Sistema   B) Modelo del sistema   hoja 1

$$G = \left(-\frac{1}{sR_2C_1}\right)\left(-1\right)\left(\frac{-1}{sR_5C_2}\right)\left(-1\right)$$

$$G = \frac{1}{R_2R_5C_1C_2} \cdot \frac{1}{s^2} \Rightarrow \boxed{G = K \cdot \frac{1}{s^2}, \quad k = \frac{1}{R_2R_5C_1C_2}}$$

$$\boxed{k = \frac{1}{10^{-4}} = 10^4}$$

Compensación (Modelo)

$$C = (-1)\left(\frac{-1}{sR_{10}C_3}\right) = \frac{1}{R_{10}C_3} \cdot \frac{1}{s} \Rightarrow \boxed{C = K \cdot \frac{1}{s}, \quad k = 10^2}$$

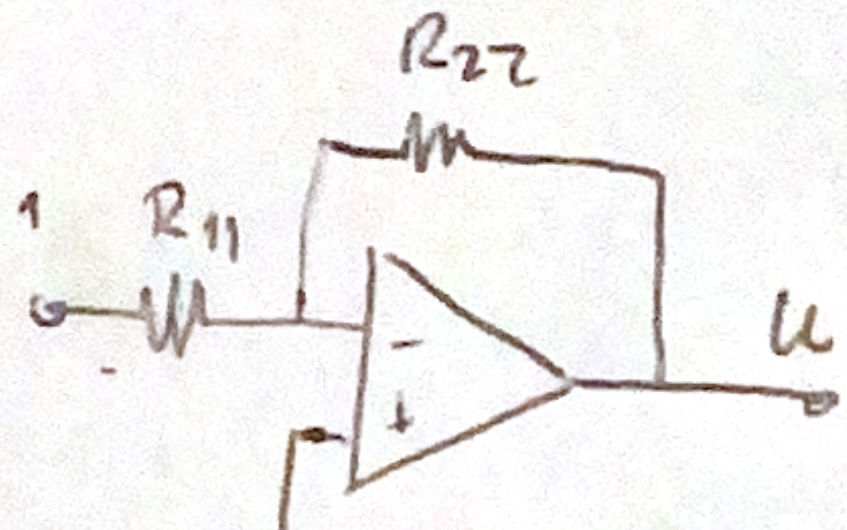
Realimentación (Modelo)

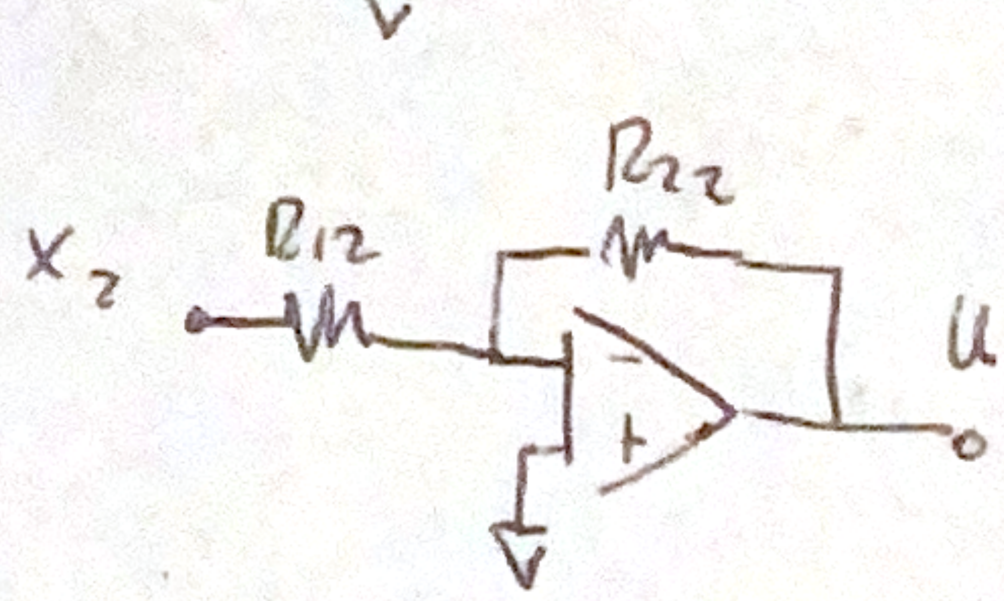
$$\frac{u}{X_1} = \frac{-R_{22}}{R_{11}}$$

