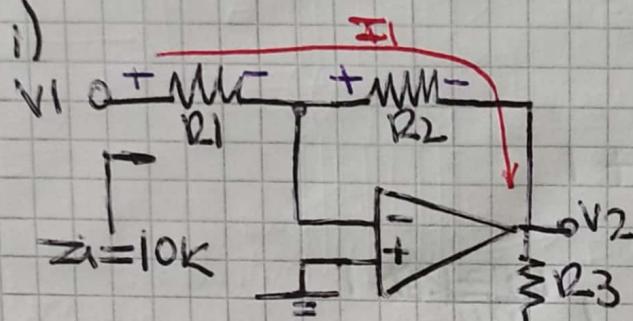


TRABAJO PRÁCTICO N° 1

i)



$$Z_i = 10k\Omega$$

$$AV = -3000$$

$$I_1 = \frac{V_1 - V_2}{R_1 + R_2} = -\frac{V_2}{R_2} \Rightarrow V_1 R_2 - V_2 R_2 = -V_2 R_2 - V_2 R_1$$

$$\boxed{\frac{V_2}{V_1} = -\frac{R_2}{R_1}}$$

$$Z_i = R_1 = 10k\Omega$$

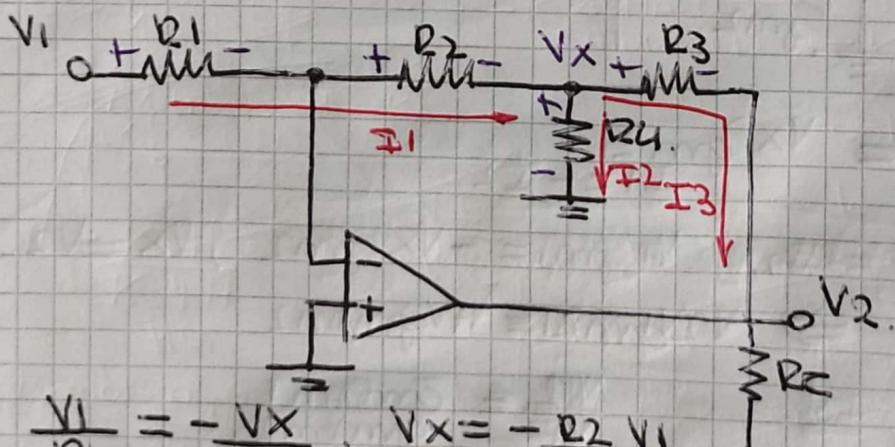
$$\Rightarrow R_2 = 3000 R_1$$

$$\boxed{R_2 = 30M\Omega}$$

$$I_1 = \frac{V_1}{R_1}$$

$$\frac{V_1}{I_1} = R_1$$

$$\boxed{Z_i = R_1}$$



$$\frac{V_1}{R_1} = -\frac{V_x}{R_2}, \quad V_x = -\frac{R_2}{R_1} V_1$$

$$\frac{V_1}{R_1} = \frac{V_x}{R_4} + \frac{V_x - V_2}{R_3} = -\frac{R_2}{R_1 R_4} V_1 - \frac{R_2}{R_1 R_3} V_1 - \frac{V_2}{R_3}$$

$$V_1 \left( \frac{1}{R_1} + \frac{R_2}{R_1 R_4} + \frac{R_2}{R_1 R_3} \right) = -\frac{V_2}{R_3}$$

$$V_1 \frac{1}{R_1} \left[ 1 + R_2 \left( \frac{1}{R_4} + \frac{1}{R_3} \right) \right] = -\frac{V_2}{R_3}$$

NOTA

$$T = -\frac{R_3}{R_1} \left[ 1 + \left( \frac{1}{R_4} + \frac{1}{R_2} \right) \right]$$

$$z_1 = R_1 = 10k$$

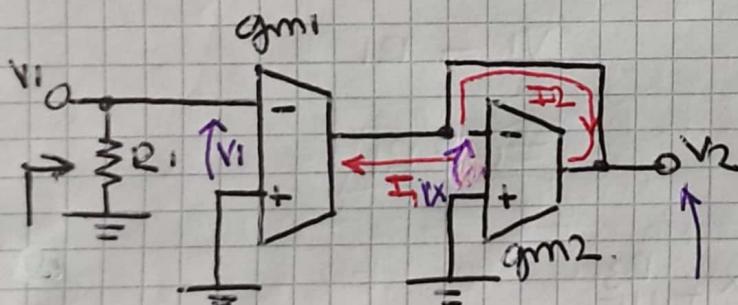
$$30M = R_3 + \frac{R_2}{R_4} R_3 + 1$$

$$30M \approx R_3 \left( 1 + \frac{R_2}{R_4} \right)$$

$$\frac{R_2}{R_4} = 100 \Rightarrow R_3 = 297k\Omega$$

$$R_3 = 300k\Omega, R_2 = 100k\Omega, R_4 = 1k$$

$$T = -3040$$



$$I_1 = V_1 g_{m1}$$

$$+ V_x g_{m2} = I_2 \quad \left. \begin{array}{l} V_1 g_{m1} = -V_x g_{m2}, \\ V_x = V_2. \end{array} \right.$$

$$V_1 g_{m1} = -V_2 g_{m2}$$

$$\frac{V_2}{V_1} = -\frac{g_{m1}}{g_{m2}}$$

$$T = -\frac{g_{m1}}{g_{m2}}$$

$$z_1 = R_1 = 10k$$

$$\frac{g_{m1}}{g_{m2}} = 3k, \quad g_{m2} = 0,1ms \Rightarrow g_{m1} = 0,3 \text{ Vs.}$$

Circuito 1 → Ventaja: simple de Armar,  $Z_i$  definida

por  $R_1$

Desventaja: si quiero  $Z_i$  alto y mucha AV.

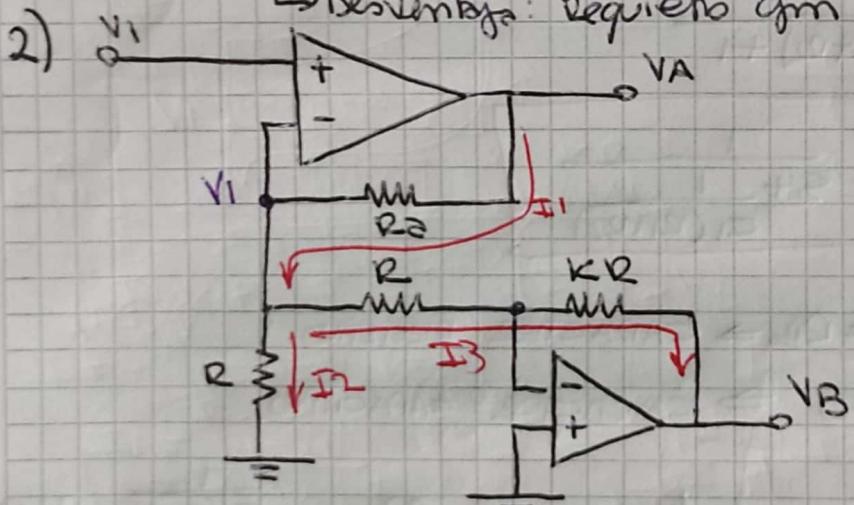
$R_2$  debe ser muy ALTA.

