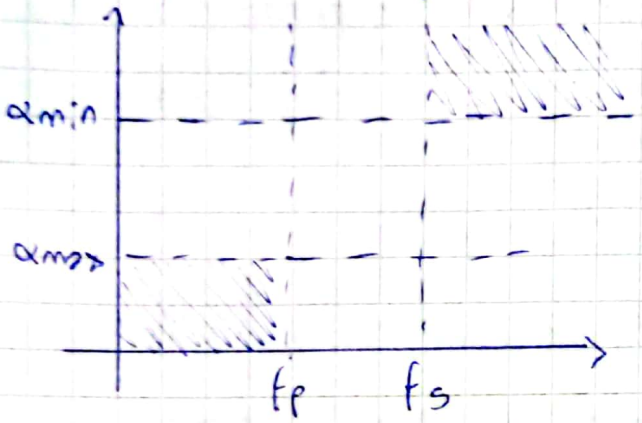
Ejercicio 3 TP2:

Filtro LP Chebyshev



$\alpha_{min} = 48dB$

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

$f_p = 3,2kHz$; $f_p' = 1$

$f_s = 9,6kHz$; $f_s' = 3$

a) $\xi^2 = 10^{\alpha_{max}/10} - 1 = 0,0964$

$1 + \xi^2 \cdot \{\cosh^2[n \cdot \text{arccosh}(ws)]\}$; $\alpha_{min}^2 = 63094,75$

$n = 3 \rightarrow 945,81 < 63094,75$

$n = 4 \rightarrow 32095,35 < 63094,75$

$n = 5 \rightarrow 1090262,73 > 63094,75$ ✓ Orden 5

- Busco polinomio de Cheby:

$C_0 = 1$; $C_1 = W$; $C_n = 2W C_{n-1} - C_{n-2}$

$C_2 = 2w^2 - 1$; $C_3 = 4w^3 - 3w$; $C_4 = 8w^4 - 8w^2 + 1$

$C_5 = 16w^5 - 16w^3 + 2w - 4w^3 + 5w = 16w^5 - 20w^3 + 5w$

$Cs = 16w^5 - 16w^3 + 4w - 4w^3 + 5w = 16w^5 - 20w^3 + 9w$

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

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

$|T(\$)|^2 = T(\$).T(-\$) \Rightarrow T(\$) = \frac{\frac{1}{\sqrt{\xi^2 \cdot 256}}}{\$^5 + 1{,}249\$^4 + 2{,}031\$^3 + 1{,}432\$^2 + 0{,}521\$ + 0{,}201}$

$T(\$) = \frac{0{,}201}{\$^5 + 1{,}249\$^4 + 2{,}031\$^3 + 1{,}432\$^2 + 0{,}521\$ + 0{,}201}$

