Controle integral no espaço de estados.

$$\dot{x} = Fx + Gu$$

$$u = \underbrace{-K\hat{x}}_{r.e} - \underbrace{K_i e}_{i}$$

$$\dot{e} = r - Hx$$

$K, K_i \rightarrow$ Alocação (Acker)

$$F_a = \begin{bmatrix} F & 0 \\ -H & 0 \end{bmatrix} \qquad G_a = \begin{bmatrix} G \\ 0 \end{bmatrix}$$

$$[K \;\vdots\; K_i]$$

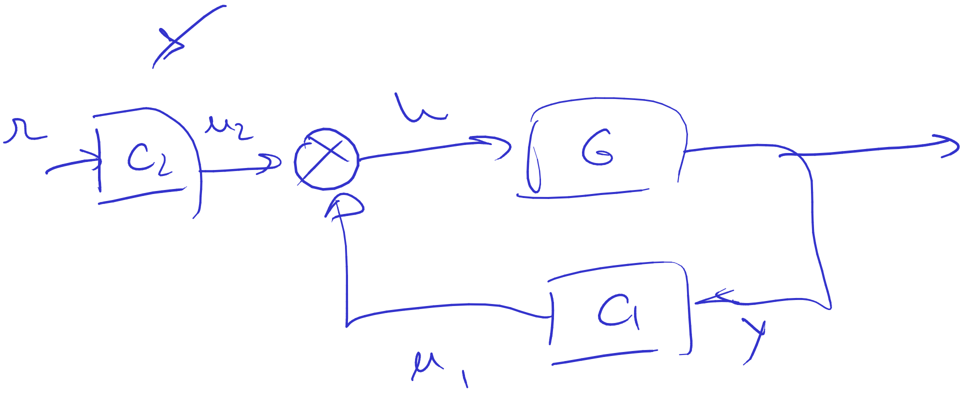
$$\begin{aligned}
\dot{\hat{x}} &= F\hat{x} + Gu + L(y - H\hat{x}) \\
&= (F - LH)\hat{x} + Gu + Ly \\
&= (F - LH)\hat{x} + G(-K\hat{x} - K_i e) + Ly \\
&= (F - LH - GK)\hat{x} - GK_i e + Ly
\end{aligned}$$

$$\dot{e} = r - y$$

$$\begin{bmatrix} \dot{\hat{x}} \\ \dot{e} \end{bmatrix} = \begin{bmatrix} F - LH - GK & -GK_i \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \hat{x} \\ e \end{bmatrix} + \begin{bmatrix} 0 & L \\ 1 & -1 \end{bmatrix} \begin{bmatrix} r \\ y \end{bmatrix}$$

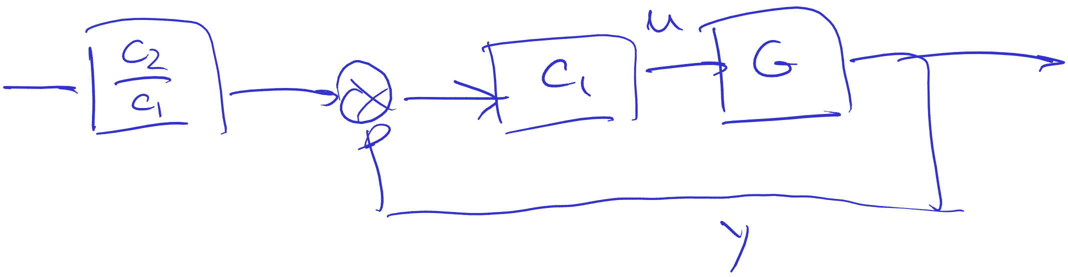
Eq. estados do controlador

$$u = \begin{bmatrix} -K & -K_i \end{bmatrix} \begin{bmatrix} \hat{x} \\ e \end{bmatrix}$$



$$u = C_1 y + C_2 r$$

$$u = C_1 \left(\frac{C_2}{C_1} r + y \right)$$



$$\dot{\hat{x}} = (F - GK - LH)\hat{x} + Ly - Gk_i e$$

$$\dot{e} = r - y$$

$$\dot{x} = Fx + G(-K\hat{x} - k_i e)$$

$$y = Hx$$

n $\quad \dot{x} = Fx - GK\hat{x} - Gk_i e$

n $\quad \dot{\hat{x}} = (F - GK - LH)\hat{x} - Gk_i e + LHx$

1 $\quad \dot{e} = r - Hx$

$\quad y = Hx$

$$\dot{x} = Fx - Gk\hat{x} - Gk_i e$$

$$\dot{\hat{x}} = (F - Gk - LH)\hat{x} - Gk_i e + LHx$$

$$\dot{e} = r - Hx$$

$$y = Hx$$

$$\begin{bmatrix} \dot{x} \\ \dot{\hat{x}} \\ \dot{e} \end{bmatrix} = \overset{Fmt}{\begin{bmatrix} F & -Gk & -Gk_i \\ LH & F-Gk-LH & -Gk_i \\ -H & 0_{1\times n} & 0_{1\times 1} \end{bmatrix}} \begin{bmatrix} x \\ \hat{x} \\ e \end{bmatrix} + \overset{Gmt}{\begin{bmatrix} 0_{n\times 1} \\ 0_{n\times 1} \\ 1 \end{bmatrix}} r$$

$$y = \begin{bmatrix} H & 0 & 0 \end{bmatrix} \begin{bmatrix} x \\ \hat{x} \\ e \end{bmatrix}$$

$$u = \begin{bmatrix} 0 & -k & -k_i \end{bmatrix} \begin{bmatrix} x \\ \hat{x} \\ e \end{bmatrix}$$

$$\begin{bmatrix} y \\ u \end{bmatrix} = \begin{bmatrix} H & 0 & 0 \\ 0 & -k & -k_i \end{bmatrix} \begin{bmatrix} x \\ \hat{x} \\ e \end{bmatrix}$$