Circuito 2 → Ventaja:  $Z_i$  definido por  $R_1$ , puedo obtener  $Z_i$  alto y MUCHA AV con resistencias normales no tan altas

Desventaja: MÁS DIFÍCIL DE CALCULAR.

Circuito 3 → Ventaja:  $Z_i$  y AV independientes entre sí.

Desventaja: Requiere gpm alto para AV alta.



$$\frac{V_B}{V_1} = -\frac{KR}{R} \Rightarrow V_B = -K V_1$$

$$I_1 = I_2 + I_3$$

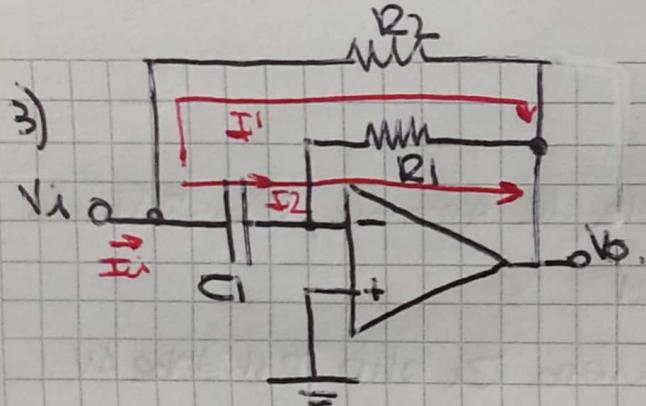
$$\frac{V_B - V_1}{R_2} = \frac{V_1}{R} + \frac{V_1 - V_B}{R + KR} = \frac{V_1}{R} + \frac{V_1 + KV_1}{R(K+1)}$$

$$V_A - V_1 = \frac{R_2}{R} V_1 + V_1 \frac{R_2}{R} \frac{K+1}{K}$$

$$V_A = V_1 + \frac{2R(K+1)}{2R} V_1 = V_1 (1 + K)$$

$$V_A = V_1 K \Rightarrow V_A - V_B = V_1 K + K V_1$$

$$\boxed{V_A - V_B = 2K V_1}$$



$$I_i = I_1 + I_2 = \frac{V_i - V_o}{R_2} + V_i s C_1, \quad -\frac{V_o}{R_1} = V_i s C_1$$

$$I_i = \frac{V_i + s C_1 R_1 V_o + V_i s C_1}{R_2}$$

$$V_o = -s C_1 R_1 V_i$$

$$I_i = V_i \left( \frac{1 + s C_1 R_1}{R_2} + s C_1 \right)$$

$$I_i = V_i \frac{s C_1 (R_1 + R_2) + 1}{R_2}$$

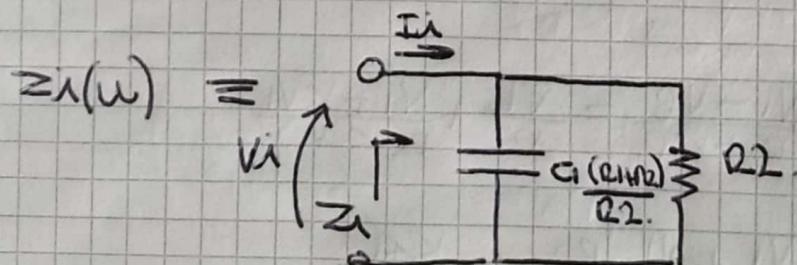
$$\frac{V_i}{I_i} = \frac{R_2}{s C_1 (R_1 + R_2) + 1}$$

$$Z_i = \frac{R_2}{(R_1 + R_2) s C_1} + \frac{1}{s C_1 (R_1 + R_2)}$$

Si  $\omega = 0$ ,  $Z_i = R_2 \Rightarrow$  CARÁCTER RESISTIVO

Si  $\omega \rightarrow \infty$ ,  $Z_i \rightarrow 0 \Rightarrow$  CARÁCTER CAPACITIVO

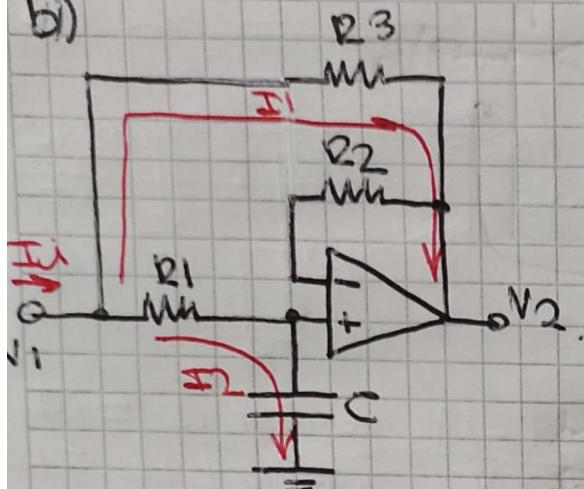
$$Z_i(\omega) = \frac{1}{j \omega C_1 \frac{(R_1 + R_2)}{R_2} + \frac{1}{R_2}}$$



$$C = C_1 \frac{(R_1 + R_2)}{R_2}$$

LA  $Z_i$  es un capacitor con una resistencia en PARALELO

b)



$$I_1 = \frac{V_1 - V_2}{R_1} + \frac{V_1}{R_1 + \frac{1}{SC}} , \quad I_2 = V_2 SC$$

$$I_3 = \frac{V_1}{R_2} - \frac{V_1}{SC(R_1+R_2+R_3)} + \frac{V_1}{R_1 + \frac{1}{SC}} \quad \frac{V_1}{R_1 + \frac{1}{SC}} = V_2 SC$$

$$I_3 = \frac{V_1}{R_2} - \frac{V_1}{R_2(SC(R_1+1))} + \frac{SC}{SC(R_1+1)} \frac{V_1}{SC(R_1+1)} = V_2$$

$$I_3 = V_1 \left( \frac{SC(R_1+1) - 1 + SC R_3}{R_2 (SC(R_1+1))} \right) = V_1 \frac{SC(R_1+R_3)}{(SC(R_1+1)) R_2}$$

$$Z_i = R_2 \frac{\frac{SC(R_1+1)}{SC(R_1+R_3)}}{S} = \frac{R_2 R_1}{R_1+R_2} \frac{S + \frac{1}{SC(R_1+1)}}{S}$$

$$Z_i = R_2 // R_1 \frac{S + \frac{1}{SC(R_1+1)}}{S}$$

Si  $\omega \rightarrow 0$   $Z_i \rightarrow \infty$ .