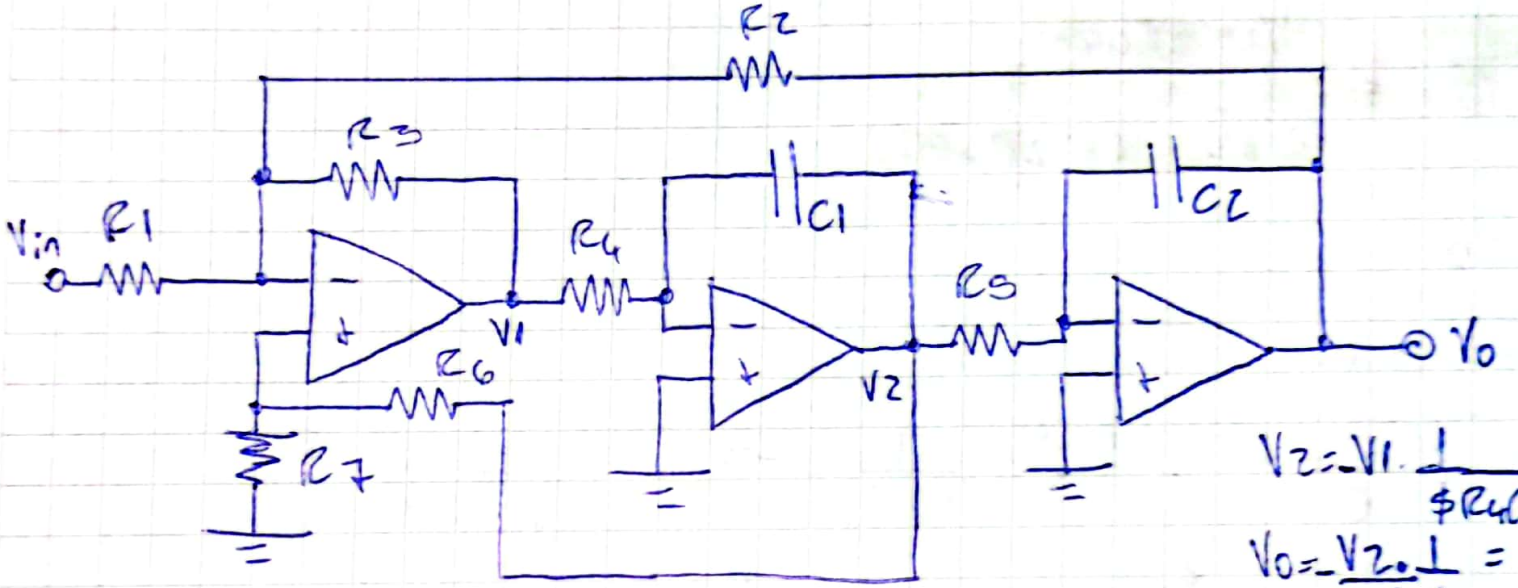
$T(\$) = \frac{0{,}201}{(\$^2 + 0{,}238\$ + 1{,}053)(\$^2 + 0{,}625\$ + 0{,}494)(\$ + 0{,}386)}$

$T(\$) = \frac{0{,}201}{1{,}053} \cdot \frac{1{,}053}{\$^2 + 0{,}238\$ + 1{,}053} \cdot \frac{0{,}201}{0{,}494} \cdot \frac{0{,}494}{\$^2 + 0{,}625\$ + 0{,}494} \cdot \frac{0{,}201}{0{,}386} \cdot \frac{0{,}386}{\$ + 0{,}386}$

$T(\$) = \frac{0{,}494}{0{,}494} \cdot \frac{1{,}053}{\$^2 + 0{,}238\$ + 1{,}053} \cdot \frac{0{,}494}{\$^2 + 0{,}625\$ + 0{,}494} \cdot \frac{0{,}386}{\$ + 0{,}386}$

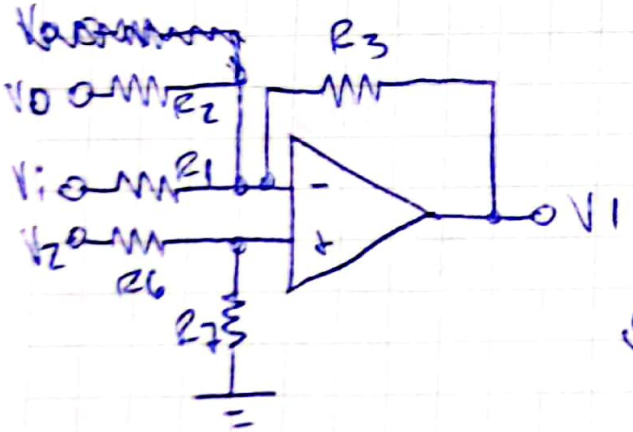
NOTA

2) Sintetizar utilizando KHN-Variable de estado:



$$V_2 = -V_1 \cdot \frac{1}{\$ R_4 C_1}$$

$$V_o = -\frac{V_2 \cdot 1}{R_5 C_2 \$} = V_1 \cdot \frac{1}{\$^2}$$



Superposición:

① $V_i = V_0 = 0 \Rightarrow V_1 = V_2 \cdot \frac{R_7}{R_7 + R_6} \cdot \left(1 + \frac{R_3}{R_1 \| R_2}\right)$

