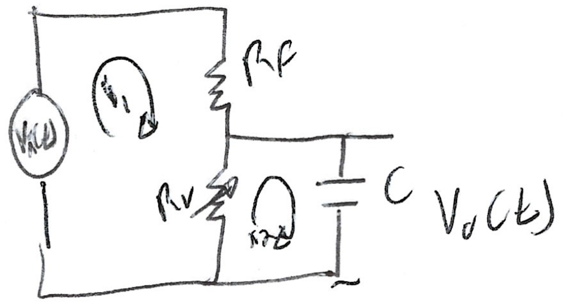


Solución

$$V_i(t) = R_f\, i_1(t) + R_v\,(i_1(t) - i_2(t)) \ldots (1)$$

$$\frac{1}{C}\int i_2(t)\,dt + R_v\,(i_2(t) - i_1(t)) = 0 \ldots (2)$$

$$V_o(t) = \frac{1}{C}\int i_2(t)\,dt \ldots (3)$$

Aplicando la transformada de Laplace

$$V_i(s) = R_f\, I_1(s) + R_v\, I_1(s) - R_v\, I_2(s) \ldots (4)$$

$$\frac{1}{sC} I_2(s) + R_v\, I_2(s) - R_v\, I_1(s) = 0 \ldots (5)$$

$$V_o(s) = \frac{1}{sC}\, I_2(s) \ldots (6)$$

V.S F.T V.E

Despejamos las variable dependientes

de (4)

$$I_1(s)(R_f + R_v) = V_i(s) + R_v\, I_2(s)$$

$$I_1(s) = \frac{1}{R_f + R_v} V_i(s) + \frac{R_v}{R_f + R_v} I_2(s) \ldots (7)$$

V.S F.T V.E F.T V.E

de (s)

$$I_2(s)\left(\frac{1}{sC} + R_v\right) = R_v I_1(s)$$

$$I_2(s) = R_v\left(\frac{sC}{1+sCR_v}\right) I_1(s)$$

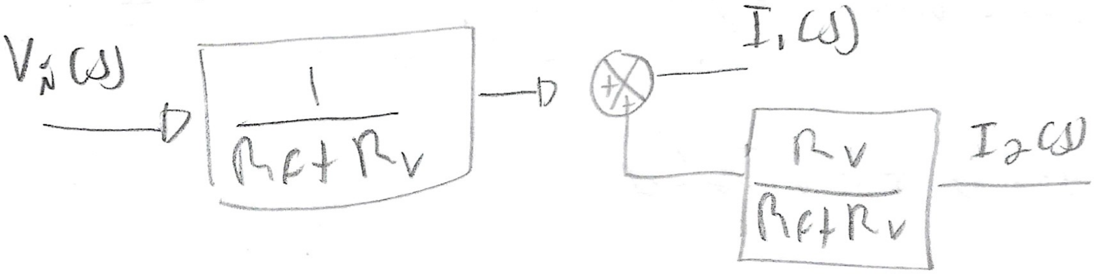
$$\underbrace{I_2(s)}_{V.S} = \underbrace{\frac{sCR_v}{1+sCR_v}}_{F.T} \underbrace{I_1(s)}_{V.E} \ldots (8)$$

Generamos un diagrama de bloque particular para cada ecuación.

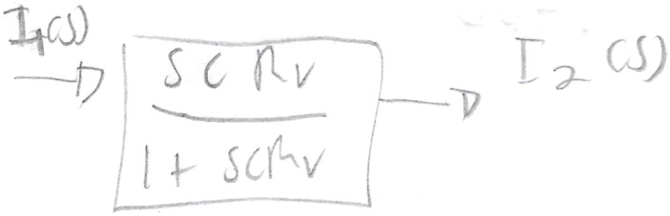
Para la ecuación (6)

$$I_2(s) \longrightarrow \boxed{\frac{1}{sC}} \longrightarrow V_o(s)$$

Para la ecuación (7)