⇒ CARÁCTER CAPACITIVO

Si  $\omega \rightarrow \infty$   $Z_i \rightarrow R_2 // R_1$

⇒ CARÁCTER RESISTIVO

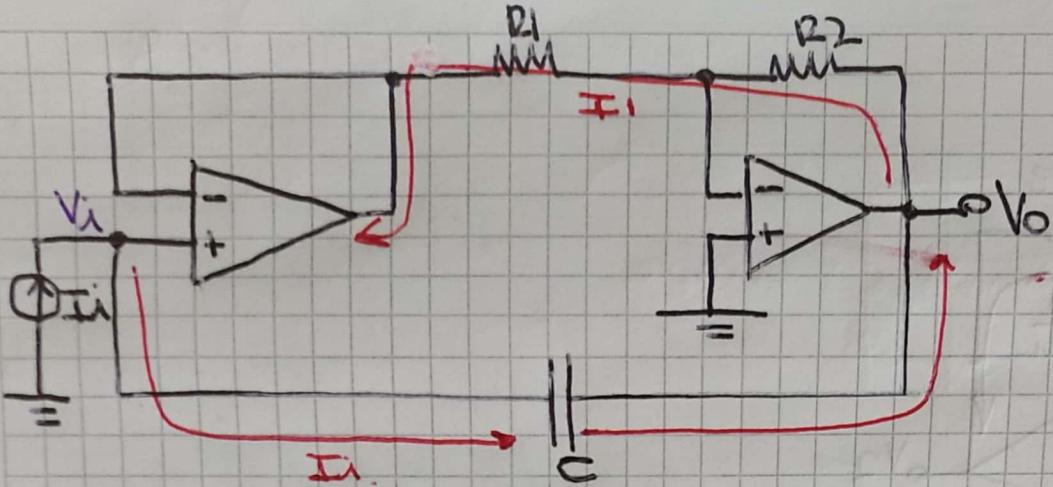
$$Z_i = R_2 // R_1 + \frac{R_2 // R_1}{j\omega C R_1} = R_2 // R_1 + \frac{1}{j\omega C \frac{R_1}{R_2 // R_1}}$$

$$Z_i = \frac{R_2 // R_1}{R_2 // R_1 + j\omega C R_1}$$

$$R = R_2 // R_1$$

$$C = C \frac{R_1}{R_2 // R_1}$$

LA  $Z_i$  es un capacitor en una resistencia en PARALELO

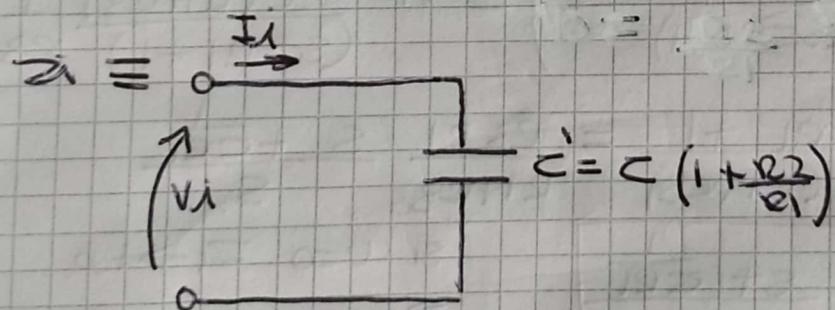


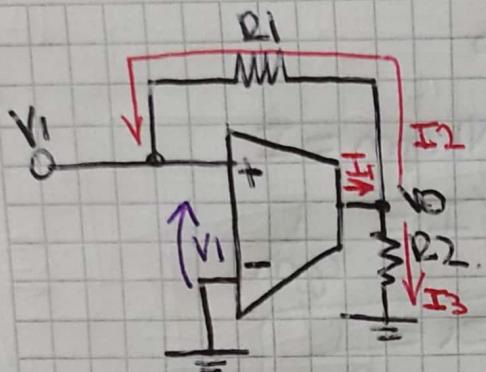
$$\frac{V_i - V_o}{\frac{1}{SC}} = I_1 \quad V_o = -\frac{R_2}{R_1} V_i$$

$$(V_i + \frac{R_2}{R_1} V_i) SC = I_1$$

$$V_i (1 + \frac{R_2}{R_1}) SC = I_1$$

$$Z_i = \frac{i}{SC (1 + \frac{R_2}{R_1})} \Rightarrow \text{CARÁTER CAPACITIVO}$$





$$I_1 = I_2 = I_1 - I_3 = V_i g_m - \frac{V_o}{R_2}$$

$$I_1 = V_i g_m - \frac{V_o}{R_2}, \quad I_2 = \frac{V_o - V_i}{R_1}$$

$$\frac{V_o - V_i}{R_1} = V_i g_m - \frac{V_o}{R_2}$$

$$V_o - V_i = V_i g_m R_1 - \frac{R_1}{R_2} V_o$$

$$V_o \left( 1 + \frac{R_1}{R_2} \right) = V_i \left( 1 + g_m R_1 \right)$$

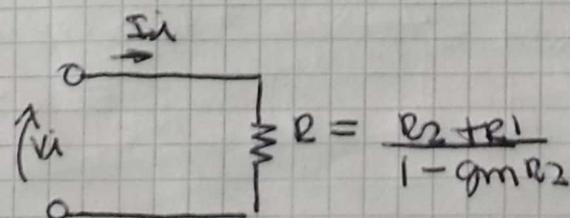
$$V_o = V_i \frac{\left( 1 + g_m R_1 \right)}{1 + \frac{R_1}{R_2}}$$

$$I_1 = \left[ V_i g_m - \frac{V_i}{R_2} \frac{1 + g_m R_1}{1 + \frac{R_1}{R_2}} \right] = V_i g_m - V_i \frac{(1 + g_m R_1)}{R_2 + R_1}$$

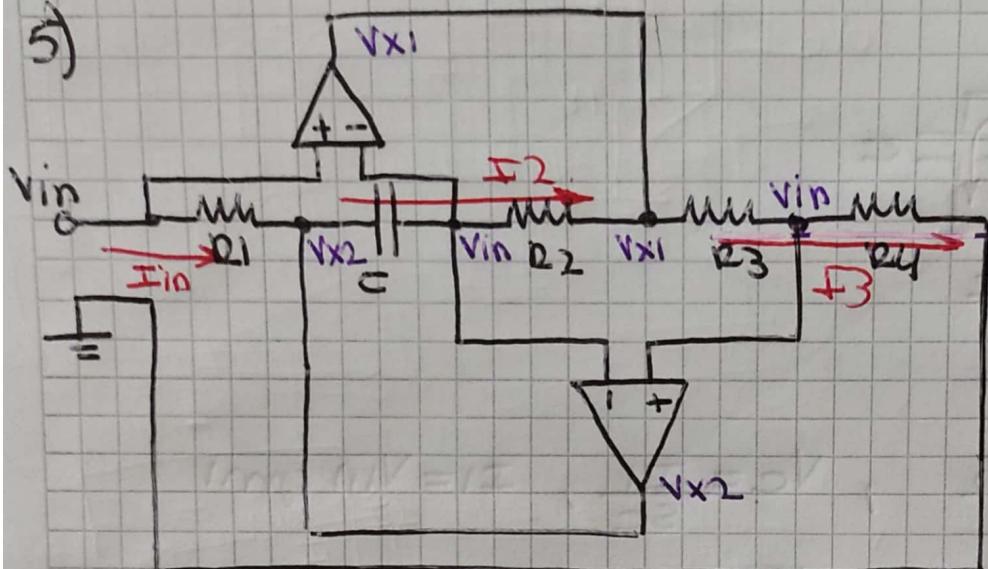
$$I_1 = \left[ V_i \left( g_m - \frac{1 + g_m R_1}{R_2 + R_1} \right) \right] = V_i \left( g_m R_2 - 1 \right) \frac{1}{R_2 + R_1}$$

$$Z_1 = \frac{R_2 + R_1}{g_m R_2 + 1}$$

$\Rightarrow$  CARÁCTER RESISTIVO



5)



$$\text{I}_{10} = \frac{V_{in} - V_{x2}}{R_1}$$

$$(V_{x2} - V_{in}) sC = \frac{(V_{in} - V_{x1})}{R_2}$$

$$V_{x2} = V_{in} \left( 1 + \frac{1}{sCR_2} \right) - \frac{V_{x1}}{sCR_2} \quad \left| \begin{array}{l} V_{x2} = \frac{V_{in} - V_{x1}}{sCR_2} + V_{in} \\ V_{x1} = \frac{V_{in} - V_{x2}}{sCR_2} \end{array} \right.$$

$$V_{x2} = V_{in} \left( 1 + \frac{1}{sCR_2} \right) - \frac{\left( 1 + \frac{R_3}{R_4} \right) V_{in}}{sCR_2}$$

