$$e^{-at} \xleftrightarrow{L} \frac{1}{z+a}$$

$$\rightarrow L\{f(t)\} = F(z) = \int_{\cancel{0}\;-\infty}^{\infty} f(t)\cdot e^{-zt}\, d_t$$

$$F(z) = \int_{-\infty}^{+\infty} \boxed{e^{-at}}\, e^{-zt}\, \partial t$$

$$= \int_{-\infty}^{+\infty} e^{-t(a+z)}\, \partial t$$

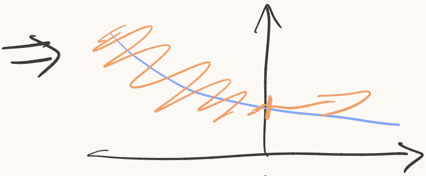
$$= \int_{-\infty(a+z)}^{+\infty(a+z)} e^{-u}\, \partial u \cdot \left(\frac{1}{z+a}\right)$$

$$u = t(z+a)$$

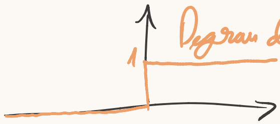
$$\frac{\partial u}{\partial t} = z+a$$

$$= \frac{1}{z+a} \int_{-\infty}^{+\infty} e^{-u}\, \partial u$$

$\Rightarrow$



$$e^{-at} \cdot H(t)$$



$U(t) =$

step $= 1$

amp $= 6V$

$$\left.\begin{array}{l} \text{step} = 1 \\ \text{amp} = 6V \end{array}\right\} H(t-1)\cdot 6 \xleftrightarrow{L} 6 \cdot \frac{1}{z+1}$$

$$G(z) = \frac{K_\theta}{1 + \tau \cancel{s}\, z}$$

$$\frac{K_\theta}{1 + \tau \cdot z}$$

$$\frac{1}{z+a}$$

$$\downarrow$$

$$\frac{K_\theta / T}{\frac{1}{\tau} + z} = \frac{K_\theta}{\tau} \cdot \frac{1}{\frac{1}{\tau} + z}$$

a

$$\updownarrow \; L^{-1}$$

$$\frac{K}{\tau} \cdot$$

Reescrita da Resolução

• $$\frac{\Omega_H(s)}{V_p(s)} = G(s) = \frac{K_\omega}{1+\tau s} \quad \to p = -\frac{1}{\tau}$$

$H(t)$, $U(t)$, $u(t)$, $\mathbb{1}(t)$,

$$\Rightarrow \Omega_H(s) = V_p(s)\cdot \frac{K_\omega/\tau}{\frac{1}{\tau}+s}$$

• $$v_p(t) = \overset{H(t-1)}{\cancel{H(t)}}\cdot 6 \Leftrightarrow 6\cdot\frac{\overset{e^{-s}}{\cancel{1}}}{s} = V_p(s)$$

$$\left(v_p(t) = \overset{H(t-1)}{\cancel{H(t)}}\cdot 6 \Leftrightarrow \mathcal{L}\{v_p(t)\} = 6\cdot\frac{\overset{e^{-s}}{\cancel{1}}}{s} \right)$$

$$\Rightarrow \Omega_H(s) = \left(\frac{6K_\omega}{\tau}\cdot\frac{1}{s}\cdot\frac{1}{\frac{1}{\tau}+s}\right)e^{-s}$$

Polos:
$G(s)\to\infty$
$\Rightarrow D_{G(s)}\to 0$
$\Rightarrow p \in$ {raízes do denominador

• Sabemos que $\Omega_H(s)$ pode ser reescrito como:
↳ teorema X

$$\Omega_H(s) = \left(\frac{R_1}{s} + \frac{R_2}{\frac{1}{\tau}+s}\right)e^{-s}$$

, tq.

$$R_1 = \Omega_H(s)\cdot s\Big|_{s=0} = \frac{6K_\omega}{\tau}\cdot\frac{1}{\frac{1}{\tau}+s}\cdot\frac{1}{\cancel{s}}\cdot\cancel{s}\Big|_{s=0}$$

$$= \frac{6K_\omega}{\tau}\cdot\frac{1}{\frac{1}{\tau}+s}\Big|_{s=0}$$

$$= \frac{6K_\omega}{\cancel{\tau}}\cdot\frac{1}{\frac{1}{\cancel{\tau}}}$$

$$= 6K_\omega$$

$$R_2 = \Omega_H(s)\cdot\left(\frac{1}{\tau}+s\right)\Big|_{s=-\frac{1}{\tau}} = \frac{6K_\omega}{\tau}\cdot\frac{1}{-\frac{1}{\tau}}$$

