type of excercises NB!!

FTMA $\rightarrow$ zeros $\rightarrow$ canonical form
Poles ε, ω_n, type oscilations
etc

$\downarrow$

$R(s) \times FTMF \rightarrow C(\infty) = \lim_{s \to 0} s \times FTMF \times R(s)$

if $R(s) = \frac{1}{s} \Rightarrow \lim_{s \to 0} FTMF = K$

$\downarrow$

Partical Fraccions

$\downarrow$

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

special case 1

$K = \lim_{s \to 0} s \times FTMF \times R(s)$

$\underline{\text{if } R(s) = \frac{1}{s}}$:

$$\frac{K}{\tau s + 1} \quad \Big| \; K = 1$$

$$K\left(1 - e^{-\frac{t}{\tau}}\right)$$

sepecial case 2

$K = \lim_{s \to 0} s \times FTMF \times R(s)$

$\underline{\text{if } R(s) = \frac{1}{s}}$:

$$\frac{K \quad \omega_n^2}{s^2 + 2\varepsilon\omega_n s + \omega_n^2} \quad \Big| \; K = 1$$

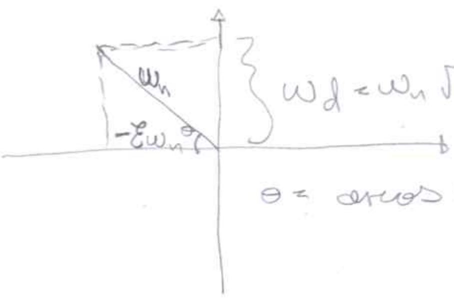
$\boxed{\text{Formulas.}}$

$$M_p = \frac{y(t_p) - y(\infty)}{y(\infty)} \times 100\% = e^{-\frac{\pi \varepsilon}{\sqrt{1-\varepsilon^2}}}$$

$$t_s = \frac{4}{\varepsilon \omega_n}$$

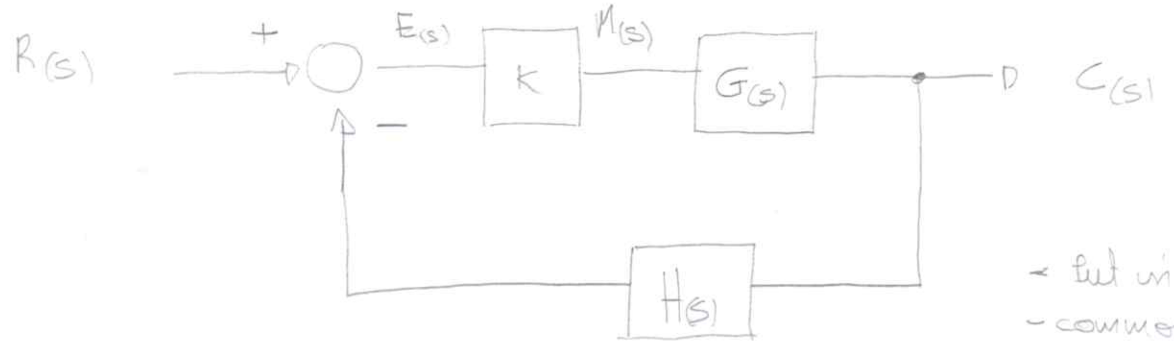
$$t_p = \frac{\pi}{\omega_n \sqrt{1-\varepsilon^2}}$$

$$y(\infty) = \lim_{t \to \infty} y(t) = \lim_{s \to 0} Y(s)$$



$\theta = \arccos(\varepsilon)$

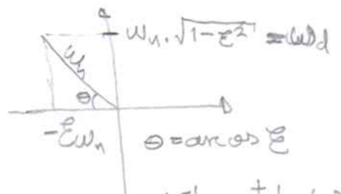
Nota! Resumo



- put in evidence
- common denominator

$$R_{(s)} \longrightarrow \boxed{\frac{K\,G_{(s)}}{1+\underbrace{KGH_{(s)}}_{FTLG}}} \longrightarrow C_{(s)}$$

