TRABAJO PRÁCTICO DE LABORATORIO N°1

Se seleccionó la plantilla (B). (PASA - ALTOS)

Función de aproximación: Chebyshev

Frecuencia de corte: $f_p = 4,6\ KHz$

Frecuencia de stop: $f_s = 1,2\ KHz$

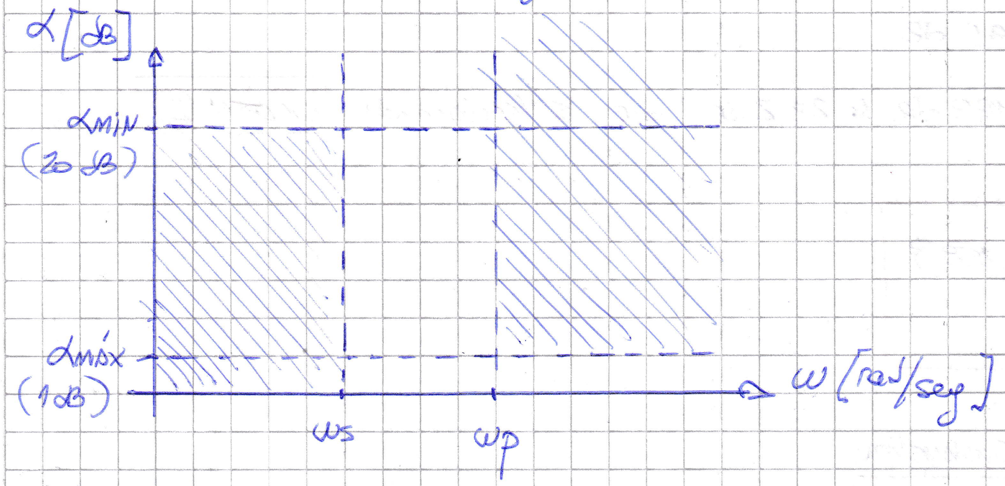
At. máxima en borde de paso: $1\ dB$ (α_{max})

At. mínima en borde de stop: $20\ dB$ (α_{min})

ELABORACIÓN DE PLANTILLA

$\omega_p = 2\pi f_p = 2\pi\, 4600$ rad/seg

$\omega_s = 2\pi f_s = 2\pi\, 1200$ rad/seg



Normalización por ω_p: ($\Omega_N = \omega_p$)

$$\omega_p' = \frac{\omega_p}{\omega_p} \Rightarrow \boxed{\omega_p' = 1}$$

$$\omega_s' = \frac{\omega_s}{\omega_p} \Rightarrow \boxed{\omega_s' = 0,261}$$

Aplico kernel de transformación de parámetros

$$\Omega = \frac{1}{\omega} \qquad \Omega p = \frac{1}{\omega p'} \Rightarrow \boxed{\Omega p = 1}$$

$$\Omega s = \frac{1}{\omega s'} \Rightarrow \boxed{\Omega s = 3{,}83}$$

Aplico Chebyshev al filtro pasabajos prototipo

$$\varepsilon^2 = 10^{\frac{\alpha_{MAX}}{10}} - 1 = 10^{1/10} - 1$$

$$\boxed{\varepsilon^2 = 0{,}2589} \qquad \boxed{\varepsilon = 0{,}51}$$

$$\alpha_{min_n} = 10 \log\left\{1 + \varepsilon^2 \cdot \cosh^2\left[n \cdot \cosh^{-1}(\Omega s)\right]\right\}$$

Con Python realizamos los cálculos:

$$\alpha_{min_1} = 6{,}81 \text{ dB}$$

$$\alpha_{min_2} = 23{,}199 \text{ dB} \approx 23{,}2 \text{ dB} \Rightarrow \text{seleccionamos } \boxed{\text{ORDEN } 2}$$

$$\boxed{\text{Chebyshev} \begin{cases} \varepsilon^2 = 0{,}2589 \\ n = 2 \end{cases}}$$