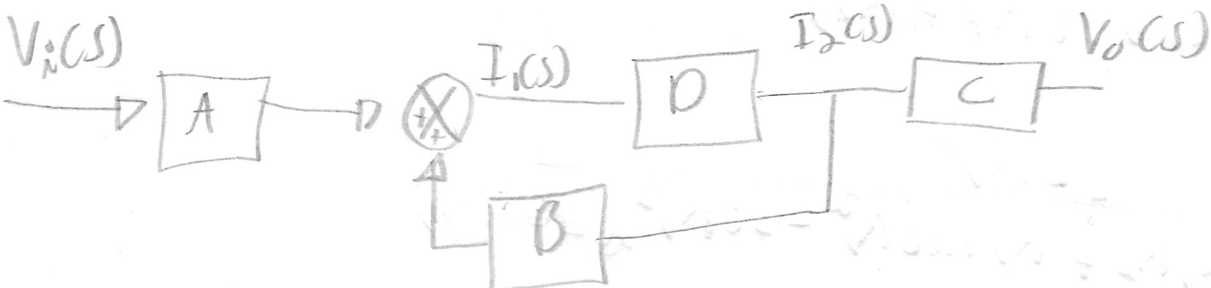


Para la ecuación (8)



Relacionamos los diagramas de bloques

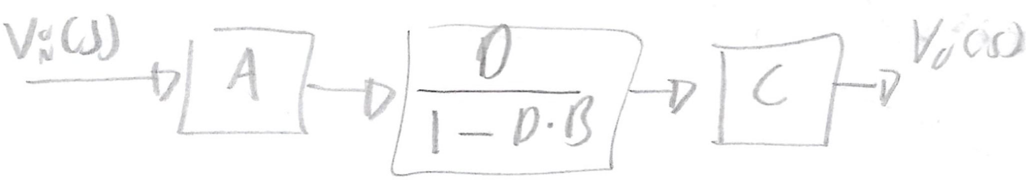
$$A = \frac{1}{R_F + R_V}, \quad B = \frac{R_V}{R_V + R_F}, \quad C = \frac{1}{sC}, \quad D = \frac{sCR_V}{1+sCR_V}$$



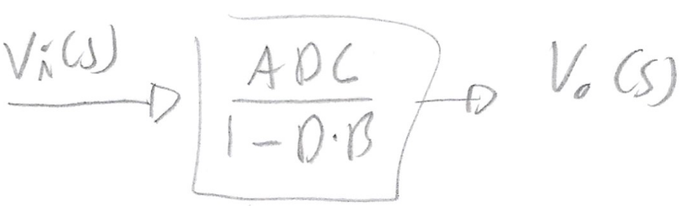
Como

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1 - H(s)\,G(s)}$$

Entonces



Aplicamos algebra de bloques



Sustituyendo A, B, C y D en $\dfrac{ADC}{1-DB}$

Tenemos que

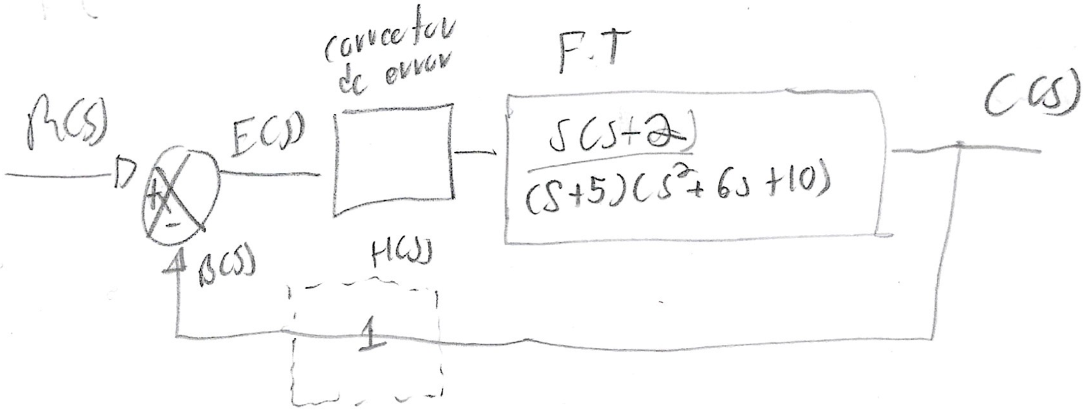
$$\frac{ADC}{1-DB} = \frac{\left(\frac{1}{R_F+R_V}\right)\left(\frac{SCR_V}{1+SCR_V}\right)\left(\frac{1}{SC}\right)}{1 - \left(\frac{SCR_V}{1+SCR_V}\right)\left(\frac{R_V}{R_F+R_V}\right)}$$

$$= \frac{\left(\frac{1}{R_F+R_V}\right)\left(\frac{SCR_V}{1+SCR_V}\right)\left(\frac{1}{SC}\right)}{\frac{(1+SCR_V)(R_F+R_V)-(SCR_V^2)}{(1+SCR_V)(R_F+R_V)}}$$