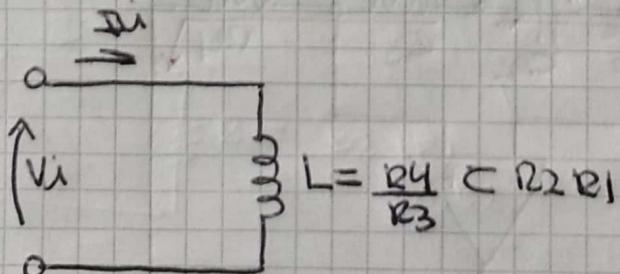
$$\frac{V_{x1} - V_{in}}{R_3} = \frac{V_{in}}{R_4}$$

$$V_{x1} = \frac{R_3}{R_4} V_{in} + V_{in}$$

$$I_{in} = \frac{V_{in} - V_{in} \left( 1 - \frac{R_3}{R_4} \right)}{R_1} \quad V_{x1} = V_{in} \left( 1 + \frac{R_3}{R_4} \right)$$

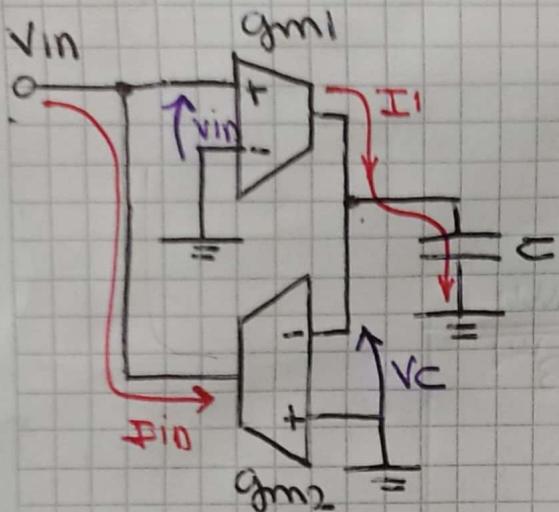
$$I_{in} = + V_{in} \frac{\frac{R_3}{R_4}}{sCR_2 R_1}$$

$$Z_m(s) = \frac{R_4}{R_3} sCR_2 R_1 \Rightarrow \text{INDUCTOR}$$



$$L = \frac{R_4}{R_3} C R_2 R_1$$

NOTA

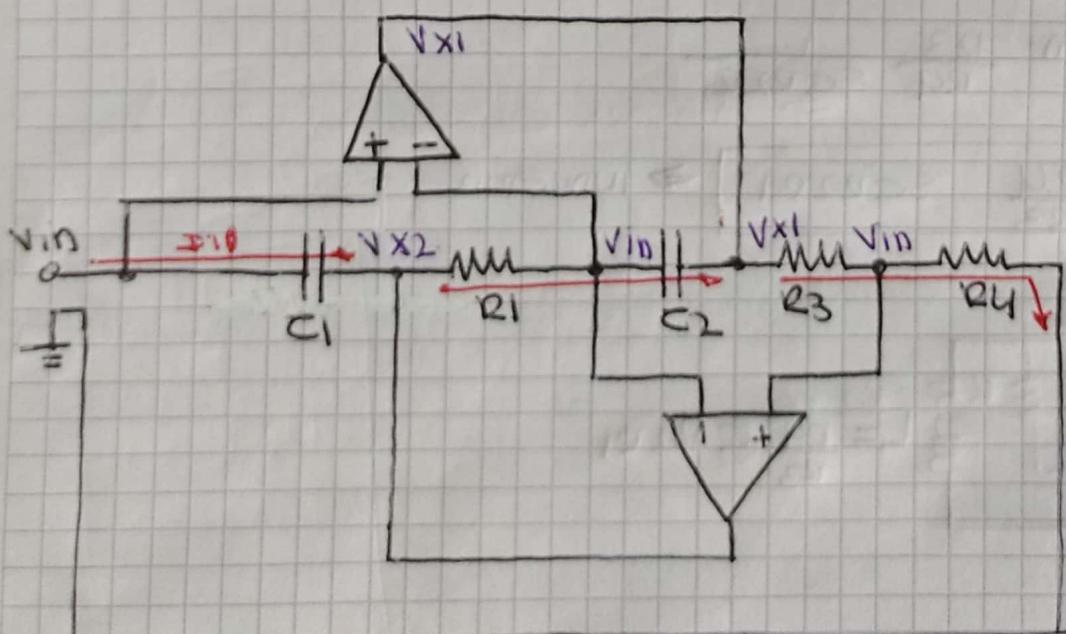
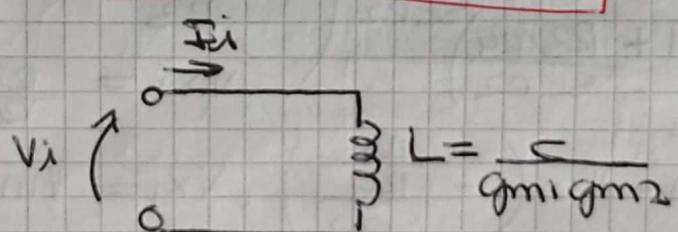


$$f_{in} = V_C \cdot g_{m2}, \quad V_C = \frac{I_L}{S_C}, \quad I_1 = V_{in} \cdot g_{m1}$$

$$V_C = \frac{V_{in} \cdot g_{m1}}{S_C}$$

$$f_{in} = V_{in} \frac{g_{m1} \cdot g_{m2}}{S_C}$$

$$Z_{in} = \frac{S_C}{g_{m1} \cdot g_{m2}} \Rightarrow \text{INDUCTOR}$$



NOTA

$$I_{in} = (V_{in} - V_{x2}) S C_1$$

$$\frac{(V_{x2} - V_{in})}{R_1} = (V_{in} - V_{x1}) S C_2$$

$$V_{x2} = S C_2 R_1 \left[ V_{in} - V_{in} \left( 1 + \frac{R_3}{R_4} \right) \right] + V_{in}$$

