

$$\omega_0 = 2\pi 22 \text{ kHz}$$

$$Q = 5$$

• chebyshev

$$\alpha_{MAX} = 0.5 \text{ dB}$$

$$|T(f_{s2})| = -16 \text{ dB}$$

$$|T(f_{s1})| = -24$$

$$\omega_0 = 2\pi 22 \text{ kHz} \Rightarrow \omega_0 = 1$$

$$\omega_{s1} = \frac{17}{22} = 0.773 \quad \text{y} \quad \omega_{s2} = \frac{36}{22} = 1.636$$

$$Q = \frac{\omega_0}{BW} \Rightarrow BW = \frac{\omega_0}{Q} = \frac{1}{5} = 0.2$$

$$\epsilon^2 = 10^{\frac{\alpha_{MAX}}{10}} - 1 = 0.122$$

Núcleo de transformación

$$K(s) = Q \frac{s^2 - 1}{s}$$

$$\begin{cases} \lambda_{s1} = Q \frac{\omega_{s1}^2 - 1}{\omega_{s1}} = -2.6 \\ \lambda_{s2} = Q \frac{\omega_{s2}^2 - 1}{\omega_{s2}} = 5.124 \end{cases}$$

Se busca un orden tal que cumpla la mínima atenuación pedida con la mínima ω_s

$$\alpha_{min} = 10 \log [1 + \epsilon^2 \cosh^2 (n \cosh^{-1} \omega_s)]$$

ω_{s1}	ω_{s2}
$n=2$ 13 dB	$n=2$ 25.1 dB
$n=3$ 26.8 dB	$n=3$ 45.23 dB

con $n=3$ cumple las 2 restricciones de α mínimo

NOTA $\pm 1h$ $\pm 1h$

Plantilla pasabanda normalizada

para averiguar ω_1 y ω_2

$$h_1 = Q \frac{\omega_1^2 - 1}{\omega_1} = -1 \Rightarrow Q(\omega_1^2 - 1) = -\omega_1$$

$$\omega_1^2 + \frac{\omega_1}{Q} - 1 = 0 \rightarrow \begin{matrix} 0,905 \\ -1,105 \end{matrix}$$

$$\omega_2^2 - \frac{\omega_2}{Q} - 1 = 0 \rightarrow \begin{matrix} -0,905 \\ 1,105 \end{matrix}$$

$$\Rightarrow$$

ω_0	ω_1	ω_2	ω_{s1}	ω_{s2}	Δ_{MAX}	Δ_{MIN}
1	0,903	1,107	0,773	1,636	0,5	-24dB

Prototipo pasabanda

Filtro pasabanda chebyshev

$$N = 3 \quad \omega_s = 2,6 \quad \omega_p = 1 \quad \Delta_{MAX} = 0,5 \text{ dB}$$

$$\epsilon^2 = 0,122$$

$$|T_{C3}|^2 = \frac{1}{1 + \epsilon^2 C_3(\omega)^2}$$

$$\hookrightarrow \text{Python } |T_{C3}|_{LP}(\omega) = \frac{0,626}{5 + 0,626} \cdot \frac{1,143}{5^2 + 5 \frac{1,069}{1,706} + 1,069^2}$$

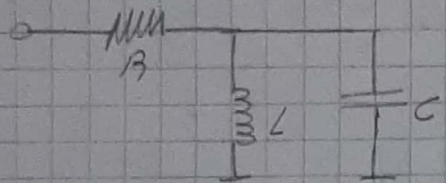
Aplica núcleo de Transformación

$$K(s) = Q \frac{(s^2 - 1)}{s}$$

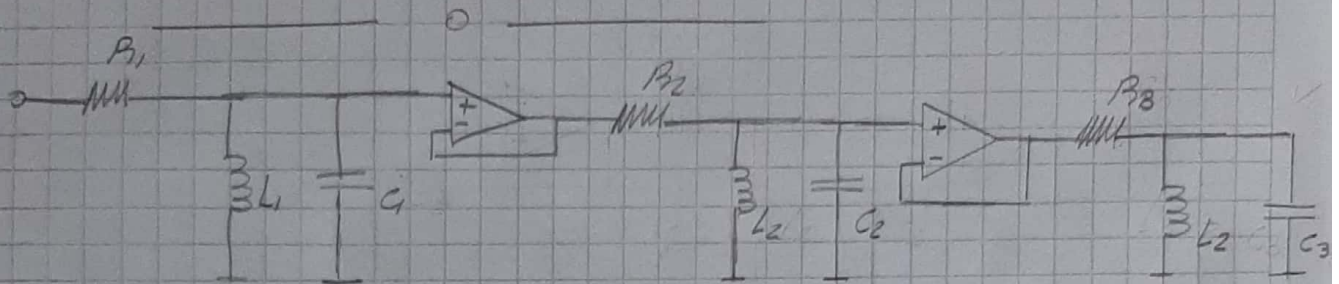
\hookrightarrow Python

$$|T_{C3BP}(s)| = \frac{5 \cdot 1,207 \cdot \frac{1}{1,981}}{s^2 + 5 \frac{1}{1,981} + 1^2} \cdot \frac{5 \cdot 2,045 \cdot \frac{0,903}{16,05}}{s^2 + 5 \frac{0,903}{16,05} + 0,903^2} \cdot \frac{5 \cdot 4,768 \cdot \frac{1,107}{16,05}}{s^2 + 5 \frac{1,107}{16,05} + 1,107^2}$$