$0 < \mathcal{E} < 1$ $\qquad G_{(s)} = \dfrac{n_{(s)}}{d_{(s)}}$



$$KGH_{(s)} = FTLG = \frac{N_{(s)}|_{FTLG}}{D_{(s)}|_{FTLG}}$$

$\rightarrow MF_{(K)}; MG_{(K)}$
$\rightarrow$ Bode
$\rightarrow$ LGR / zeros / polos
$\rightarrow e_{ss}$

$\left.\begin{matrix}\omega\\K\end{matrix}\right\rangle D_{(s)} = 0 \;\Big|_{s=j\omega}$ (LGR)

$$tg^{-1}(\alpha \pm \beta) = \frac{tg^{-1}(\alpha) \pm tg^{-1}(\beta)}{1 \mp tg^{-1}(\alpha)\cdot tg^{-1}(\beta)} \leftarrow \frac{d}{ds}K = 0 \text{ (LGR)} \leftarrow D_{(s)}|_{FTMF} = D_{(s)}|_{FTLG} + N_{(s)}|_{FTLG}$$

Dominio do tempos

$R_{(s)} \cdot FTMF$

FTLG
- MG; MF
- Bode; zeros
- polos; LGR
- e_{ss}

Routh Hurwitz
$\downarrow$ estabilidade $\rightarrow K$
$\downarrow$ sintonia Zeig MF — K, T_i, T_d $\Leftrightarrow 0 < \mathcal{E} < 1$

$$\left.\begin{aligned} b = 0 &\Rightarrow R_{(s)} = \frac{1}{s} \Rightarrow K_p = \lim_{s \to 0} FTLG \\ b = 1 &\Rightarrow R_{(s)} = \frac{1}{s^2} \Rightarrow K_v = \lim_{s \to 0} FTLG \\ b = 2 &\Rightarrow R_{(s)} = \frac{1}{s^3} \Rightarrow K_a = \lim_{s \to 0} FTLG \end{aligned}\right\} \rightarrow e_{ss}$$

$y = \log K$

$K = 10^y$

$s = -\mathcal{E}\cdot\omega_n \pm \omega_n\sqrt{\mathcal{E}^2 - 1}$ $\qquad \mathcal{E} \geq 1$ $\qquad t_{(s)} = \dfrac{4}{\mathcal{E}\omega_n}$

$s = -\mathcal{E}\omega_n \pm j\,\omega_n\sqrt{1-\mathcal{E}^2}$

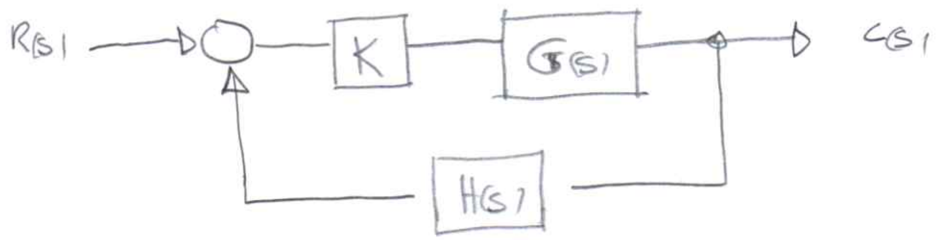
$t_p = \dfrac{\pi}{\omega_n\sqrt{1-\mathcal{E}^2}}$; $y(t_p) = 1 + e^{-\frac{\mathcal{E}\pi}{\sqrt{1-\mathcal{E}^2}}}$

$M_p = e^{-\frac{\mathcal{E}\pi}{\sqrt{1-\mathcal{E}^2}}}$; $t_{(s)} = \dfrac{4}{\mathcal{E}\omega_n}$

$= \dfrac{y(t_p) - y(\infty)}{y(\infty)}$ $\qquad t_{(r)} \cong \dfrac{e^{\theta/\tan\theta}}{\omega_n}$; $\theta = \arccos(\mathcal{E})$

$$\mathcal{E} = \sqrt{\frac{1}{1 + \left(\frac{\pi\, t_{(s)}}{4 t_p}\right)^2}}$$