$$V_{x2} = \left( S C_2 R_1 \frac{R_3}{R_4} + 1 \right) V_{in}$$

$$I_{in} = S C_1 V_{in} \left( S C_2 \frac{R_1 R_3}{R_4} \right)$$

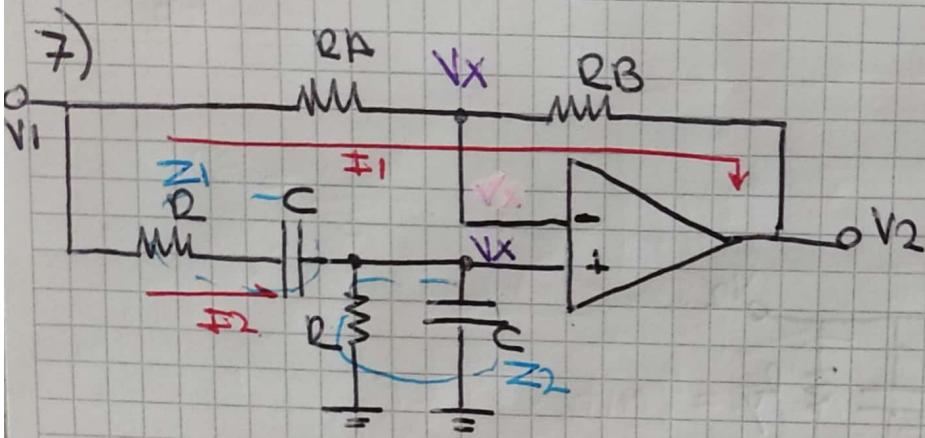
$$I_{in} = S^2 \frac{C_1 C_2 R_1 R_3}{R_4} V_{in}$$

$$\frac{V_{in}}{I_{in}} = \frac{R_4}{S^2 C_1 C_2 R_1 R_3}$$

$$Z_{in}(s) = \frac{R_4}{S^2 C_1 C_2 R_1 R_3}$$

$$\hookrightarrow \text{si } s = j\omega \quad Z_{in}(\omega) = \frac{-1}{\omega^2} \frac{R_4}{C_1 C_2 R_1 R_3}$$

RESISTOR NEGATIVO  
DEPENDIENTE DE LA FRECUENCIA



$$\frac{V_1 - V_x}{R_A} = \frac{V_x - V_2}{R_B}, \quad V_x = V_1 \frac{z_2}{z_2 + z_1}$$

$$V_x = V_1 \frac{\frac{R_1}{S C R_1 + 1}}{\frac{R_1}{S C R_1 + 1} + \frac{S C R + 1}{S C}}$$

$$V_x = V_1 \frac{\frac{1}{R_1 + S C}}{\frac{1}{R_1 + S C} + R + \frac{1}{S C}}$$

$$V_x = V_1 \frac{\frac{R_1}{S C R_1 + 1}}{\frac{S C R_1 + S^2 C^2 R R_1 + S C (R + 2 R_1) + 1}{(S C R_1 + 1) S C}}$$

$$V_x = V_1 \frac{S C R_1}{S^2 C^2 R R_1 + S C (R + 2 R_1) + 1}$$

$$V_1 - V_x = \frac{R_A}{R_B} (V_x - V_2) \Rightarrow V_1 - V_1 A(s) = \frac{R_A}{R_B} (V_1 A(s) - V_2(s))$$

$$V_1 \left[ 1 - A(s) - \frac{R_A}{R_B} A(s) \right] = - \frac{R_A}{R_B} V_2(s)$$

$$V_1 \left[ 1 - A(s) \left( 1 + \frac{R_A}{R_B} \right) \right] = - \frac{R_A}{R_B} V_2(s)$$

$$\frac{V_2(s)}{V_1(s)} = - \frac{R_B}{R_A} \left[ 1 - A(s) \left( 1 + \frac{R_A}{R_B} \right) \right]$$

NOTA

$$T(s) = -\frac{R_B}{R_A} \left[ 1 - \frac{SCR_1}{s^2 C^2 R_1 + SC(R+2R_1) + 1} \right] \left( 1 + \frac{R_A}{R_B} \right)$$

$$T(s) = -\frac{R_B s}{R_A} \left[ \frac{s^2 C^2 R^2 + SC3R + 1 - SC R \left( 1 + \frac{R_A}{R_B} \right)}{s^2 C^2 R^2 + SC3R + 1} \right]$$

$$T(s) = -\frac{R_B}{R_A} \frac{s^2 + s \frac{3}{CR} - s \frac{1}{CR} \left( 1 + \frac{R_A}{R_B} \right) + 1/C^2 R^2}{s^2 + s \frac{3}{CR} + 1/C^2 R^2}$$

$$T(s) = -\frac{1}{5} \frac{s^2 + s \frac{3}{CR} - s \frac{1}{CR} (1+s) + 1/C^2 R^2}{s^2 + s \frac{3}{CR} + 1/C^2 R^2}$$

$$\boxed{T(s) = -\frac{1}{5} \frac{s^2 - s \frac{3}{CR} + \frac{1}{C^2 R^2}}{s^2 + s \frac{3}{CR} + \frac{1}{C^2 R^2}}}$$

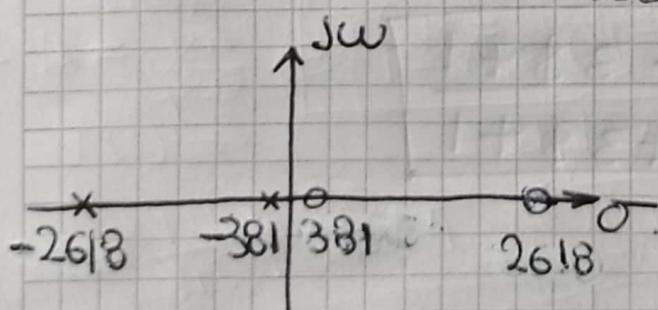
$$C = 1/MF, R = 1/K$$

$$\text{zeros} = 2618$$

$$-381, 97$$

$$\text{poles} = -2618$$

$$-381, 97$$



$$|T(0)| = \frac{2618, 381}{2618, 381} \approx \frac{1}{5} \left\{ \begin{array}{l} |T(w \rightarrow \infty)| = \frac{1}{\sqrt{1 + \frac{1}{s^2}}} \approx \frac{1}{s} \\ |T(w \rightarrow 0)| = \frac{1}{s} \end{array} \right.$$

$$|T(0)| = \frac{1}{5} \quad \left. \begin{array}{l} \text{inf de} \\ \text{de MISMA MAG} \end{array} \right)$$