Armado polinomio de Chebyshev

$$C_2(\Omega) = 2 \cdot \Omega^2 - 1$$

Armado de TRANSFERENCIA

$$|T(j\Omega)|^2 = \frac{1}{1 + \varepsilon^2 \cdot C_2^2(\Omega)} = \frac{1}{1 + \varepsilon^2 \cdot (2\Omega^2 - 1)^2}$$

$$= \frac{1}{1+\varepsilon^2(4\Omega^4 - 4\Omega^2 + 1)} = \frac{1}{4\varepsilon^2\Omega^4 - 4\varepsilon^2\Omega^2 + \varepsilon^2 + 1}$$

$$= \frac{\frac{1}{4\varepsilon^2}}{\Omega^4 - \Omega^2 + 1/4 + 1/4\varepsilon^2} = \frac{\frac{1}{4\varepsilon^2}}{\Omega^4 - \Omega^2 + \left(\frac{\varepsilon^2+1}{4\varepsilon^2}\right)}$$

$$T_{LP}(\$) \Rightarrow T(\$).T(-\$) = |T(j\omega)|^2 \Big]_{\Omega = \frac{s}{j}}$$

$$|T(j\Omega)|^2 \Big]_{\Omega=\frac{s}{j}} = \frac{\overbrace{1/4\varepsilon^2}^{=\frac{1}{2\varepsilon}}}{\$^4 + \$^2 + \left(\frac{\varepsilon^2+1}{4\varepsilon^2}\right)} = T(\$).T(-\$)$$

Reemplazo: $(\varepsilon^2 = 0{,}2589)$

$$T(\$).T(-\$) = \frac{0{,}98}{\$^4 + \$^2 + 1{,}2156} = 0{,}98 \ldots \frac{1}{s^2+as+b} \cdot \frac{1}{s^2-cs+d}$$

$$\boxed{T_{LP}(\$) = \frac{0{,}98}{\$^2 + \$1{,}098 + 1{,}102}}$$

TRANSFERENCIA PASA BAJOS PROTOTIPO

Aplico Kernel de transformación

$$p = K(s) = \frac{1}{s}$$

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

$$T_{HP}(s) = \frac{0,98}{\frac{1}{s^2} + 1,098\frac{1}{s} + 1,102}$$

$$T_{HP}(s) = \frac{0,98 \cdot s^2}{1 + 1,098 s + 1,102 s^2}$$

$$T_{HP}(s) = \frac{0,98}{1,102} \cdot \frac{s^2}{s^2 + 0,996 s + 0,907}$$

$$\boxed{T_{HP}(s) = (0,89) \cdot \frac{s^2}{s^2 + 0,996 s + 0,907}}$$

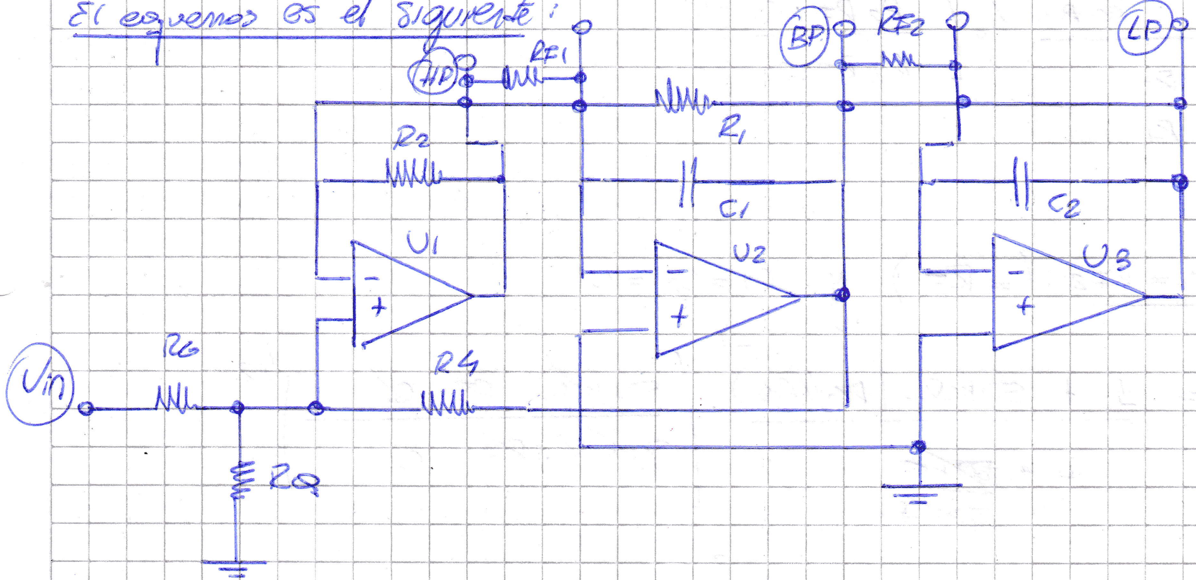
TRANSFERENCIA

PASA ALTOS

IMPLEMENTACIÓN

Para la implementación se utilizará un circuito universal de filtrado UAF42.

