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COMP 22 CMC-12 LISTA 11

01 $G_f(s) = \dfrac{K}{s(s+1)(s+2)+K} = \dfrac{Y(s)}{X(s)}$

$X(s) = \dfrac{1}{s^2}$ (rampa)

$$\lim_{s \to 0} s \cdot (X(s) - Y(s)) \leq 1$$

$$\lim_{s \to 0} s \cdot \left(\frac{1}{s^2} \left(1 - \frac{K}{s(s+1)(s+2)+K} \right) \right) \leq 1$$

$$\frac{2}{K} \leq 1$$

$$K \geq 2$$

$$\angle KG(jw) = \operatorname{atan}\left(\frac{2w - w^3}{-3w^2} \right) = -180°$$

$$2w - w^3 = 0$$

$$w_{CG} = \sqrt{2}$$

$$|K\,G(j\,w_{CG})| = \left| \frac{K}{\sqrt{2}j(\sqrt{2}j+1)(\sqrt{2}j+2)} \right| = \frac{K}{\sqrt{2} \cdot \sqrt{3} \cdot \sqrt{6}} = \frac{K}{6}$$

$$-20 \log_{10} \frac{K}{6} \geq 6$$

$$\log_{10} \frac{K}{6} \leq -0,3$$

$$\frac{K}{6} \leq 0,5$$

$$K \leq 3,007$$

(02) 1) antes do lag

$$G_F(s) = \frac{54}{s^2+5s+60} = \frac{Y(s)}{X(s)}$$

$$X(s) = \frac{1}{s} \qquad E(s) = \frac{1}{s}\left(\frac{s^2+5s+6}{s^2+5s+60}\right)$$

$$e_\infty = \lim_{s\to 0} sE(s) = 0{,}1$$

$$|KG(j\omega_{cp})| = 1$$

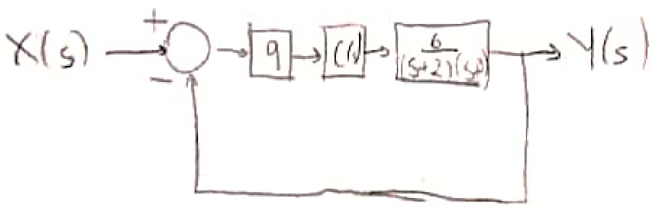
$$\frac{54}{\sqrt{4+\omega^2}\,\sqrt{9+\omega^2}} = 1$$

$$54^2 = \omega^4 + 13\omega^2 + 36$$

$$\omega^4 + 13\omega^2 - 2880 = 0$$

$$\omega_{cp} = 6{,}8962192$$

2) lag:



$$C(s) = \alpha\frac{(Ts+1)}{(\alpha Ts+1)} \qquad T = 1{,}45007$$

$$G_f'(s) = \frac{54\alpha(Ts+1)}{(s+2)(s+3)(\alpha Ts+1) + 54\alpha(Ts+1)}$$

$$E'(s) = \frac{1}{s}\left(\frac{(s+2)(s+3)(\alpha Ts+1)}{(s+2)(s+3)(\alpha Ts+1) + 54\alpha(Ts+1)}\right)$$

$$0{,}05 = \frac{6}{6+54\alpha}$$

$$\alpha = 2{,}T$$

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(03) $G'(s) = \dfrac{k(s-z)}{(Ls+R)(s-p)s}$

$$G_F(s) = \frac{k(s-z)}{(Ls+R)(s-p)s + k(s-z)}$$

$$E(s) = \frac{1}{s^2}\left(\frac{(Ls+R)(s-p)s}{(Ls+R)(s-p)s + k(s-z)}\right)$$

$$\boxed{e_\infty = \frac{Rp}{kz} \leq 0{,}05}$$

$$G_F(0) = 1$$

$$|G_F(jw_b)| = \frac{\sqrt{2}}{2} \Rightarrow \frac{k\sqrt{w_b^2+z^2}}{\sqrt{((-R+pL)w_b^2-kz)^2+((k-Rp)w_b-Lw_b^3)^2}} = \frac{\sqrt{2}}{2}$$