$$= \frac{SCR_V}{(R_F+SCR_VR_F+R_V+SCR_V^2-SCR_V^2)(SC)}$$

$$= \frac{R_V}{R_F+SCR_VR_F+R_V}$$

$$= \frac{R_V}{SCR_VR_F+R_F+R_V}$$



$$e_{ee} = \lim_{s \to 0} \frac{s\,R(s)}{1 + H(s)G(s)}$$

$$e_{ee} = \lim_{s \to 0} \frac{s\,\frac{1}{s}}{1 + \frac{s(s+2)}{(s+5)(s^2+6s+10)}} = \lim_{s \to 0} \frac{1}{\frac{(s+5)(s^2+6s+10) + s(s+2)}{(s+5)(s^2+6s+10)}}$$

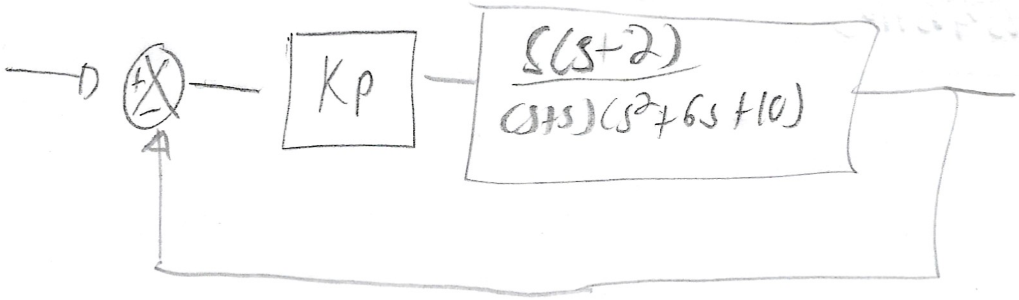
$$= \lim_{s \to 0} \frac{s^3+6s^2+10s+5s^2+30s+50}{s^3+6s^2+10s+5s^2+30s+50+s^2+2s}$$

$$= \frac{50}{50} = 1 = 100\%$$

Observamos que el error es mayor al 2%

⇒ Necesitamos una estrategia para reducirlo

Haciendo uso de un integrador



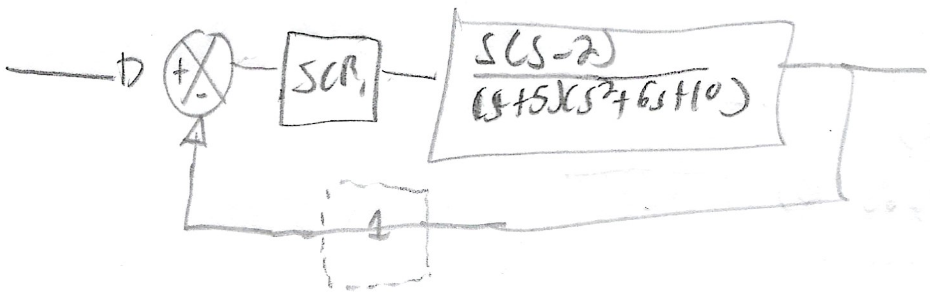
$$e_{ee} = \lim_{s \to 0} \frac{s\left(\frac{1}{s}\right)}{1 + \frac{Kp(s-2)s}{(s+5)(s^2+6s+10)}}$$

$$= \lim_{s \to 0} \frac{1}{\frac{(s+5)(s^2+6s+10) + Kp\,s(s-2)}{(s+5)(s^2+6s+10)}}$$

$$= \lim_{s \to 0} \frac{s^3+6s^2+10s+5s^2+30s+50}{s^3+6s^2+10s+5s^2+30s+50+Kps^2-Kps2}$$

$$= \frac{50}{50}_{s \to 0} = 1 = 100\%$$

Haciendo uso de un Integrador



$$e_{ee} = \lim_{s \to 0} \frac{s\left(\frac{1}{s}\right)}{1 + \frac{s(s-2)}{s(s+5)(s^2+6s+10)}}$$

$$= \lim_{s \to 0} \frac{1}{\frac{(s+5)(s^2+6s+10) + s-2}{(s+5)(s^2+6s+10)}}$$

$$= \lim_{s \to 0} \frac{s^3+6s^2+10s+5s^2+30s+50}{s^3+6s^2+10s+5s^2+30s+50+s-2}$$

$$= \frac{50}{48} = 1.04 = 104\%$$