Resumo 1



$$R(s) \longrightarrow \boxed{\frac{KG(s)}{1+KGH(s)}} \longrightarrow C(s)$$

$$\boxed{\begin{array}{c} 1+\frac{a}{b}=\phi \\ b+a=\phi \end{array}}$$

$R(s) \cdot FTMF \to$ eq parciais

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

Dominio dos tempos $R(s)=\frac{1}{s}$

casos especiais

$\leftarrow \boxed{FTMF = \frac{KG(s)}{1+KGH(s)}}$

$$= 1 + \underbrace{KGH(s)}_{FTLG}$$

$$KGH(s) = \frac{N}{D} \qquad D_{(s)} = D + N \qquad \boxed{D_{(s)} = \phi}$$

KGH(s) [FTLG]
- $\to MF_{(K)}$; $MG_{(K)}$
- $\to$ Bode ; Nyquist
- $\to$ LGR
  - zeros
  - polos
  - δ ; α — α polo
- $\to$ ess

$D_{(s)}$ [$D_{(s)\,FTMF}$]
- Quebra $\frac{dK}{ds}=\phi \to s \to K$
- intercepção eixo im $D(s)=\phi|_{s=j\omega} < {K \atop \omega}$
- Routh Hurwitz
  - $\to$ estabilidade
  - $\to$ sintonia Zeig NF
  - $\to$ casos especiais
- PID

Quebra: $D_{(s)} \to \frac{dK}{ds} = \phi \to s \to K$

intercepção eixo imaginario: $D(s) \to D(s) = \phi|_{s=j\omega} < {K \atop \omega}$

Dominio dos tempos

FTMF

$R(s) = \frac{1}{s} \Rightarrow \frac{K}{s+a} \Rightarrow \frac{K}{a} \frac{1}{\frac{s}{a}+1}$ $\tau = \frac{1}{a}$

$y(t) = \frac{K}{a}\left(1 - e^{-\frac{t}{\tau}}\right)$

$R(s) = \frac{1}{s} \Rightarrow \frac{K \cdot \omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2} \Big| K=1$

$\xi \geq 1$

$s = -\xi\omega_n \pm \omega_n\sqrt{\xi^2 - 1}$

$0 < \xi < 1$

$s = -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2}$

—//—

Frequência

$R(t) = \text{sen}(\omega t)$ $t > 0$ $y(t) = |G(j\omega)| \cdot \text{sen}[\omega t + \angle G(j\omega)]$

- Diagrama de Blocos   Matéria

- Modelação de sistemas
  - por variável em evidência
  - denominador comum.

FTMA
FTMF
$G_{(s)}$
$GH_{(s)} \to FTLG$
$\downarrow$
$D_{(s)}$

$F_R = ma$

$T_r = J\ddot{\theta}$

térmico

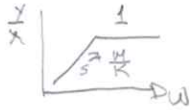
Hidráulico

- tirar equações
- Matrizes.
- acelerómetro

$$\frac{Y_{(s)}}{X_{(s)}} = \frac{s^2M}{s^2M+sB+K}$$

$$\lim_{s\to 0} \frac{Y_{(s)}}{X_{(s)}} = \frac{s^2M}{K}$$

$$\lim_{s\to\infty} \frac{Y_{(s)}}{X_{(s)}} = 1$$



- Análise de sistemas no domínio dos tempos [FTMF]

$$R_{(s)} = \frac{1}{s} \Rightarrow \frac{K}{s+a} \Rightarrow \frac{K}{a}\,\frac{1}{\left(\frac{s}{a}+1\right)} \qquad \tau = \frac{1}{a}$$

$$\Rightarrow \frac{K}{a}\left(1-e^{-\frac{t}{\tau}}\right)$$

$$R_{(s)} = \frac{1}{s} \Rightarrow \frac{K\cdot\omega_n^2}{s^2+2\xi\omega_n+\omega_n^2}\ \Big|\ K=1$$

