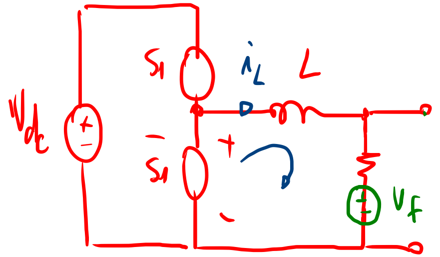
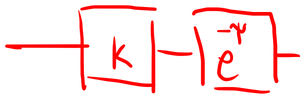
clase 04 - EPD413

$ff_d = \omega L i_q$

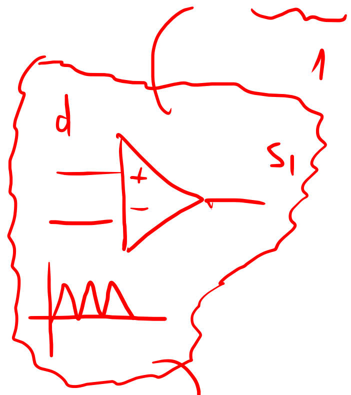
$-V_f \qquad ff_q = -\omega L i_d$





$V_{dc} S_1 - L\frac{di_L}{dt} - R i_L = 0 \qquad S_1 \in \{0,1\}$

$V_{dc} d_1 - L\frac{di_L}{dt} - R i_L = 0 \quad / \ \mathcal{L} \qquad d_1 \in [0,1]$



$$H(s) = \frac{I_L(s)}{D_1(s)} = \frac{V_{dc}}{Ls+R} = V_{dc} \cdot \underbrace{\frac{1}{Ls+R}} \approx \frac{V_{dc}}{Ls}$$

f_{sw}

BW, ζ $\longrightarrow$?

1) $\overbrace{H(s) \rightarrow C(s)}^{} \rightarrow \overbrace{C_d(z)}^{} \rightarrow$ 10kHz

$H_i(s) = \frac{1}{Ls+R} \rightarrow$ Z.O.H.

2) $H(s) \rightarrow H_d(z) \rightarrow C_d(z) \rightarrow$ 10kHz

BW, ζ

$H(z) = c2d(H_i(s), T_s, \text{'ZOH'})$

Euler "Tustin"

Taylor ZOH

$$H(z) = \left(\frac{z-1}{z}\right) \mathcal{Z}\left(\mathcal{L}^{-1}\left(\frac{1}{s} H_i(s)\right)\Big|_{t=k\cdot T_s}\right) \overset{\Delta\, ZOH}{=} \frac{K}{z-a} \Rightarrow C(z)$$

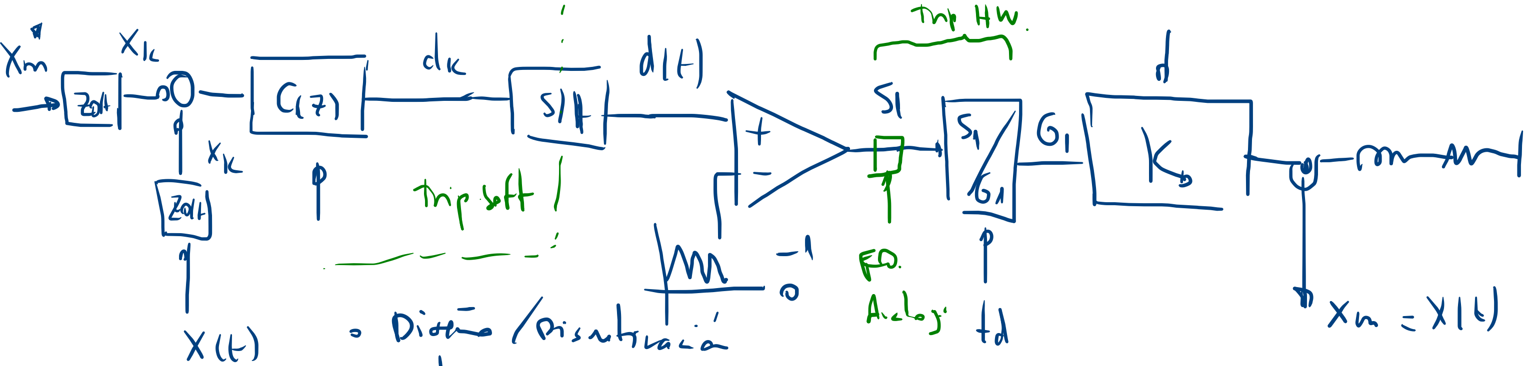
$$H_i(s) = \frac{1}{Ls+R} \qquad K = \frac{1-a}{R} \qquad a = e^{-\frac{R}{L}T_s}$$