Circuito Pasabanda Pasivo



$$H(s) = \frac{5 \frac{1}{s}}{s^2 + 5 \frac{1}{s} + \frac{1}{s}}$$



$$|T_{CBP}(s)| = |T_{SOS_1}(\omega)| \cdot |T_{SOS_2}(\omega)| \cdot |T_{SOS_3}(\omega)|$$

Como los circuitos pasivos no amplifican \Rightarrow se hacen todos los filtros de 0dB

$$SOS_1: T(s) = \frac{5 \cdot \frac{1}{7.981}}{s^2 + 5 \frac{1}{7.981} + 1^2}$$

$$\begin{cases} \frac{1}{L_1 C_1} = 1 \\ \frac{1}{R_1 C_1} = \frac{1}{7.981} \end{cases} \quad \begin{aligned} &\text{proporciono } C_1 = 1 \Rightarrow L_1 = 1 \\ &\text{y } R_1 = Q = 7.981 \end{aligned}$$

$$SOS_2: T(s) = \frac{5 \cdot \frac{0.903}{16.05}}{s^2 + 5 \frac{0.903}{16.05} + 0.903^2}$$

$$\begin{cases} \frac{1}{L_2 C_2} = 0.903^2 \\ \frac{0.903}{16.05} = \frac{1}{R_2 C_2} \end{cases} \quad \begin{aligned} &\text{Proporciono } C_2 = 1 \Rightarrow L_2 = \frac{1}{0.903^2} = 1.226 \\ &\Rightarrow R_2 = \frac{16.05}{0.903} = 17.774 \end{aligned}$$

$$SOS_3: T(s) = \frac{5 \cdot \frac{1.107}{16.05}}{s^2 + 5 \frac{1.107}{16.05} + 1.107^2}$$

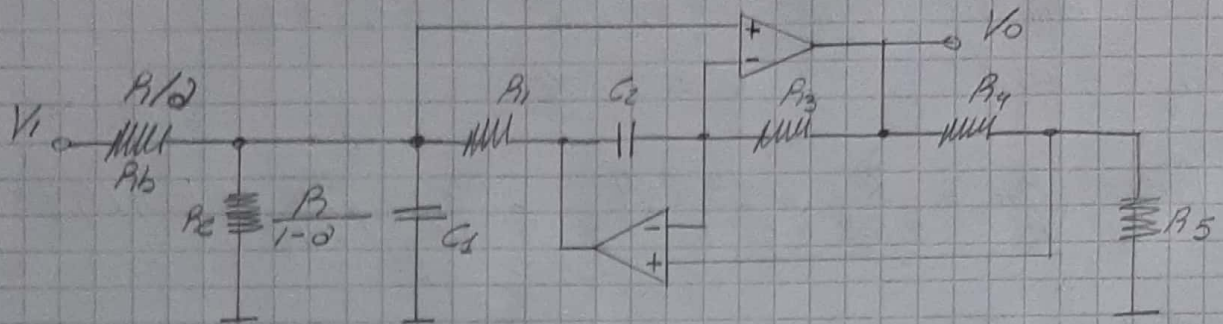
$$\begin{cases} \frac{1}{L_3 C_3} = 1.107^2 \\ \frac{1.107}{16.05} = \frac{1}{R_3 C_3} \end{cases} \quad \begin{aligned} &\text{Proporciono } C_3 = 1 \Rightarrow L_3 = \frac{1}{1.107^2} = 0.816 \\ &\Rightarrow R_3 = \frac{16.05}{1.107} = 14.499 \end{aligned}$$

NOTA 14:15 \rightarrow 20:34

+6h

GIC pasabanda

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$$T(s) = \frac{V_o}{V_i} = \frac{5\alpha \left(1 + \frac{G_5}{G_4}\right) \frac{G_1}{C_1}}{s^2 + 5 \frac{G_1}{C_1} + \frac{G_1 G_3 G_5}{C_1 C_2 G_4}}$$