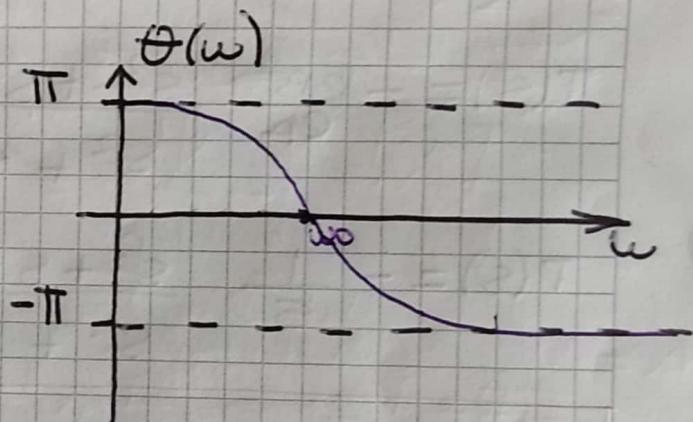
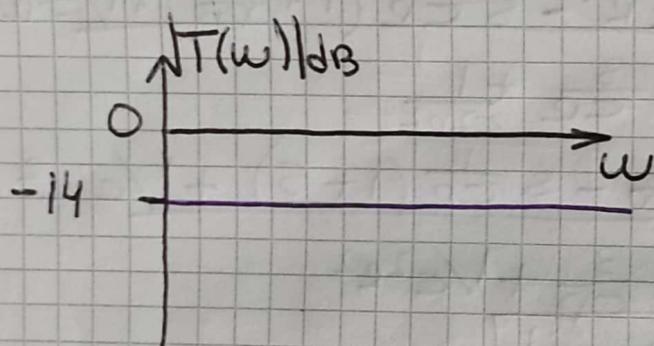
$$\Theta(0) = (\pi + \pi - 0 - 0) - \pi$$

$$\Theta(0) = \pi - \pi$$

$$\Theta(\omega \rightarrow +\infty) = (\pi/2 + \pi/2 - \pi/2 - \pi/2) - \pi$$

$$\Theta(\omega \rightarrow +\infty) = -\pi$$

$$\Theta(\omega_0) = \pi - \pi = 0.$$



b-  $\omega_0 = \frac{1}{CR} \Rightarrow \omega_0 = \frac{1}{CR}, \quad \$ = \frac{5}{1/CR}$ .

$$\Rightarrow T(\$) = -\frac{1}{5} \frac{\$^2 \frac{1}{(CR)^2} - \$ \frac{1}{CR} \frac{3}{CR} + \frac{1}{(CR)^2}}{\$^2 \frac{1}{(CR)^2} + \$ \frac{1}{CR} \frac{3}{CR} + \frac{1}{(CR)^2}}$$

$$T(\$) = -\frac{1}{5} \frac{\$^2 - 3\$ + 1}{\$^2 + 3\$ + 1}$$

donde  $\omega_0 = RB$

$$\Rightarrow RB' = 1$$

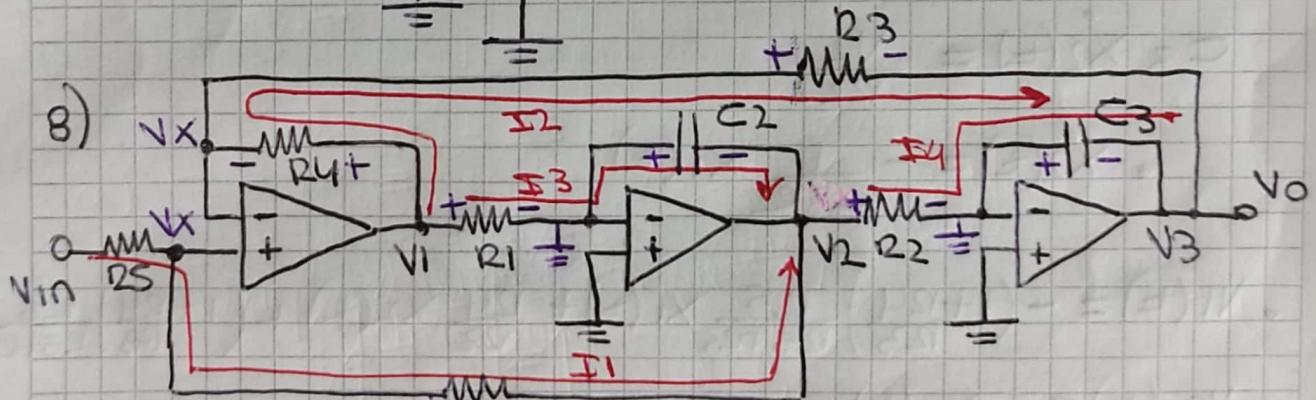
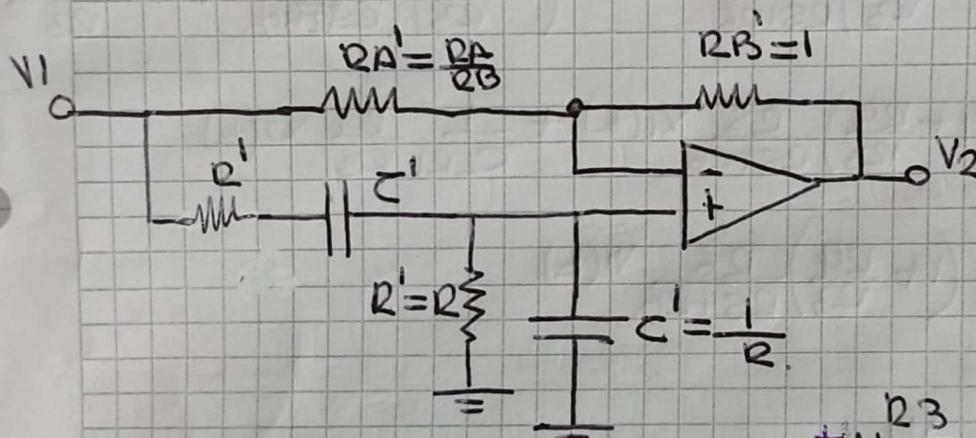
$$RA' = \frac{RA}{\omega_0} = \frac{RA}{RB}$$

$$\Rightarrow T(\$) = -\frac{1}{RA'} \frac{\$^2 - \$ (RA' - 2) + 1}{\$^2 + \$ 3 + 1}$$

NOTA

$$\Rightarrow Z_C = \frac{1}{sC} = \frac{1}{s \frac{1}{Z_R}} = \frac{1}{\frac{1}{s} \frac{1}{(R_C C)}}$$

$$\begin{cases} C' = \frac{1}{R} \\ R' = R \end{cases}$$



$$X(t) = \begin{bmatrix} X_1(t) \\ X_2(t) \end{bmatrix} = \begin{bmatrix} V_{C2}(t) \\ V_{C3}(t) \end{bmatrix}$$

$$C_2 \dot{X}_1(t) = \frac{V_1}{R_1}, \quad \frac{V_1 - V_X}{R_4} = \frac{V_X - V_3}{R_3}, \quad V_3 = -X_2(t).$$

$$\frac{V_1 - V_X}{R_4} = \frac{V_X + X_2(t)}{R_3}, \quad \frac{V_X - V_2}{R_6} = \frac{V_2 - V_X}{R_5}.$$

$$V_2 = -X_1(t).$$

$$V_X = \frac{R_6}{R_5} \frac{R_5}{R_5 + R_6} V_1 - \frac{R_5}{R_5 + R_6} X_1(t).$$

$$V_X = \frac{R_6}{R_5 + R_6} V_1(t) - \frac{R_5}{R_5 + R_6} X_1(t).$$

NOTA

$$V_X \left( 1 + \frac{R_6}{R_5} \right) = \frac{R_6}{R_5} V_1 - X_1(t)$$

$$V_1 = \frac{R_4}{R_3} (Vx + x_2) + Vx$$

$$V_1 = Vx \left( 1 + \frac{R_4}{R_3} \right) + \frac{R_4}{R_3} x_2(t)$$

$$\dot{x}_1(t) = \frac{1}{C_2 R_1} \left[ Vx \left( 1 + \frac{R_4}{R_3} \right) + \frac{R_4}{R_3} x_2(t) \right]$$