Formulário
- tipo de sistema } FT LG
- e_{ss}

Fracções parciais $\Rightarrow \mathcal{L}^{-1}$

- Critério de Estabilidade de Routh-Hurwitz

$GH_{(s)} \to D_{(s)}$ - Rout-Hurwitz.

special cases

- Lugar Geométrico de Raízes [Muito Importante]

$$GH_{(s)} \to D_{(s)} \to \frac{d}{ds}K = 0 \to s \to \text{Quebra}$$

s, α Polos   zeros

$D_{(s)} = \emptyset \,\big|\, s = j\omega < \begin{matrix} K \\ \omega \end{matrix}$ intercept imaginário

nota special

— Domínio das Frequências

$GH_{(s)} \to$ Bode
$\to$ Nyquist
$\to$ LGR

Limit format for graphs
↳ $K \to 20\log(K)$ - inic point

$\frac{1}{j\omega} = \frac{1}{\omega} \cdot \underline{|-90^{\circ}}$

$(j\omega+1) = \sqrt{\omega^2+1^2}\ \underline{|\arctan\left(\frac{\omega}{1}\right)}$

— PID

FTMF $\to D_{(s)} \to$ Zeigler-Nichols closed Loop

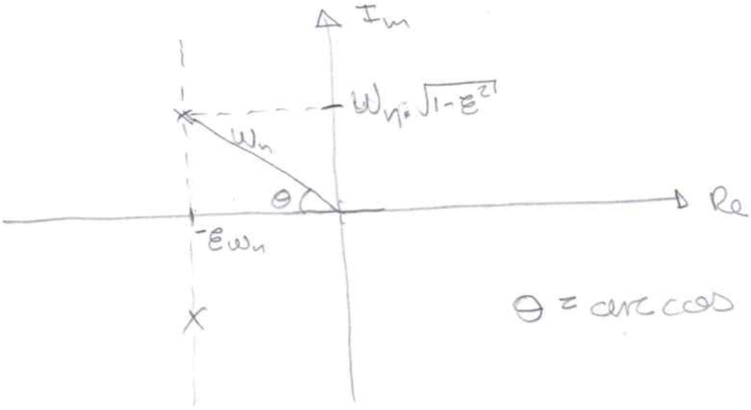
$D_{(s)}$ ↓ 2^a ordem Epsilon casos

Zeigler-Nichols closed Loop ↓ $c_{n-1} = 0$
↳ K
$b_{n-1} + a_{n-2}|_K$
↓ s

note

$$0 \leq \xi < 1$$

$$p_1, p_2 = -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2}$$



$$\theta = \arccos \xi$$

$$\omega_d = \omega_n \cdot \sqrt{1-\xi^2}$$

Note $\omega_d \leq \omega_n$ e que $\omega_d = \omega_n$ para $\xi = \emptyset$

$\omega_d \to$ frequencia amortecida

$\omega_n \to$ frequencia natural.

$$\boxed{0 \leq \xi < 1}$$

$$t_p = \frac{\pi}{\omega_n \cdot \sqrt{1-\xi^2}} \quad , \quad y(t_p) = 1 + e^{-\frac{\xi\pi}{\sqrt{1-\xi^2}}}$$

$$M_p = e^{-\frac{\xi\pi}{\sqrt{1-\xi^2}}}$$

$$t_s = \frac{4}{\xi \cdot \omega_n}$$

$$t_r \cong \frac{e^{(\theta/\tan\theta)}}{\omega_n} \quad , \quad \theta = \cos^{-1}(\xi)$$

$$tg^{-1}(\alpha \pm \beta) = \frac{tg^{-1}(\alpha) \pm tg^{-1}(\beta)}{1 \mp tg^{-1}(\alpha) \cdot tg^{-1}(\beta)}$$

Modeling systems

Apontamento

2nd order system

if the response to a unit step input is known, then it is mathematically possible to compute the response to any input.