$$|G'(jw_{cp})| = 1$$

$$\frac{k\cdot\sqrt{w^2+z^2}}{\sqrt{R^2+L^2w^2}\sqrt{p^2+w^2}\cdot w} = 1$$

$$k^2w_{cp}^2 + k^2z^2 = w_{cp}^2(R^2+L^2w_{cp}^2)(p^2+w_{cp}^2)$$

$$\angle G'(jw_{cp}) \geq -130^\circ$$

fazendo $p=0$ $\quad K=1 \quad wb=20$

$$2(400+z^2) = (z+400)^2 + (20-800)^2$$

$$z^2+800 = 800z + 16000 + 780^2$$

$$z^2 - 800z - 767600 = 0$$

$$z = 1363{,}12$$

$$w_{cp} = 23{,}221$$

$$\angle G'(jw_{cp}) = -67^\circ$$

$$PM = 112^\circ$$

04

$$G'(s) = \frac{k_p + K_d s}{s(ms+b)} \qquad G_f(s) = \frac{K_p + K_d s}{ms^2 + (b+K_d)s + K_p}$$

os polos estão em:

$$p_{1,2} = -\frac{(b+K_d)}{2m} \pm \frac{\sqrt{4mK_p - (b+K_d)^2}}{2m} j$$

$$\begin{cases} \xi w_n = 1{,}4\pi = \frac{b+K_d}{2m} \rightarrow K_d = 874{,}46 \\ w_n = 2\pi = \sqrt{\frac{K_p}{m}} \rightarrow K_p = 39478{,}42 \end{cases}$$

$T = 0{,}1s$

$$\text{atraso} = \frac{T}{2} + 0{,}05 = 0{,}1s$$

$$|G(w_{cp} j)| = 1$$

$$K_p^2 + (K_d w_{cp})^2 = w_{cp}^2 \left((m w_{cp})^2 + b^2\right)$$

$$m^2 w_{cp}^4 + (b^2 - K_d^2) w_{cp}^2 - K_p^2 = 0$$

$$w_{cp} = 9{,}6549$$

$$\Delta PM = 55{,}32^{\circ}$$

05

$$s = \frac{2}{T}\left(\frac{z-1}{z+1}\right)$$

$$F_m(z) = \frac{w_n^2}{\frac{4}{T^2}\left(\frac{z^2-2z+1}{z^2+2z+1}\right) + \frac{4\xi w_n}{T}\left(\frac{z-1}{z+1}\right) + w_n^2} = \frac{T^2 w_n^2 (z^2+2z+1)}{4z^2 - 8z + 4 + 4\xi w_n T z^2 - 4\xi w_n T + T^2 w_n^2 (z^2+2z+1)}$$

$$U(z)\cdot\left(\left(4 + 4\xi w_n T + T^2 w_n^2\right) z^2 + \left(-8 + 2T^2 w_n^2\right) z + \left(4 - 4\xi w_n T + T^2 w_n^2\right)\right) = E(z)\left(T^2 w_n^2 \cdot z^2 + 2T^2 w_n^2 z + T^2 w_n^2\right)$$

$$U(z)\left(\left(4 + 4\xi w_n T + T^2 w_n^2\right) + \left(-8 + 2T^2 w_n^2\right) z^{-1} + \left(4 - 4\xi w_n T + T^2 w_n^2\right) z^{-2}\right) = E(z)\left(T^2 w_n^2 + 2T^2 w_n^2 z^{-1} + T^2 w_n^2 z^{-2}\right)$$

$$u[k] = \frac{1}{4 + 4\xi w_n T + T^2 w_n^2}\Big((8 - 2T^2 w_n^2) u[k-1] + (-4 + 4\xi w_n T - T^2 w_n^2) u[k-2] + (T^2 w_n^2) e[k] + (2T^2 w_n^2) e[k-1] + (T^2 w_n^2) e[k-2] \Big)$$

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