$$\dot{x}_1(t) = \frac{1}{C_2 R_1} \left[ \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} V_1(t) - \left( 1 + \frac{R_4}{R_3} \right) \frac{R_5}{R_5 + R_6} x_1(t) + \frac{R_4}{R_3} x_2(t) \right]$$

$$\begin{aligned} \dot{x}_1(t) = & - \frac{1}{C_2 R_1} \left( 1 + \frac{R_4}{R_3} \right) \frac{R_5}{R_5 + R_6} x_1(t) + \frac{1}{C_2 R_1} \frac{R_4}{R_3} x_2(t) \\ & + \frac{1}{C_2 R_1} \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} V_1(t) \end{aligned}$$

$$C_3 \dot{x}_2(t) = \frac{V_2}{R_2}$$

$$x_2(t) = - \frac{1}{C_3 R_2} x_1(t)$$

$$V_1(t) = - \left( 1 + \frac{R_4}{R_3} \right) \frac{R_5}{R_5 + R_6} x_1(t) + \frac{R_4}{R_3} x_2(t) + \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} V_1(t)$$

$$V_2(t) = - x_1(t)$$

$$V_3(t) = - x_2(t)$$

$$\begin{bmatrix} \dot{x}_1(t) \\ x_2(t) \end{bmatrix} = \begin{bmatrix} - \frac{1}{C_2 R_1} \left( 1 + \frac{R_4}{R_3} \right) \frac{R_5}{R_5 + R_6} & \frac{1}{C_2 R_1} \frac{R_4}{R_3} \\ - \frac{1}{C_3 R_2} & 0 \end{bmatrix} + \begin{bmatrix} \frac{1}{C_2 R_1} \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} V_1(t) \\ V_2(t) \\ V_3(t) \end{bmatrix} = \begin{bmatrix} - \left( 1 + \frac{R_4}{R_3} \right) \frac{R_5}{R_5 + R_6} & \frac{R_4}{R_3} \\ -1 & 0 \\ 0 & -1 \end{bmatrix} + \begin{bmatrix} \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} \\ 0 \\ 0 \end{bmatrix} V_1(t)$$

NOTA

$$(S\bar{I} - A) = \begin{bmatrix} S + \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_5}{R_5 + R_6} & -\frac{1}{C_2 R_1} \frac{R_4}{R_3} \\ \frac{1}{C_3 R_2} & S \end{bmatrix}$$

$$\det(S\bar{I} - A) = S^2 + S \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_5}{R_5 + R_6} + \frac{1}{C_2 C_3 R_1 R_2 R_3} \frac{R_4}{R_3}$$

$$(S\bar{I} - A)^{-1} = \frac{1}{\det} \begin{bmatrix} S & +\frac{1}{C_2 R_1} \frac{R_4}{R_3} \\ -\frac{1}{C_3 R_2} & S + \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_5}{R_5 + R_6} \end{bmatrix}$$

$$(S\bar{I} - A)^{-1} B = \frac{1}{\det} \begin{bmatrix} S & \frac{1}{C_2 R_1} \frac{R_4}{R_3} \\ -\frac{1}{C_3 R_2} & S + \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_5}{R_5 + R_6} \end{bmatrix} \begin{bmatrix} \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6} \\ 0 \end{bmatrix}$$

$$= \frac{1}{\det} \begin{bmatrix} S \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6} \\ -\frac{1}{C_2 C_3 R_1 R_2} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6} \end{bmatrix}$$

$$C(S\bar{I} - A)^{-1} B = \frac{1}{\det} \begin{bmatrix} -\left(1 + \frac{R_4}{R_3}\right) \frac{R_5}{R_5 + R_6} & \frac{R_4}{R_3} \\ -1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} S \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6} \\ -\frac{1}{C_2 C_3 R_1 R_2} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6} \end{bmatrix}$$

$$= \frac{1}{\det} \begin{bmatrix} -S \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right)^2 \frac{R_5 R_6}{(R_5 + R_6)^2} - \frac{1}{C_2 C_3 R_1 R_2} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6} \frac{R_4}{R_3} \\ -S \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6} \\ + \frac{1}{C_2 C_3 R_1 R_2} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6} \end{bmatrix}$$

$$T_2(s) = \frac{V_2}{V_{in}} = \frac{-s \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6}}{s^2 + s \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \frac{R_5}{R_5 + R_6} + \frac{1}{C_2 C_3 R_1 R_2} \frac{R_4}{R_3}}$$

$$\omega_0 = \sqrt{\frac{1}{C_2 C_3 R_1 R_2} \frac{R_4}{R_3}}$$

$$\left. \begin{array}{l} |T_2(0)| = 0 \\ |T_2(\omega \rightarrow +\infty)| = 0 \\ |T_2(\omega_0)| = \frac{R_6}{R_5} \end{array} \right\} \Rightarrow \text{FILTRO PASA BANDA}$$

$$T_3(s) = \frac{V_3}{V_{in}} = \frac{\frac{1}{C_2 C_3 R_1 R_2} \left(1 + \frac{R_4}{R_3}\right) \frac{R_6}{R_5 + R_6}}{s^2 + s \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \left(\frac{R_5}{R_5 + R_6}\right) + \frac{1}{C_2 C_3 R_1 R_2} \frac{R_4}{R_3}}$$

$$T_3(s) = \frac{V_3}{V_{in}} = \frac{\left(\frac{R_3}{R_4} + 1\right) \frac{R_6}{R_5 + R_6} - \frac{1}{C_2 C_3 R_1 R_2} \frac{R_4}{R_3}}{s^2 + s \frac{1}{C_2 R_1} \left(1 + \frac{R_4}{R_3}\right) \left(\frac{R_5}{R_5 + R_6}\right) + \frac{1}{C_2 C_3 R_1 R_2} \frac{R_4}{R_3}}$$

$$\left. \begin{array}{l} |T(0)| = \left(\frac{R_3}{R_4} + 1\right) \frac{R_6}{R_5 + R_6} \\ |T_3(\omega \rightarrow +\infty)| = 0 \\ |T_3(\omega_0)| = \left(\frac{R_3}{R_4} + 1\right) \frac{R_6}{R_5} \end{array} \right\} \text{FILTRO PASA BAJO}$$

NOTA

$$T_1(\omega) = \frac{V_1}{V_2} = \frac{\det \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} - S \frac{1}{C_2 R_1} \left( 1 + \frac{R_4}{R_3} \right)^2 \frac{R_5 R_6}{(R_5 + R_6)^2}}{-\frac{1}{C_2 C_3 R_1 R_2} \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} \frac{R_4}{R_3}}$$

det.

$$T_1(\omega) = \frac{S^2 \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} + S \frac{1}{C_2 R_1} \left( 1 + \frac{R_4}{R_3} \right)^2 \frac{R_5 R_6}{(R_5 + R_6)^2} + \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6}}{\frac{1}{C_2 C_3 R_1 R_2} \frac{R_4}{R_3} - S \frac{1}{C_2 R_1} \left( 1 + \frac{R_4}{R_3} \right)^2 \frac{R_5 R_6}{(R_5 + R_6)^2}}$$

$$-\frac{1}{C_2 C_3 R_1 R_2} \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} \frac{R_4}{R_3}$$

det.