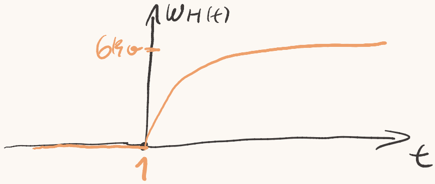
$$= -6K_\omega$$

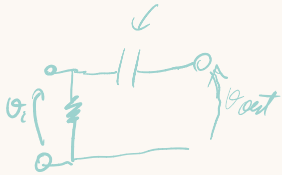
$$\Rightarrow \Omega_H(s) = \left(\frac{6K_\omega}{s} + \frac{-6K_\omega}{\frac{1}{\tau}+s}\right)\cdot e^{-s}$$

$$\Big\updownarrow \mathcal{L}^{-1}$$

$$\Rightarrow \omega_H(t) = 6K_\omega \cdot \overset{H(t-1)}{\cancel{H(t)}} \cdot 1 - 6K_\omega \cdot \overset{H(t-1)}{\cancel{H(t)}} \cdot e^{-\frac{1}{\tau}\cdot(t-1)}$$

$$= \overset{H(t-1)}{\cancel{H(t)}} \cdot 6K_\omega\left(1 - e^{-\frac{1}{\tau}(t-1)}\right)$$





- adrar $K_\omega \Rightarrow t \to \infty$
- adrar $\tau \Rightarrow \omega_H(t) = 63{,}2\% \to t = \tau$

↳ ct temporal

$$\left(e^{-\frac{1}{\tau}\cdot t} \xrightarrow[t=\tau]{} e^{-\frac{1}{\tau}\cdot\tau} = e^{-1} = \frac{1}{e}\right)$$

3.2.1)

- $\ddot{\theta} = \frac{1}{J_p}\left(F_0 \cdot D_t - D_p \dot{\theta} - M_b \cdot g \cdot D_m \cdot \operatorname{sen}(\theta)\right)$

- Linearizing:

$$\frac{\partial}{\partial t}\dot{\theta} \approx \left[\left.\frac{\partial \ddot{\theta}}{\partial \theta}\right|_{\bar{\theta}=0} \quad \left.\frac{\partial \ddot{\theta}}{\partial \dot{\theta}}\right|_{\bar{\dot{\theta}}=0}\right]\begin{bmatrix}\theta \\ \dot{\theta}\end{bmatrix} + \left.\frac{\partial \ddot{\theta}}{\partial F_0}\right|_{F_0=\bar{F}_0} \cdot F_0$$

$$\boxed{\frac{\partial \dot{\theta}}{\partial t} \approx \frac{1}{J_p}\left(\left[-M_b \cdot g \cdot D_m \quad -D_p\right]\begin{bmatrix}\theta \\ \dot{\theta}\end{bmatrix} + D_t \cdot F_0\right)}$$

↳ certeza que vai ser citada, então já bota label

3.1.2)

Add no início:

$$\cancel{\ddot{\theta}(t) \cdot J_p} = \underline{F_0(t)} \cdot D_t - D_p \cancel{\underline{\dot{\theta}(t)}} - M_b \cdot g \cdot D_m \cdot \operatorname{sen}(\underline{\theta(t)})$$

($\ddot{\theta}$ e $\dot{\theta}$ são nulos por estarem "steady-state")

3.2.2)

- If $F_0 = 0$ and $\sin(\theta) \approx \theta$:

$$\ddot{\theta} J_p = -D_p \dot{\theta} - M_e \cdot g \cdot D_m \cdot \theta \qquad (eq)$$

$$\Rightarrow \ddot{\theta} + \frac{D_p}{J_p}\dot{\theta} + \frac{M_e \cdot g \cdot D_m}{J_p} \cdot \theta = 0 \qquad (eq)$$

- So, it is possible to correlate

$$\boxed{2\zeta \omega_0 = \frac{D_p}{J_p}} \quad \text{and} \quad \boxed{\omega_0^2 = \frac{M_e \cdot g \cdot D_m}{J_p}}$$

- (no matlab: • pegar o T (visual e marquei no gráfico)
  • Escolhi k = 4 para pegar um intervalo maior do que T porém ainda não distorcido pela não-linearidade)