[control system fundamentals CRC]

1. Rise time (t_r)
2. Percent overshoot (PO)
3. Peak time (t_p)
4. Settling time (t_s)
5. Delay time (t_d)

time rise for overdamped [0% → 100%]
" " underdamped [10% → 90%]

settling time is when it is within [2% → 5%] of final value.

Delay time is the time to reach half of its final value.

$$G(s) = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

$$PO = \frac{-\xi\pi}{\sqrt{1-\xi^2}} \quad ; \quad t_p = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$$

$$t_{s_{2\%}} = \frac{4}{\omega_n \xi} \quad ; \quad t_{s_{5\%}} = \frac{3}{\xi\omega_n}$$

$$t_d \cong \frac{1{,}1 + 0{,}125\,\xi + 0.469\,\xi^2}{\omega_n}$$

$$t_r \cong \frac{1 - 0{,}4167\,\xi + 2{,}917\,\xi^2}{\omega_m}$$

if $\xi < 1$

$$p_1 = -\xi\omega_n + j\omega_n\sqrt{1-\xi^2} \; ; \; p_2 = -\xi\omega_n - j\omega_n\sqrt{1-\xi^2}$$

Notas: 2019 → 2020

sistemas electricos, electronicos com operacionais, alavancas, engrenagens rodas dentadas, não sei em testes vai ser dado em sisel.

"Motores não sei"
usar electrico para treinar

Matéria.

tanques, térmico, mecanica.

$$\boxed{\begin{aligned} y &= 20 \log_a K \\ K &= a^{\frac{y}{20}} \end{aligned}}$$

$$\mathrm{Arg} = \mathrm{Arctan}\left(\frac{J}{R}\right)$$
$$= \sqrt{J^2 + R^2}$$

$$\mathrm{arctan}(\alpha \pm \beta) = \frac{\mathrm{arctan}(\alpha) \pm \mathrm{arctan}(\beta)}{1 \mp \mathrm{arctan}(\alpha) \cdot \mathrm{arctan}(\beta)}$$

$$\frac{2}{3}\pi r^2 h$$

23/4/2020

Modelação sistemas

review

exercícios térmico

Água

9) 10)

Análise de sistemas no

Domínio dos tempos

$0 < \xi < 1$

subamortecido

e depois

ordens s^N ; $N=1$, $N=2$ e 3

9) 13)

- melhorar algoritmos + completos e abrangente.

Basics

$\sqrt{a} \times \sqrt{b} = \sqrt{ab}$ $\qquad \sqrt{1} = 1$

$\frac{\sqrt{a}}{\sqrt{b}} = \sqrt{\frac{a}{b}}$ $\qquad 1^0 = 1$ $\qquad \sqrt{5} \cdot \sqrt{5} = (\sqrt{5})^2 = \sqrt{25}$

$1^n = 1$

$\frac{1}{\sqrt{\frac{a}{b}}} = \sqrt{\frac{b}{a}}$ $\qquad (\sqrt{a})^2 = a$ $\qquad \sqrt{a^2} = a$ $\qquad \frac{1}{\emptyset} = \infty$ $\qquad \frac{1}{\infty} = \emptyset$

$\boxed{\frac{a}{a} = 1}$ $\qquad a \cdot 1 = a$ $\qquad \boxed{\frac{\Delta}{\Delta} = 1}$

$5 = 5 \times 3^{-3}$

$\frac{a}{1} = a$ $\qquad \frac{1}{a} = a^{-1}$ $\qquad (a^n)^m = a^{m \cdot n}$

$a^n \cdot b^m = b^m \cdot a^n$

$a^m \cdot a^n = a^{m+n}$ $\qquad \frac{a^n}{a^m} = a^{n-m}$

$a + b + c$
$= (a+b) + c$
$= a + (b+c)$
$= b + (a+c)$

$a \cdot a = a^2$ $\qquad \sqrt[m]{a^n} = a^{\frac{n}{m}}$

$\frac{a}{a} = a^0 = 1$

$\frac{1}{1+\frac{a}{b}} = \frac{1}{\frac{b+a}{b}} = \frac{b}{b+a}$ $\qquad \sqrt{a} = a^{\frac{1}{2}}$