El esquema es el siguiente:



Los valores de los componentes integrados son:

$$\begin{cases} R_1 = R_2 = R_4 = 50\ k\Omega \\ C_1 = C_2 = 1000\ pF \end{cases}$$

Los parámetros de diseño debe ser:

$$\begin{cases} Amp = K = 0{,}89 \\ Q = 0{,}956 \\ \omega_0 = 2\pi 4600 \cdot 0{,}952. \end{cases}$$

$$\frac{\omega_0}{Q} = 0{,}996 \quad \wedge \quad \omega_0^2 = 0{,}905$$

$$\boxed{\omega_0 = 0{,}952}$$

$$Q = \frac{0{,}952}{0{,}996}$$

$$\boxed{Q = 0{,}956}$$

Aplico las ecuaciones de diseño otorgados por el fabricante del UAF42 (TEXAS INSTRUMENTS):

$$\omega_0^2 = \frac{R_2}{R_1 R_{F1} R_{F2} C_1 C_2} \qquad Amp = \frac{1 + R_2/R_1}{R_G\left[\frac{1}{R_G} + \frac{1}{R_Q} + \frac{1}{R_4}\right]}$$

$$Q = \frac{1 + R_4\left(\frac{R_G + R_Q}{R_G R_Q}\right)}{1 + \frac{R_2}{R_1}} \cdot \left[\frac{R_2 R_{F1} C_1}{R_1 R_{F2} C_2}\right]^{1/2}$$

<u>Adoptamos $R_{F1} = R_{F2}$</u> : $(= R_F)$ y $C_1 = C_2 = C$:

$$Q = 0{,}956 = \frac{1 + 50k\Omega \cdot (R_G // R_Q)^{-1}}{1 + \frac{\cancel{50k\Omega}}{\cancel{50k\Omega}}} \cdot \left[\frac{\cancel{50k\Omega} \cdot \cancel{R_F} \cdot \cancel{C}}{\cancel{50k\Omega} \cdot \cancel{R_F} \cdot \cancel{C}}\right]^{1/2}$$

$$0{,}956 = \frac{1 + \frac{50k\Omega}{(R_G // R_Q)}}{2}$$

$$R_G // R_Q = \left(\frac{(2 \cdot 0{,}956) - 1}{50k\Omega}\right)^{-1}$$

$$\boxed{R_G // R_Q \cong 54{,}82\ k\Omega}$$

$$Amp = \frac{1 + \cancel{50k\Omega}^{\,1} / \cancel{50k\Omega}}{R_G \cdot \left[\underbrace{\frac{R_G + R_Q}{R_G R_Q}}_{\frac{1}{R_G // R_Q}} + \frac{1}{50k\Omega}\right]} = \frac{2}{R_G \cdot \left(\frac{1}{54{,}82k\Omega} + \frac{1}{50k\Omega}\right)}$$

$$Amp = 0{,}89 \Rightarrow R_G = \frac{2}{0{,}89\left(\frac{1}{54{,}82k\Omega} + \frac{1}{50k\Omega}\right)} \Rightarrow \boxed{R_G \cong 58{,}76\ k\Omega}$$

$$\frac{R_G \cdot R_Q}{R_G + R_Q} = 54{,}82\,k\Omega$$

$$R_Q = \frac{R_G \cdot 54{,}82\,k\Omega}{R_G - 54{,}82\,k\Omega} = \frac{58{,}76\,k\Omega \cdot 54{,}82\,k\Omega}{58{,}76\,k\Omega - 54{,}82\,k\Omega}$$

$$\boxed{R_Q \cong 817{,}54\,k\Omega}$$

$$\omega_0^2 = (2\pi \cdot 4000 \cdot 0{,}852)^2 = \frac{\cancel{50\,k\Omega}}{\cancel{50\,k\Omega}}^{1} \cdot \frac{1}{R_F^2 \cdot (1000\,pF)^2}$$

$$R_F = \frac{1}{2\pi \cdot 4000 \cdot 0{,}852 \cdot 1000\,pF} = 36{,}34\,k\Omega$$

$$\boxed{R_{F1} = R_{F2} = 36{,}34\,k\Omega}$$

Definición de valores comerciales

$$\boxed{R_G = 56\,k\Omega}$$

$$\boxed{R_Q = 820\,k\Omega}$$

$$\boxed{R_{F1} = R_{F2} = 33\,k\Omega \text{ ó } 39\,k\Omega}$$