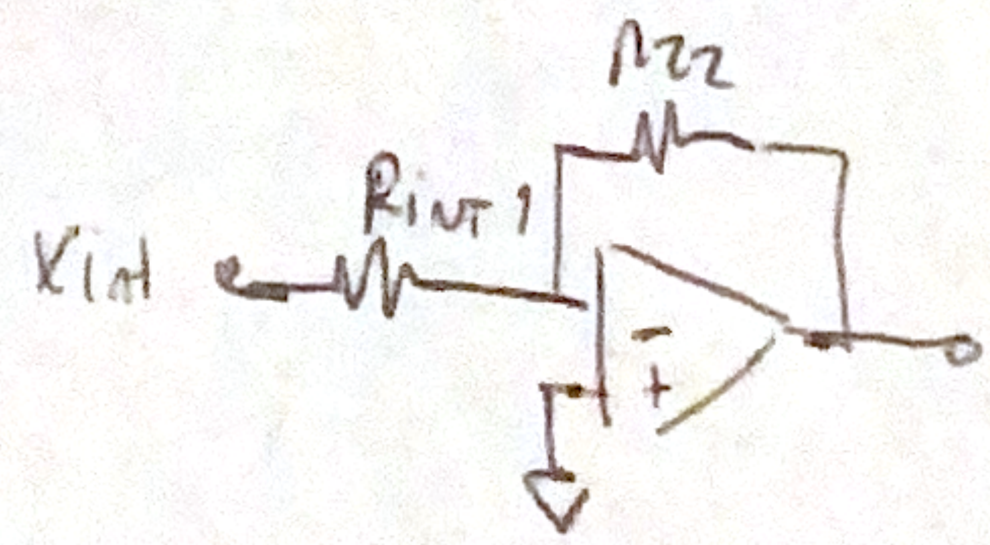
$$\frac{u}{X_2} = \frac{-R_{22}}{R_{12}}$$

$$\frac{u}{X_{INT1}} = -\frac{R_{22}}{R_{INT1}}$$

$$\frac{u}{R} = \frac{+R_{22}}{R_8}$$







$\Downarrow$

$$\boxed{U = R - R_{22}\left(\frac{X_1}{R_{11}} + \frac{X_1}{R_{12}} + \frac{X_{int}}{R_{INT1}}\right)}$$

C) $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} u \qquad y = \begin{bmatrix} c_1 & c_2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

Planteo:

$$X_2 = U \cdot \frac{1}{sR_2C_1} \rightarrow sX_2 = U \cdot \frac{1}{R_2C_1} \rightarrow \dot{x}_2 = u \cdot \frac{1}{R_2C_1}$$

$$X_1 = X_2 \cdot \frac{1}{sR_5C_2} \rightarrow sX_1 = X_2 \frac{1}{R_5C_2} \rightarrow \dot{x}_1 = X_2 \frac{1}{R_5C_2}$$

$$\boxed{\begin{aligned} &\Rightarrow \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{R_5C_2} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{R_2C_1} \end{bmatrix} u \\ &\Rightarrow y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \end{aligned}}$$

Bloque I

X_{INT}

$$X_{INT} = \frac{1}{sR_{10}C_3} \cdot U \rightarrow \dot{X}_{INT} = U \cdot \frac{1}{R_{10}C_3}$$

$$Y = X_{INT}$$

$$\Downarrow$$

$$\begin{bmatrix} \dot{X}_{INT} \end{bmatrix} = \begin{bmatrix} 0 \end{bmatrix} \begin{bmatrix} X_{INT} \end{bmatrix} + \begin{bmatrix} \frac{1}{R_{10}C_3} \end{bmatrix} u$$

$$\begin{bmatrix} Y \end{bmatrix} = \begin{bmatrix} 1 \end{bmatrix} \begin{bmatrix} X_{INT} \end{bmatrix}$$

Bloque II

$$X_{INT} = -R \cdot \frac{1}{R_{10} C_3 \cdot s} + X_1 \cdot \frac{1}{s R_{10} C_3} \cdot \cancel{\frac{R_{17}}{R_{13}}}^{\,1} \quad (1)$$

$$Y = X_{INT}$$

de (1): $\dot{X}_{INT} = \left(\frac{1}{R_{10} C_3}\right) X_1 - \left(\frac{1}{R_{10} C_3}\right) R = \frac{1}{R_{10} C_3} \left(X_1 - R\right)$

$$Y = X_{INT}$$

$\Rightarrow$ Matriz expandida

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_{INT} \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{R_5 C_2} & 0 \\ 0 & 0 & 0 \\ \frac{1}{R_{10} C_3} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_{INT} \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ \frac{1}{R_2 C_1} & 0 \\ 0 & \frac{-1}{R_{10} C_3} \end{bmatrix} \begin{bmatrix} u \\ r \end{bmatrix}$$

