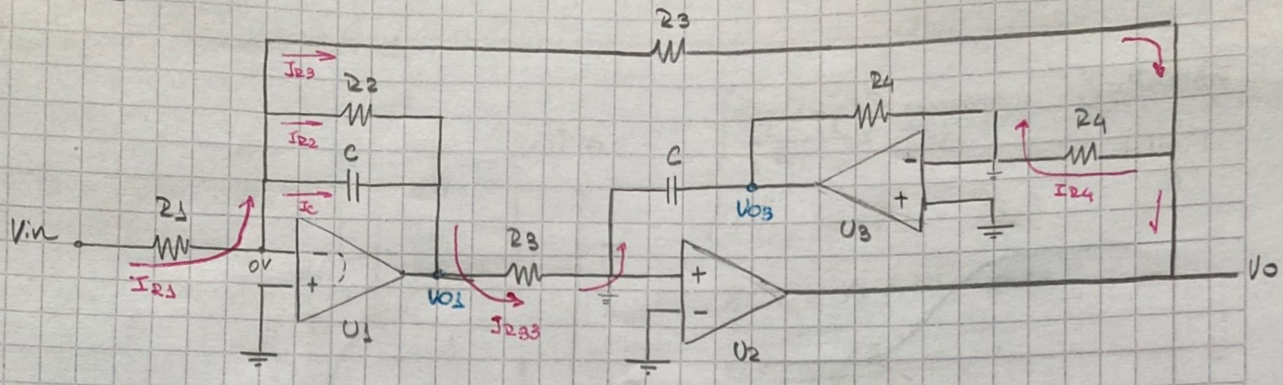
T 8 2



$$\frac{V_{in}}{R_1} = I_{R1} \qquad I_{R1} = I_C + I_{R2} + I_{R3} = -V_{O1}\, sC - \frac{V_{O1}}{R_2} - \frac{V_O}{R_3}$$

$$\frac{V_{in}}{R_1} = -V_{O1}\left(sC + \frac{1}{R_2}\right) - \frac{V_O}{R_3}$$

$$\frac{V_{O1}}{R_3} = -V_{O3}\, sC$$

$$\frac{V_O}{\cancel{R_4}} = -\frac{V_{O3}}{\cancel{R_4}} \longrightarrow V_{O3} = -V_O \longrightarrow \frac{V_{O1}}{R_3} = V_O\, sC \longrightarrow V_{O1} = V_O \cdot sC R_3$$

$$\frac{V_{in}}{R_1} = -V_O\, sCR_3\left(sC + \frac{1}{R_2}\right) - \frac{V_O}{R_3} = -V_O\left(s^2C^2R_3 + \frac{sCR_3}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{V_O}{V_i} = \frac{1}{R_1} \cdot \frac{-1}{s^2C^2R_3 + sC\frac{R_3}{R_2} + \frac{1}{R_3}} = \frac{1}{R_1} \cdot \frac{1}{C^2R_3} \cdot \frac{-1}{s^2 + s \cdot \frac{1}{CR_2} + \frac{1}{C^2R_3^2}}$$

$$T(s) = \frac{-1/C^2R_1R_3}{s^2 + s \cdot \frac{1}{CR_2} + \frac{1}{C^2R_3^2}} \Longrightarrow \frac{1}{C^2R_3^2} = \omega_0^2 \wedge \frac{1}{CR_2} = \frac{\omega_0}{Q} \qquad Q = \frac{R_2}{R_3}$$

$$T(s) = -\frac{\frac{R_3}{R_1}\,\omega_0^2}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2} = k\,\frac{\omega_0^2}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2} \qquad \text{con } k = -\frac{R_3}{R_1}$$

b) $\omega_0 = 1 \wedge Q = 3 \Longrightarrow \begin{cases} 3 = \frac{R_2}{R_3} \longrightarrow 3R_3 = R_2 \\ 1 = \frac{1}{CR_3} \longrightarrow R_3 = \frac{1}{C} \end{cases}$

ω_0 y Q no dependen de R_1 y R_4. $R_2 = 3R_3 \wedge C = \frac{1}{R_3}$

NOTA

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HOJA Nº 3

FECHA

c) $|T(0)| = 20\ dB$

$|T(0)| = \frac{R_3}{R_1}$ $\quad |T(0)|_{[dB]} = 20 \log\left(\frac{R_3}{R_1}\right) = 20\ dB$

$\log\left(\frac{R_3}{R_1}\right) = 1\ dB \longrightarrow 10 = \frac{R_3}{R_1} \longrightarrow R_1 = \frac{R_3}{10}$

Bonus

I) $\Omega_\omega = \frac{1}{R_3 C}$ normalizando $T(s) = k \frac{1}{s^2 + s\frac{R_3}{R_2} + 1}$

$\Omega_z = R_3 \longrightarrow R_1 = \frac{R_3}{10} \Longrightarrow R_1' = \frac{1}{10}$

$R_3' = 1 \qquad R_2 = 3R_3 \Longrightarrow R_2' = 3$

$R_4' = R_4 / R_3 \qquad C = 1/R_3 \Longrightarrow C' = 1$

$T(s) = -10 \cdot \frac{1}{s^2 + s\cdot\frac{1}{3} + 1} \longrightarrow |T(\omega)| = |T(s)|\Big|_{s=j\omega} = 10 \cdot \frac{1}{\sqrt{(1-\omega^2)^2 + (\omega/3)^2}}$