② $V_i = V_2 = 0 \Rightarrow V_1 = V_0 \cdot \left(-\frac{R_3}{R_2}\right)$

③ $V_0 = V_2 = 0 \Rightarrow V_1 = V_i \cdot \left(-\frac{R_3}{R_1}\right)$

③ en ①: $V_i \cdot \left(\frac{-R_3}{R_1}\right) = V_0 \cdot \$ \cdot \frac{R_7}{R_7 + R_6}$

$$V_2 = -V_1 \cdot \frac{1}{\$ R_4 C_1}; \quad V_0 = -V_2 \cdot \frac{1}{\$ R_5 C_2} \Rightarrow V_2 = -V_0 \$ R_5 C_2$$

$$V_1 = -V_2 \cdot \$ R_4 C_1 \longrightarrow V_\phi = V_0 \$^2 C_1 C_2 R_4 R_5$$

$$V_1 = V_2 \frac{R_7}{R_7 + R_6}\left(1 + \frac{R_3}{R_1 \| R_2}\right) + V_0 \cdot \left(-\frac{R_3}{R_2}\right) + V_i \cdot \left(-\frac{R_3}{R_1}\right)$$

$$V_0 \$^2 C_1 C_2 R_4 R_5 = -V_0 \$ C_2 R_5 \cdot \frac{R_7}{R_7 + R_6}\left(1 + \frac{R_3}{R_1 \| R_2}\right) + V_0\left(\frac{-R_3}{R_2}\right) + V_i \cdot \left(\frac{-R_3}{R_1}\right)$$

$$V_0\left[\$^2 C_1 C_2 R_4 R_5 + \$ C_2 R_5 \frac{R_7}{R_7 + R_6}\left(1 + \frac{R_3}{R_1 \| R_2}\right) + \frac{R_3}{R_2}\right] = V_i \cdot \left(-\frac{R_3}{R_1}\right)$$

$$\frac{V_0}{V_i} = \frac{-\frac{R_3}{R_1}}{\$^2 C_1 C_2 R_4 R_5 + \$ C_2 R_5 \frac{R_7}{R_7 + R_6}\left(1 + \frac{R_3}{R_1 \| R_2}\right) + \frac{R_3}{R_2}}$$

- Si: $R_7 = R_1 = R_2 = R_3 = R$ y $R_6 = 2R$

$$T(s) = \frac{-1}{s^2 C_1 C_2 R_4 R_5 + s C_2 R_5 + 1}$$

$$T(s) = \frac{-1/C_1 C_2 R_4 R_5}{s^2 + s\left(\frac{1}{C_1 R_4} + \frac{1}{C_1 C_2 R_4 R_5}\right)}$$

- Normalizo:

$R_4 = R_5 = R$

② $\frac{\omega_0}{Q} = \frac{1}{C_1}$; $\omega_0^2 = \frac{1}{C_1 C_2} \rightarrow C_1 = \frac{1}{\omega_0^2 C_2}$ ①

① en ② $\frac{\omega_0}{Q} = \omega_0^2 C_2 \Rightarrow C_2 = \frac{1}{Q\omega_0}$; $C_1 = \frac{1}{\omega_0^2 \frac{1}{Q\omega_0}}$

$$C_1 = \frac{Q}{\omega_0}$$

- Busco componentes para SOS:

T1: $\omega_0 = 0.738$

- Busco componentes para SOS:

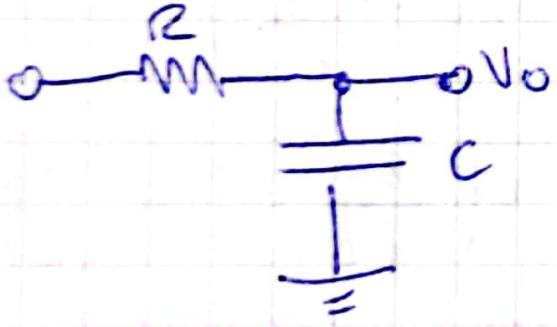
T1: $\frac{W_0}{Q} = 0{,}238$ → $Q = 4{,}311$ → $C_1 = 4{,}12$; $C_2 = 0{,}226$

$W_0^2 = 1{,}053$

T2: $\frac{W_0}{Q} = 0{,}625$ → $Q = 1{,}124$ → $C_1 = 1{,}6$; $C_2 = 1{,}27$

$W_0^2 = 0{,}494$

- Sección de primer orden:



$$T(\$) = \frac{1/\$C}{R + 1/\$C} = \frac{1}{\$CR + 1} = \frac{1/CR}{\$ + \frac{1}{CR}}$$

$$R = R \Rightarrow T(\$) = \frac{1/C}{\$ + \frac{1}{C}}$$

$$\frac{1}{C} = 0{,}386 \rightarrow C = 2{,}59$$