$a + a = 2a$ $\qquad a \cdot a = a^2$

$a - a = \emptyset$ $\qquad a \div a = 1$

$(-a) \cdot (-a) = a^2$

$ab + ac = (b+c) \cdot a$

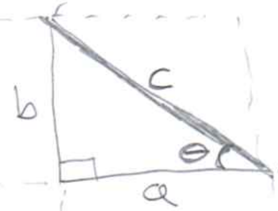
$a + b - c = a + (b-c)$
$= b - (c-a)$

$\underbrace{ab}_{1} + ac = 0$

$1 + \frac{\cancel{a}c}{\cancel{a}b} = 0 \Leftrightarrow 1 + \frac{c}{b}$

$a+bi=c \qquad |c| = \mathrm{Abs}(a+bi) = \sqrt{a^2+b^2}$

$a+ai=c \qquad |c| = a\sqrt{2}$



$a+bi=c \qquad \angle c = \mathrm{Arg}(a+bi) = \theta$

$= \arctan\left(\frac{b}{a}\right)$

$a+ai=c \qquad \angle c = 45^\circ$

$(a+bi)(c+di) = e \qquad |e| = \mathrm{Abs}(a+bi).\mathrm{Abs}(c+di)$

$e = |e|.\angle e$

$\angle e = \mathrm{Arg}(a+bi) + \mathrm{Arg}(c+di)$

$X_C = \frac{1}{2\pi f C} = \frac{1}{\omega C} = \frac{1}{j\omega C} = \frac{1}{\omega C}\angle{-90^\circ}$

$X_L = 2\pi f L = \omega L = j\omega L = \omega L \angle 90^\circ$

$\mathrm{Log}_a x = z$

$x = a^z$

$$\arctan(\alpha \pm \beta) = \frac{\arctan(\alpha) \pm \arctan(\beta)}{1 \mp \arctan(\alpha).\arctan(\beta)}$$

transitorio Rules

1.

$$y(t) = 1 - e^{-st} = 1 - e^{-\frac{1}{RC}t}$$

$$\tau = RC$$

$$t_r = t_{90} - t_{10}$$

$$t_s = 4\tau$$

$$\frac{\frac{K}{s(s+2)}}{1 + \frac{K}{s(s+2)}}$$

$$\frac{K}{s(s+2)} \cdot \frac{1}{1 + \frac{K}{s(s+2)}} = \frac{K}{s(s+2) + K}$$

$$= \frac{K}{s^2 + 2s + K}$$

$$2\xi\omega_n = 2$$

$$K = \omega_n^2$$

$$2\xi\sqrt{K} = 2$$

$$\xi = \frac{1}{\sqrt{K}}$$

—— // ——

NOTA.

$$G(s) = \frac{s+2}{s(s+4)}$$

$$K_p = \lim_{s \to 0} G(s)$$ constante de erro posição

$$K_v = \lim_{s \to 0} s \cdot G(s)$$ constante de erro velocidade

$$K_a = \lim_{s \to 0} s^2 G(s)$$ constante de erro aceleração

erro regime permanente

OT

22/10/2009
20:00

SISEL

—— // ——

$$G(j\omega) = \frac{j\omega B + K}{(j\omega)^2 M + j\omega B + K} \rightarrow \left(j\frac{\omega}{T} + 1\right)$$

$$\rightarrow \left(1 + 2\xi\left(j\frac{\omega}{\omega_n}\right) + \left(j\frac{\omega}{\omega_n}\right)^2\right)$$

$$G(j\omega) = \frac{j\omega\frac{B}{K} + 1}{(j\omega)^2\frac{M}{K} + j\omega\frac{B}{K} + 1}$$