- calcular η
- calcular ξ pelo η

$$\left(\frac{\eta}{\pi}\right)^2 = \frac{\xi^2}{1-\xi^2} \Rightarrow \left(\frac{\eta}{\pi}\right)^2 - \left(\frac{\eta^2}{\pi}\right)\cdot\xi^2 = \xi^2$$

$$\left(\frac{\eta}{\pi}\right)^2 = \xi^2\left(1+\left(\frac{\eta}{\pi}\right)\right)$$

$$\xi = \frac{\eta/\pi}{\sqrt{1+\eta/\pi}}$$

- calcular w_0 pelo T

$$w_0 = \frac{2\pi}{T\sqrt{1-\xi^2}}$$

- $J_p = \dfrac{M_a \cdot g \cdot D_m}{w_0^2}$
- $D_p = 2 \cdot \xi \cdot w_0 \cdot J_p$

3.2.5) A partir da equação linearizada (a famosa):

$$\frac{\partial \dot\theta}{\partial t} = \frac{1}{J_p}\left(\begin{bmatrix} -M_b \cdot g \cdot D_m & -D_p \end{bmatrix} \begin{bmatrix} \theta \\ \dot\theta \end{bmatrix} + D_t \cdot F_0 \right)$$

$$\boxed{\begin{cases} \dfrac{\partial}{\partial t}\begin{bmatrix} \theta \\ \dot\theta \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -\dfrac{M_b \cdot g \cdot D_m}{J_p} & -D_p/J_p \end{bmatrix} \begin{bmatrix} \theta \\ \dot\theta \end{bmatrix} + \begin{bmatrix} 0 \\ D_t/J_p \end{bmatrix} F_0 \\ y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} \theta \\ \dot\theta \end{bmatrix} \end{cases}}$$

↳ essa também vai precisar de label 2

4.2.1)

- $F_0(t) = K_t \cdot \omega_H(t)$

⇒ Substituindo na label 2

$$\begin{cases} \dfrac{\partial}{\partial t}\begin{bmatrix} \theta \\ \dot\theta \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -\dfrac{M_b \cdot g \cdot D_m}{J_p} & -D_p/J_p \end{bmatrix} \begin{bmatrix} \theta \\ \dot\theta \end{bmatrix} + \begin{bmatrix} 0 \\ \dfrac{D_t \cdot K_t}{J_p} \end{bmatrix} \omega_H \\ y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} \theta \\ \dot\theta \end{bmatrix} \end{cases}$$

$$\Rightarrow A = \begin{bmatrix} 0 & 1 \\ -\dfrac{M_b \cdot g \cdot D_m}{J_p} & -D_p/J_p \end{bmatrix}, \; B = \begin{bmatrix} 0 \\ \dfrac{D_t \cdot K_t}{J_p} \end{bmatrix}, \; C = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

4.2.2.)

(matlab ou LATEX)

4.2.3)

Vai precisar rodar de novo quando tirar o K_t e o FO_b corretor

4.2.4)

$$\begin{cases} \dfrac{\partial}{\partial t}\begin{bmatrix}\theta\\ \dot{\theta}\\ z_i\end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ -\dfrac{M_b \cdot g \cdot D_m}{J_p} & -D_p/J_p & 0 \\ 1 & 0 & 0 \end{bmatrix}\begin{bmatrix}\theta\\ \dot{\theta}\\ z_i\end{bmatrix} + \begin{bmatrix} 0 \\ \dfrac{D_t \cdot K_t}{J_p} \\ 0 \end{bmatrix} w_H + \begin{bmatrix}0\\0\\-1\end{bmatrix}\theta_{ref} + B' \cdot d \\ y = \begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}\theta\\ \dot{\theta}\\ z_i\end{bmatrix} \end{cases}$$

6.2.1)

- $\hat{x} = \begin{bmatrix} \hat{\theta} \\ \hat{\dot{\theta}} \end{bmatrix}$ and $\hat{y} = C\hat{x}$

- $\dot{\hat{x}} = A \cdot \hat{x} + B \cdot U + L(y - \hat{y})$

$\Rightarrow \dot{\hat{x}} = A \cdot \hat{x} + B \cdot U + Ly - LC\hat{x}$

$$\boxed{\dot{\hat{x}} = (A - LC)\hat{x} + B \cdot U + Ly}$$