"Analisis de sistemas lineales", Salgado, 2014. Lema 11.3

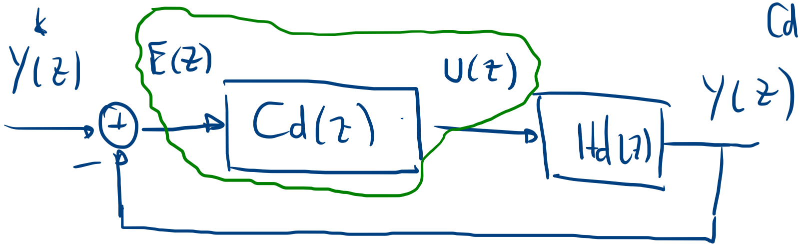
$$C(s) = k_p + \frac{k_i}{s} \Rightarrow \boxed{C(z) = \frac{k_{pd}\, z + k_{id}}{z-1}}$$

" $k_{pd} = k_p$ " " $k_{id} = -(k_p - k_i \cdot T_s)$ "

$$C(z) = \frac{1.5\,z - 1.3}{z-1}$$



- Diseño / discretización
- Saturación →
- Antiwindup.



$$C_d(z) = \frac{U(z)}{E(z)} = \frac{k_{pd} z + k_{id}}{z - 1} = \frac{k_{pd} + z^{-1} k_{id}}{1 - z^{-1}}$$

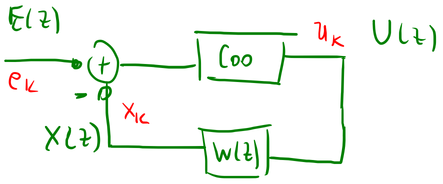
$$U(z) = U(z) \cdot z^{-1} + k_{pd} E(z) + k_{id} z^{-1} E(z) \Big/ z^{-1}$$

$$\boxed{u_k = u_{k-1} + k_{pd} e_k + k_{id} e_{k-1}}$$

Sat. ⇒ $u_k = u_k > U_{max} : U_{max} \; ? \; u_k < U_{min} : U_{min} \; ? \; u_k \; ;$

Antiwindup

$$C(z) = \frac{k_{pd}\, z + k_{id}}{z - 1} = \qquad C_\infty = \lim_{z \to \infty} \frac{k_{pd}\, z + k_{id}}{z - 1} = k_{pd}$$



$$U(z) = k_{pd}\,(E(z) - X(z))$$

$$U(z) = k_{pd}\,(E(z) - W(z)\,U(z))$$

Control system Design. Salgado 2001

Fig 11.2

$$(1 + k_{pd}\, W(z))\, U(z) = k_{pd}\, E(z)$$

$$C(z) = \frac{k_{pd}\, z + k_{id}}{z - 1} = \frac{U(z)}{E(z)} \qquad \frac{U(z)}{E(z)} = \frac{k_{pd}}{1 + k_{pd}\, W(z)} = \frac{k_{pd}\, z + k_{id}}{z - 1}$$

$$W(z) = ?$$

$$W(z) = -\frac{(k_{pd} + k_{id})}{k_{pd}^2\, z + k_{id}\, k_{pd}} = \frac{X(z)}{U(z)}$$

Variable interna $\Rightarrow$ $x_k = \underbrace{-\frac{k_{id}}{k_{pd}}}_{K_x} x_{k-1} \underbrace{- \frac{(k_{pd} + k_{id})}{k_{pd}^2}}_{k_u} u_{k-1}$ ✓

p

Act. $\Rightarrow$ $u_k = k_{pd}\,(e_k - x_k)$

$$u_k = f(u_k, \text{sat})$$

Prog:

$e_k = y_k^* - y_k;$

$x_{k-1} = x_k;$

$u_{k-1} = u_k;$

$x_k = k_u\, u_{k-1} + k_x\, x_{k-1};$

$u_k = k_{pd}\,(e_k - x_k);$

$* \quad u_k = u_k > U_{max} \; ? \; U_{max} : u_k < -U_{max} \; ? \; -U_{max} : u_k;$