II) $S_C^{\omega_0} \quad S_{R_2}^{Q} \quad S_{R_3}^{Q} \qquad \omega_0 = \frac{1}{R_3 C} \qquad Q = \frac{R_2}{R_3}$

$S_C^{\omega_0} = \frac{C}{\omega_0} \cdot \frac{\partial \omega_0}{\partial C} = \cancel{R_3} C^2 \cdot \frac{1}{\cancel{R_3}}\left(-\frac{1}{C^2}\right) = -1 \longrightarrow$ ω_0 es inversamente proporcional a C

$S_{R_2}^{Q} = \frac{R_2}{Q} \cdot \frac{\partial Q}{\partial R_2} = \frac{\cancel{R_3}\cancel{R_2}}{\cancel{R_2}} \cdot \frac{1}{\cancel{R_3}} = 1 \longrightarrow$ Q es directamente proporcional a R_2

$S_{R_3}^{Q} = \frac{R_3}{Q} \cdot \frac{\partial Q}{\partial R_3} = \cancel{R_3} \cdot \frac{\cancel{R_3}}{\cancel{R_2}} \cdot \cancel{R_2}\left(-\frac{1}{\cancel{R_3^2}}\right) = -1 \longrightarrow$ Q es inversamente proporcional a R_3

III) $|T_{B_{2o}}(\omega)|^2 = \frac{1}{1+\omega^4} \longrightarrow |T_B(s)|^2 = \frac{1}{1+s^4}$

$T_{B_2}(s) = \frac{1}{s^2 + s\sqrt{2} + 1}$

$T(s) = k \frac{\omega_0^2}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2}$ con $k = -R_3/R_1,\ \omega_0 = 1/CR_3,\ Q = \frac{R_2}{R_3}$

Para que $T(s) = T_{B_2}(s) \quad \omega_0 = 1 \ \wedge\ Q = 1/\sqrt{2}$

Mantengo la norma en frecuencia $\Omega_\omega = 1/R_3 C$

NOTA

$$T(s) = k \frac{1}{s^2 + s\frac{R_3}{R_2} + 1} = k \frac{1}{s^2 + s \cdot \frac{1}{Q} + 1}$$

Para que $Q = \frac{1}{\sqrt{2}}$, $R_2 = \sqrt{2}\ R_3$

Tomando la misma norma de impedancia, $\Omega_Z = R_3$:

$R_3'' = 1 \quad C'' = 1 \quad R_2'' = \sqrt{2}$

Si mantengo $|T(0)| = 20\,dB$, $R_1'' = 1/10$. De lo contrario, si quiero que $|k| = 1$, $R_1 = R_3 \therefore R_1'' = 1$

$$T(s) = k \cdot \frac{1}{s^2 + s\sqrt{2} + 1}$$

IV) Para obtener un filtro pasabanda debo tomar la salida en V_{o1} en vez de V_o

$$T_{PB}(s) = \frac{V_{o1}}{V_{in}}$$

Utilizando las relaciones calculadas en el primer punto:

$$\frac{V_{in}}{R_1} = -V_{o1}\left(sC + \frac{1}{R_2}\right) - \frac{V_o}{R_3}$$

$$V_o = V_i\left[-\frac{1}{C^2R_1R_3} \cdot \frac{1}{s^2 + s\cdot\frac{1}{CR_2} + \frac{1}{C^2R_3^2}}\right]$$

$$\frac{V_{in}}{R_1} + \frac{V_{in}}{R_3}\left[\frac{-1/C^2R_1R_3}{s^2 + s\cdot 1/CR_2 + (1/CR_3)^2}\right] = \frac{V_{in}}{R_1}\left[1 - \frac{(1/CR_3)^2}{s^2 + s\cdot 1/CR_2 + (1/CR_3)^2}\right] =$$

$$= \frac{V_{in}}{R_1}\left[\frac{s^2 + s\cdot 1/CR_2 + (1/CR_3)^2 - (1/CR_3)^2}{s^2 + s\cdot 1/CR_2 + (1/CR_3)^2}\right] = -V_{o1} \cdot \frac{sCR_2 + 1}{R_2}$$

$$\frac{V_{o1}}{V_{in}} = -\frac{1}{R_1} \cdot \frac{R_2}{sCR_2 + 1} \cdot \frac{s(s + 1/CR_2)}{s^2 + s\cdot 1/CR_2 + (1/CR_3)^2}$$

$$\frac{V_{o1}}{V_{in}} = -\frac{R_2}{R_1} \cdot \frac{1}{CR_2} \cdot \frac{1}{s + 1/CR_2} \cdot \frac{s(s + 1/CR_2)}{s^2 + s\cdot 1/CR_2 + (1/CR_3)^2}$$

con $k' = -\frac{R_2}{R_1}$

$$T_{PB}(s) = \frac{k' \cdot s \cdot 1/CR_2}{s^2 + s\cdot 1/CR_2 + (1/CR_3)^2} = k' \frac{s \cdot \omega_0/Q}{s^2 + s\cdot\frac{\omega_0}{Q} + \omega_0^2}$$

$\omega_0 = \frac{1}{CR_3}$

$Q = \frac{R_2}{R_3}$

Normalizo para $\Omega_\omega = 1/CR_3 \ \wedge\ \Omega_Z = R_3$

$$T_{PB}(s) = k' \cdot \frac{s \cdot 1/3}{s^2 + s \cdot 1/3 + 1}$$