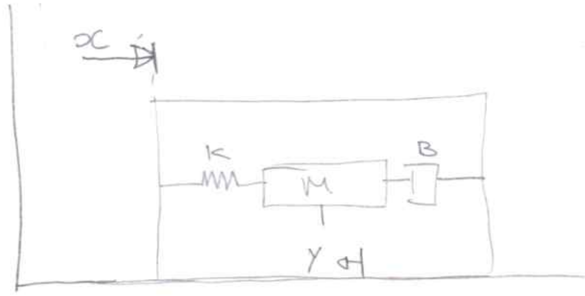
$$= \frac{j\frac{\omega}{250} + 1}{\frac{(j\omega)^2}{25} + j\frac{\omega}{250} + 1}$$

$$\log\left(\frac{a}{b}\right) = \log(a) - \log(b)$$

$$= 20\log\sqrt{1 + \left(\frac{\omega}{250}\right)^2} - 20\log\sqrt{\left(1 - \frac{\omega^2}{25}\right) + \left(\frac{\omega}{250}\right)^2}$$

note

A celerometro



$$\Sigma F_R = M\, a_{(t)}$$

$$-K\, y_{(t)} - B \frac{d}{dt} y_{(t)} = M \frac{d^2}{dt^2}(y - x)$$

se $\frac{d}{dt} x_{(t)} = K$

$$\Rightarrow y_{(t)} = \left(\frac{M}{K}\right) \frac{d^2}{dt^2} x_{(t)}$$

2ª Lei de Newton	$\Sigma F_{(t)} = M\, a_{(t)}$
2ª Lei de Newton	$\Sigma T_{(t)} = J\, \alpha_{(t)}$

$$\begin{cases} q = \dfrac{\theta_{1(t)} - \theta_{2(t)}}{R} \\ q = C \dfrac{d}{dt}\left[\theta_{1(t)} - \theta_{2(t)}\right] \end{cases}$$

$$\begin{cases} C = A \dfrac{d h_{(t)}}{dt} = \dfrac{d}{dt} V_{(t)} \\ q_0 = \dfrac{h}{R} \end{cases}$$

Control system Fundamentals

apontamentos

$$F(s) = \frac{c}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

$\omega_n > 0 \land 0 < \xi < 1$

$$p_1 = -\xi\omega_n \pm \omega_n\sqrt{\xi^2 - 1}$$

$\omega_n > 0 \land \xi > 1$, polos reais diferentes

$$F(s) = \frac{c}{(s-p_1)(s-p_2)} = \frac{c}{p_1 - p_2}\left[\frac{1}{s-p_1} - \frac{1}{s-p_2}\right]$$

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

$$f(t) = \frac{c}{p_1 - p_2}\left[e^{p_1 t} - e^{p_2 t}\right]$$

$\omega_n > 0 \land \xi = 1$, $p_1 = p_2 = -\omega_n$

$$F(s) = \frac{c}{(s+\omega_n)^2} \quad ; \; p_1 = p_2 = -\omega_n$$

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

$$f(t) = c.t.e^{-\omega_n t}$$

Proof.

$$s^2 + 2\varepsilon\omega_n s + \omega_n^2$$

$$s = \frac{-2\varepsilon\omega_n \pm \sqrt{(2\varepsilon\omega_n)^2 - 4\omega_n^2}}{2}$$

$$= -\varepsilon\omega_n \pm \frac{\sqrt{(2\varepsilon\omega_n)^2 - 4\omega_n^2}}{2} \qquad \frac{\sqrt{a}}{\sqrt{b}} = \sqrt{\frac{a}{b}}$$

$$= -\varepsilon\omega_n \pm \sqrt{\frac{(\cancel{2}\varepsilon\omega_n)^2 - 4\omega_n^2}{\cancel{2^2}}}$$

$$= -\varepsilon\omega_n \pm \sqrt{(\varepsilon\omega_n)^2 - \frac{\cancel{4}\omega_n^2}{\cancel{4}}} \qquad \varepsilon^2\omega_n^2 - \omega_n^2 \qquad \sqrt{(\varepsilon^2 - 1)\omega_n^2}$$

$$= -\varepsilon\omega_n \pm \sqrt{} \qquad \sqrt{\varepsilon^2 - 1}\ \cancel{\sqrt{\omega_n^2}}$$