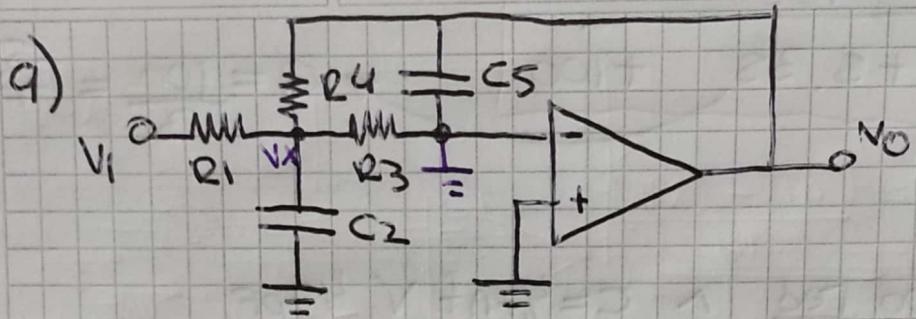
$$T_1(\omega) = \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6} \cdot \frac{S^2}{S^2 + S \frac{1}{C_2 R_1} \left( 1 + \frac{R_4}{R_3} \right) \left( \frac{R_5}{R_5 + R_6} \right) + \frac{R_4}{R_3} C_2 C_3 R_1 R_2}$$

$$|T_1(0)| = 0$$

$$|T_1(\omega \rightarrow \infty)| = \left( 1 + \frac{R_4}{R_3} \right) \frac{R_6}{R_5 + R_6}$$

$$|T_1(\omega_0)| = \omega_0 \frac{R_6}{R_5} \frac{1}{C_2 R_1}$$

FILTRO PASAALLOS



$$\left( \frac{1}{R_1} + \frac{1}{R_4} + S C_2 + \frac{1}{R_3} \right) V_x = \frac{V_1}{R_1} + \frac{V_O}{R_4}$$

$$\frac{V_x}{R_3} = -V_O S C_5, \quad V_x = -S C_5 R_3 V_O.$$

$$-\left( \frac{R_4 R_3 + R_1 R_3 + S C_2 R_1 R_4 R_3 + R_1 R_4}{R_1 R_4 R_3} \right) S C_5 R_3 V_O = \frac{V_1}{R_1} + \frac{V_O}{R_4}$$

$$-\frac{(S^2 C_2 C_5 R_1 R_4 R_3^2 + S C_5 R_3 (R_4 R_3 + R_1 R_3 + R_1 R_4)) V_O - \frac{V_O}{R_4}}{R_1 R_4 R_3} = \frac{V_1}{R_1}$$

$$-\frac{[S^2 C_2 C_5 R_1 R_4 R_3^2 + S C_5 R_3 (R_4 R_3 + R_1 R_3 + R_1 R_4) + R_1 R_3]}{R_1 R_4 R_3} V_O = \frac{V_1}{R_1}$$

$$\frac{V_O(s)}{V_I(s)} = -\frac{R_1 R_3}{S^2 C_2 C_5 R_1 R_4 R_3^2 + S C_5 R_3 (R_4 R_3 + R_1 R_3 + R_1 R_4) + R_1 R_3}$$

$$T(s) = -\frac{\frac{1}{C_2 C_5 R_1 R_3}}{S^2 + S \left[ \frac{1}{C_2 R_1} + \frac{1}{C_2 R_4} + \frac{1}{C_2 R_3} \right] + \frac{1}{C_2 C_5 R_4 R_3}}$$

$$T(s) = -\frac{\frac{R_4}{R_1}}{S^2 + S \left[ \frac{1}{C_2 R_1} + \frac{1}{C_2 R_4} + \frac{1}{C_2 R_3} \right] + \frac{1}{C_2 C_5 R_4 R_3}}$$

$$\omega_0 = \frac{1}{\sqrt{C_2 C_5 R_4 R_3}} = 10 \frac{\text{rad}}{\text{s}} \quad |T(0)| = \frac{R_4}{R_1} = 1$$

NOTA

$$T(s) = - \frac{100}{s^2 + 3s + 100} \rightarrow Q = \frac{100}{3} = 3,3$$

b) si  $\omega_0 = 1000 \frac{\text{rad}}{\text{s}}$   $\wedge C = 4,7 \text{nF}$   $\vee 4,7 \text{pF}$ .

$$Q = 3,3$$

$$\Rightarrow \frac{\omega_0}{Q} = \begin{cases} 300 = \frac{1}{C_2} \left( \frac{1}{R_1} + \frac{1}{R_4} + \frac{1}{R_3} \right) \\ 1M = \frac{1}{C_2 C_5 R_4 R_3} \end{cases} \wedge R_4 = R_3$$

utilizo  $C_2 = 4,7 \text{nF}$   $C_1 = 4,7 \text{pF}$

$$\Rightarrow \begin{cases} 300 = \frac{1}{4,7 \text{nF}} \left( \frac{2}{R_4} + \frac{1}{R_3} \right) \\ 1M = \frac{1}{4,7 \text{nF} \cdot 4,7 \text{pF} \cdot R_4 R_3} \end{cases}$$

$$\checkmark R_4 = R_3 = 2,12 \text{ M}\Omega$$

$$R_4 = 4,25 \text{ M}\Omega \wedge R_3 = 1,06 \text{ M}\Omega$$

$$\Rightarrow \underline{R_4 = 4,3 \text{ M}\Omega} \quad \underline{R_3 = 1 \text{ M}\Omega}$$

$$R_1 = 4,3 \text{ M}\Omega$$

$$R_3 = 1 \text{ M}\Omega$$

$$R_4 = 4,3 \text{ M}\Omega$$

$$C_1 = 4,7 \text{ pF}$$

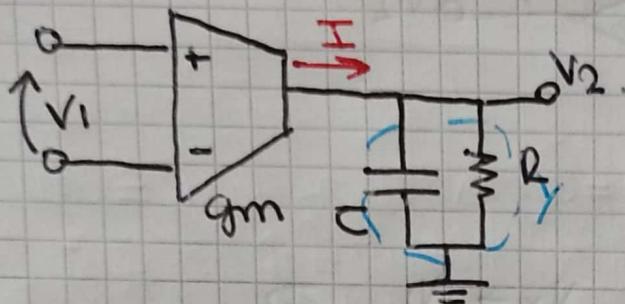
$$C_2 = 4,7 \text{nF}$$

$$Q = 3,3$$

$$\omega_0 = 1026,06 \frac{\text{rad}}{\text{s}}$$

NOTA

10)



$$I(s) = gm V_1(s)$$

$$I(s) \cdot \frac{1}{Y(s)} = gm V_1(s) \frac{1}{Y(s)}$$

$$V_2(s) = gm V_1(s) \frac{1}{\frac{1}{R} + sC}$$

$$\frac{V_2(s)}{V_1(s)} = \frac{gm R}{sCR + 1}$$

$$T(s) = \frac{\frac{gm}{s}}{s + \frac{1}{CR}}$$

$$T(s) = \frac{5 \times 10^{10} \text{ gm}}{s + 5 \times 10^6}$$