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CMC-12 LISTA 10 COMP-22

(02) $\left((R(s)-X(s))K_p - X(s)\,s\right)K_N = X(s)\,(s(ms+b))$

$$(R(s)-X(s))K_pK_N = X(s)\,(ms^2+(b+K_N)s)$$

$$G_f(s) = \frac{X(s)}{R(s)} = \frac{K_pK_N}{ms^2+(b+K_N)s+K_pK_N}, \quad G(s) = \frac{K_pK_N}{s(ms+b+K_N)}$$

$$\begin{cases} \omega_n^2 = \dfrac{K_pK_N}{m} \\ 2\xi\omega_n = \dfrac{b+K_N}{m} \end{cases}$$

$$\begin{cases} \left(\dfrac{2\pi}{\omega_n}\right)^2 = 1-2\xi^2+\sqrt{4\xi^4-4\xi^2+2} \\ \dfrac{4\xi^2}{3} = -2\xi^2+\sqrt{4\xi^4+1} \end{cases}$$

- $\frac{10}{3}\xi^2 = \sqrt{4\xi^4+1}$

$\frac{100}{9}\xi^4 = 4\xi^4+1$

$\xi^2 = \frac{3}{8}$

$$\omega_n = \frac{2\pi}{\sqrt{1-2\xi^2+\sqrt{4\xi^4-4\xi^2+2}}}$$

03

$|G(j\omega)|_{dB} = 0 \Rightarrow \angle(G(j\omega)) = -105°$

$PM = 75°$

$\angle(G(j\omega)) = -180° \Rightarrow |G(j\omega)|_{dB} = -16$

$GM = 16\ dB$

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$$G_a(s) = \frac{9s+6}{0,1s+1} \cdot \frac{\nu}{s^2} \cdot e^{-Ts}$$

$$|G_a(j\omega_{cp})| = 1 \Rightarrow \left| \frac{6+9\omega_{cp}j}{1+0,1\omega_{cp}j} \cdot \frac{\nu^2}{-\omega_{cp}^2} \cdot e^{-T\omega_{cp}j} \right|^{\frac{1}{2}} = 1$$

$$\frac{\sqrt{36+81\omega^2}}{\sqrt{1+0,01\omega^2}} \cdot \frac{1}{\omega^2} = 1$$

$$36+81\omega^2 = \omega^4(1+0,01\omega^2)$$

$$0,01\omega^6 + \omega^4 - 81\omega^2 - 36 = 0$$

roots $\Rightarrow$ $\omega_{cp} = 7,3$

$$\Delta PM = (100-30)ms \cdot 7,3\ \frac{rad}{s} = 0,511\ rad =$$

$$= 29,3°$$

5) · G_R

$$\left(R(s)\cdot\frac{K_i}{K_p s+K_i}-Y(s)\cdot\frac{a}{s+a}\right)K_p s+K_i = Y(s)\cdot s(Ls+R)$$

$$R(s)\cdot K_i = Y(s)\left(Ls^2+Rs+\frac{K_p sa+K_i a}{s+a}\right)$$

$$G_R(s)=\frac{(s+a)K_i}{Ls^3+(La+R)s^2+(R+K_p)as+K_i a}$$

· G_N

$$-(Y(s)+N(s))\frac{a}{s+a}\cdot\frac{K_p s+K_i}{s(Ls+R)} = Y(s)$$

$$-N(s)(a(K_p s+K_i)) = Y(s)\left((s+a)(Ls+R)s+a(K_p s+K_i)\right)$$

$$G_N(s)=\frac{-aK_p\cdot s-aK_i}{Ls^3+(R+La)s^2+(R+K_p)as+aK_i}$$

· G_D

$$D(s)-Y(s)\frac{a}{s+a}\cdot\frac{K_p s+K_i}{s} = Y(s)\cdot(Ls+R)$$

$$G_D(s)=\frac{s(s+a)}{Ls^3+(R+La)s^2+(R+K_p)as+aK_i}$$