$$= -\varepsilon\omega_n \pm \omega_n\sqrt{\varepsilon^2 - 1}$$

$$= -\omega_n\left(\varepsilon \pm \sqrt{\varepsilon^2 - 1}\right)$$

$\varepsilon^2 - 1 > 0$ $\qquad$ $\varepsilon^2 - 1 < 0$

$\varepsilon^2 > 1$ $\qquad$ $\varepsilon^2 < 1$

$\varepsilon > 1$ $\qquad$ $\varepsilon < 1$

$\varepsilon^2 - 1 = 0$

$\varepsilon = 1$

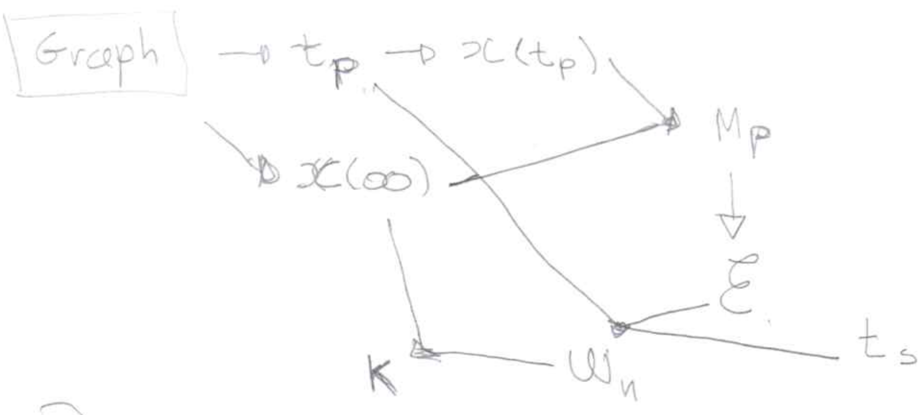
Analisis

17/4/2020

NOTA

t_s t_p

$\xi ; \omega_n$



$\xi > 1$

$\xi = 1$

$0 < \xi < 1$

Diferentes dampening diferent equations

$0 < \xi < 1 \Rightarrow$ Poles $= -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2}$

NOTA

$$G(s) = \frac{(s+z)}{(s+p_1)(s+p_2)}$$

$|G(s)| \rightarrow$ modulo (Abs)

$\arg[G(j\omega)] \rightarrow$ Fase

$$|G(s)| = \frac{\overline{BD}}{\overline{CD} \cdot \overline{AD}}$$

$\arg[G(j\omega)] = \beta - \gamma - \alpha$ (Arg)

Definições

$$\arg[G.H(j\omega_\pi)] = -\pi \Rightarrow MG = \frac{1}{|GH(j\omega_\pi)|}$$

ou $MG_{dB} = 20 \log_{10} \frac{1}{|GH(j\omega_\pi)|}$

Definições

$$|GH(j\omega_1)| = 1 \Rightarrow MF = 180^\circ + \arg[GH(j\omega_1)]$$

Analise de sistemas no
Dominio das Frequências.

- → FTMA
- → Grafico em frequencias
- → Diagrama polares
- → Diagrama de Bode
- → FTMF
- → estabilidade → MG → margem ganho
  → MF → margem de fase

$$u(t) \longrightarrow \boxed{G(s)} \longrightarrow y(t)$$

$$u(t) = \text{sen}\,(2t) = \frac{\omega}{s^2+\omega^2}$$

$$G(s) = \frac{1}{s+1}$$

$$s = j2$$

$$Y(s) = G(s) \cdot U(s)$$

$$= \left.\frac{1}{s+1}\right|_{s=j2} \cdot \frac{2}{s^2+2^2}$$

$$= \frac{1}{j2+1} \cdot \frac{2}{s^2+2^2}$$

$$= \frac{1}{\sqrt{5}} \cdot e^{-j1{,}11} \cdot \frac{2}{s^2+2^2} = \frac{1}{\sqrt{5}} \cdot \text{sen}\left(2t-1{,}11\right)$$