Se propone

$$C_1 = C_2 \text{ y } R_1 = R_3 = R_4 = R_5$$

$$H = 2 \left(1 + \frac{G_5}{G_4}\right)$$

H puede ser mayor a 2 si $R_4 > R_5$
pero esto provocará errores en
 ω_0 y Q \therefore se fija $R_4 = R_5$
 \times lo que $H_{MAX} = 2$ cuando $\alpha = 1$

$$\Rightarrow T(s) = \frac{5 \cdot 2\alpha \cdot \frac{1}{RC}}{s^2 + 5 \frac{1}{RC} + \frac{1}{(R_1 C)^2}}$$

$$\begin{cases} Q = \frac{R}{R_1} \\ H = 2\alpha \\ \omega_0 = \frac{1}{R_1 C} \end{cases}$$

$$|T_{CBP}(\omega)| = |T_{5051}| \cdot |T_{5052}| \cdot |T_{5053}|$$

$$5051: |T_{5051}| = \frac{5 \cdot 1,207 \cdot \frac{1}{7,981}}{5^2 + 5 \cdot \frac{1}{7,981} + 1^2} = \frac{522 \cdot \frac{1}{10}}{5^2 + 5 \cdot \frac{1}{10} + 1^2}$$

$$\left\{ \begin{aligned} \omega_0 &= \frac{1}{R_{11} C_1} = 1 \end{aligned} \right.$$

$$\left\{ \begin{aligned} Q &= \frac{R_{d1}}{R_{11}} = 7,981 \end{aligned} \right.$$

Propongo $C_1 = 1 \Rightarrow R_{11} = 1$

$$\Rightarrow R_{d1} = Q = 7,981$$

$$2\alpha_1 = 1,207$$

$$Q = 0,604$$

$$R_{b1} = \frac{R_{d1}}{\alpha_1} = \frac{Q}{0,604} = 13,214$$

$$R_{c1} = \frac{R_{d1}}{1 - \alpha_1} = 20,154$$

$$5052: |T_{5052}| = \frac{5 \cdot 2,045 \cdot \frac{0,903}{16,05}}{5^2 + 5 \cdot \frac{0,903}{16,05} + 0,903^2}$$

$$\left\{ \begin{aligned} \omega_0 &= \frac{1}{R_{12} C_2} = 0,903 \end{aligned} \right.$$

propongo $C_2 = 1$

$$\left\{ \begin{aligned} Q &= \frac{R_{d2}}{R_{12}} = 16,05 \end{aligned} \right.$$

$$R_{12} = \frac{1}{0,903} = 1,107$$

$$2\alpha_2 \approx 1 \rightarrow \alpha_2 = 1/2$$

$$R_{d2} = Q \cdot R_{12} = 17,767$$

como $H > 2$ luego
que esta etapa amplifique
1 y luego agregue un amp

$$R_{b2} = \frac{R_{d2}}{\alpha_2} = 35,534 \text{ y } R_{c2} = \frac{R_{d2}}{1 - \alpha_2} = 35,534$$

$$5053: |T_{5053}| = \frac{5 \cdot 4,768 \cdot \frac{1,107}{16,05}}{5^2 + 5 \cdot \frac{1,107}{16,05} + 1,107^2}$$

En este caso $H > 2 \therefore$ como el GIC solo puede amplificar
2 veces como máximo, se agregará una etapa amplificadora.

$$\Rightarrow \text{se propone } 2\alpha_3 = 1 \Rightarrow \alpha_3 = 1/2$$

$$\left\{ \begin{aligned} \omega_0 &= \frac{1}{R_{13} C_3} = 1,107 \end{aligned} \right.$$

se propone $C_3 = 1$

$$\left\{ \begin{aligned} Q &= \frac{R_{d3}}{R_{13}} = 16,05 \end{aligned} \right.$$

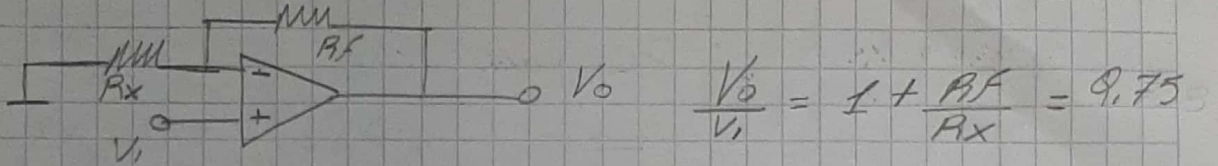
$$\Rightarrow R_{13} = \frac{1}{1,107} = 0,903$$

$$R_{d3} = Q \cdot R_{13} = 14,493$$

$$R_{b3} = \frac{R_{d3}}{\alpha_3} = 28,986$$

$$R_{c3} = \frac{R_{d3}}{1 - \alpha_3} = 28,986$$

Amplificador no inversor de $4,768 \cdot 2,045 = 9,75$



Propongo $R_x = 1 \Rightarrow R_F = 8,75$.