2.2 Diseño de realimentación a)

$$[A - BK] = \begin{bmatrix} 0 & \frac{1}{R_5 C_2} \\ 0 & 0 \end{bmatrix} - \begin{bmatrix} 0 \\ \frac{1}{R_2 C_1} \end{bmatrix} \cdot \begin{bmatrix} K_1 & K_2 \end{bmatrix}$$

$$\Rightarrow [A - BK] = \begin{bmatrix} 0 & \frac{1}{R_5 C_2} \\ 0 & 0 \end{bmatrix} - \begin{bmatrix} 0 & 0 \\ \frac{K_1}{R_2 C_1} & \frac{K_2}{R_2 C_1} \end{bmatrix}$$

$$[A - BK] = \begin{bmatrix} 0 & \frac{1}{R_5 C_2} \\ \frac{-K_1}{R_2 C_1} & \frac{-K_2}{R_2 C_1} \end{bmatrix} = A_{LC}$$

$$\begin{bmatrix} -\lambda & \frac{1}{R_5 C_2} \\ \frac{-K_1}{R_2 C_1} & \frac{-K_2}{R_2 C_1} - \lambda \end{bmatrix} = \lambda \mathbb{I} - A$$

$$\cancel{\det[\lambda \mathbb{I} - A]} = \det[A - \lambda \mathbb{I}]$$

$$\lambda \left(\lambda + \frac{K_2}{R_2 C_1} \right) - \left(\lambda + \frac{K_1}{R_2 C_1} \right)\left(\lambda - \frac{1}{R_5 C_2} \right)$$

$$\lambda^2 + \frac{K_2}{R_2 C_1} \lambda - \left[\lambda^2 + \lambda \left[\frac{K_1}{R_2 C_1} - \frac{1}{R_5 C_2} \right] - \frac{K_1}{R_2 R_5 C_1 C_2} \right]$$

$$\lambda^2 + \frac{K_2}{R_2 C_1} \lambda$$

$$\lambda\left(\lambda+\frac{k_2}{R_2C_1}\right)+\frac{k_1}{R_2C_1C_2R_5} = \lambda^2+\frac{\lambda k_2}{R_2C_1}+\frac{k_1}{R_2C_1C_5R_5}$$

Polos cojugados ($s = \cancel{\pm}100 \pm j300$)

$$\lambda^2+\frac{\lambda k_2}{R_2C_1}+\frac{k_1}{R_2R_5C_1C_5} = (\lambda+100-j300)(\lambda+100+j300)$$

$$= \lambda^2+\lambda[200]+(100+j300)(100-j300)$$

$$= \lambda^2+\lambda(200)+(100^2+300^2)$$

$$\lambda^2+\frac{\lambda k_2}{R_2C_1}+\frac{k_1}{R_2R_5C_1C_5} = \lambda^2+\lambda(200)+\cancel{40.000}\ 100000$$

$$\Rightarrow \frac{k_2}{R_2C_1} = 200 \rightarrow k_2 = 200 \cdot \underbrace{R_2C_1}_{1/100} = 2$$

$$\Rightarrow k_1 = \cancel{10}000 \cdot \underbrace{R_2R_5C_1C_5}_{1/10^4} = 10$$

$\therefore$ si $\frac{u}{x_1} = \frac{-R_{22}}{R_{11}}$, $\frac{u}{x_2} = \frac{R_{22}}{R_{12}}$

$\Rightarrow$

$$k_1 = \frac{R_{22}}{R_{11}} \rightarrow R_{11} = \frac{R_{22}}{k_1} = 4k7$$

$$k_2 = \frac{R_{22}}{R_{12}} \rightarrow R_{12} = \frac{R_{22}}{k_2} = 23{,}5k$$

Polos $\lambda_1 = -100$, $\lambda_2 = -500$

$$\lambda^2 + \frac{\lambda K_2}{R_2 C_1} + \frac{K_1}{R_2 C_1 R_5 C_2} = (\lambda + 100)(\lambda + 500)$$

$$= \lambda^2 + 600\lambda + 50.000$$

$\Rightarrow \frac{K_2}{R_2 C_1} = 600 \rightarrow K_2 = 600 . R_2 C_1 = 6$, $R_{11} = 9K4$

$\Rightarrow K_1 = R_2 R_5 C_1 C_2 . (50.000) = 5$, $R_{12} = 7K8$

Polos en $\lambda = -100 \pm j100$

100^2

$$= (\lambda + 100 + j100)(\lambda + 100 - j100)$$

$$= \lambda^2 + \lambda(200) + 20.000$$

$\Rightarrow \frac{K_2}{R_2 C_1} = 200 \rightarrow K_2 = 2$

$R_{12}, R_{11} = 23K5$

$\frac{K_1}{R_2 C_1 R_5 C_2} = 20.000 \rightarrow K_1 = 2$