}$$

$$R_{GIC2} = R_{GIC4} = R_{GIC5} = \Omega_z = 1k\Omega$$



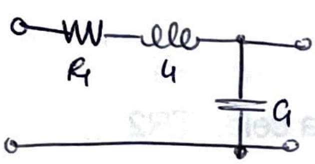
R2 y C2 conservan los valores anteriores.

$$|T(j\omega)|^2 = \frac{1}{1+\varepsilon^2\omega^{2n}} \rightarrow \text{considerando } \omega_B^n = \varepsilon^{\varepsilon}\omega^n \rightarrow \omega_B = \varepsilon^{1/n}\omega = \frac{\omega}{\varepsilon^{-1/n}}$$

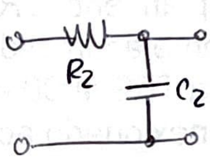
$$\Rightarrow |T(j\omega)|^2 = \frac{1}{1+\omega^{2n}} \rightarrow |T(s)|^2 = \frac{1}{1+(s/j)^{2n}} = \frac{1}{1-s^6}$$

$$T_{BW3}(s) = \frac{1}{s+1}\cdot\frac{1}{s^2+2\cos\psi\, s+1} \quad \text{con } \psi = \pi/3 \rightarrow 2\cos\psi = 1$$

$$= \frac{1}{s+1}\cdot\frac{1}{s^2+s+1} \qquad \left\{Q = \frac{1}{2\cos\psi} = 1\right\}$$



$R_1 = 1$
$L_1 = Q = 1$
$C_1 = 1/Q = 1$



$R_2 = 1$
$C_2 = 1$

Desnormalizando: $\Omega_Z = 1k\Omega$ (arbitrario) $\qquad \Omega_\omega = 2\pi f_p \cdot \varepsilon^{1/n}$

$R_1 = R_2 = 1k\Omega \qquad L_1 = \frac{\Omega_Z}{\Omega_\omega} = 84{,}72\,mHy \qquad C_1 = 84{,}72\,nF = C_2$