

$$① \quad p(s) = \frac{14,145}{(s^2 + 0,8425s + 2,829)} \quad \therefore \frac{K u_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$$= \frac{5 \cdot (2,829)}{s^2 + 0,8425s + 2,829}$$

Valor de sobressinal  $\Rightarrow M_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$

Tempo de subida  $\Rightarrow t_r = \frac{\pi}{2\omega_n}$

Tempo de acomodação  $\Rightarrow t_s = \frac{4}{\zeta} \therefore 4T$

Instante de pico do sistema  $\Rightarrow t_p = \frac{\pi}{\omega_d}$

$$\omega_n = \sqrt{2,829} \approx 1,682$$

$$M_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}} = e^{\frac{-0,2503 \cdot 3,14}{\sqrt{1-0,2503^2}}}$$

$$\zeta = \frac{3,34}{2 \cdot 1,682} = \frac{3,34}{3,364} \approx 0,9334$$

$$= e^{\frac{-0,785942}{\sqrt{1-0,0626}}}$$

$$0,842 = 2 \cdot \zeta \cdot 1,682$$

$$= e^{\frac{-0,7859}{0,9682}}$$

$$\zeta = \frac{0,842}{3,364} \approx 0,2503$$

$$= e^{-0,8317} \approx 0,444$$

$$T_s \text{ ex.} = 4 \cdot \frac{1}{\zeta\omega_n} = 4 \cdot \frac{1}{0,2503 \cdot 1,682} = \frac{4}{0,421} = 9,501$$

$$T_p = \frac{\pi}{\omega_d} = \frac{3,14}{1,682 \cdot 0,9682} \approx 1,9281$$

$$\textcircled{2} \text{ a) } G(s) = \frac{16}{s^2 + 3s + 16}$$

$$\begin{aligned} \bullet \quad 2\zeta\omega_n &= 3 \rightarrow \omega_n = \sqrt{16} = 4 \\ 2\zeta &= \frac{3}{4} \end{aligned}$$

$$\begin{aligned} \bullet \quad \zeta &= e^{\frac{-2\pi\zeta}{\sqrt{1-\zeta^2}}} = e^{\frac{-2,355}{\sqrt{0,92702}}} \\ \zeta &\approx 0,0788 \end{aligned}$$

$$\zeta = \frac{3}{8} = 0,375$$

$$\bullet \quad T_s \approx \frac{4}{\zeta \cdot \omega_n} = \frac{1}{0,375} = 2,666$$

$$\bullet \quad T_p = \frac{\pi}{\omega_n \cdot \sqrt{1-\zeta^2}} = \frac{3,14}{4 \cdot 0,92702} \approx 0,8468$$

$$\bullet \quad T_n \approx \frac{\pi}{2\omega_n} \rightarrow T_n \approx \frac{3,14}{8} \approx 0,3925$$

$$\text{b) } G(s) = \frac{0,04}{s^2 + 0,025s + 0,04}$$

$$\bullet \quad 2\zeta\omega_n = 0,02 \rightarrow \omega_n = \sqrt{0,04} = 0,2$$

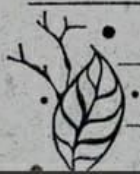
$$\zeta = \frac{0,01}{0,2} = 0,05$$

$$\bullet \quad \zeta = e^{\frac{-0,314}{\sqrt{1-\zeta^2}}} = e^{\frac{-0,314}{0,9987}} = e^{-0,314708} = 0,7302$$

$$\bullet \quad T_s \approx \frac{4}{\zeta \cdot \omega_n} = \frac{4}{0,05 \cdot 0,2} = 400$$

$$\bullet \quad T_p = \frac{\pi}{\omega_n \cdot \sqrt{1-\zeta^2}} = \frac{3,14}{0,2 \cdot 0,9987} \approx 15,7204$$

$$\bullet \quad T_n = \frac{\pi}{2\omega_n} = \frac{3,14}{0,4} = 7,85$$



$$\textcircled{3} \quad \frac{Y(s)}{R(s)} = \frac{\frac{K}{s(s+2)}}{1 + \frac{K}{s(s+2)}} = \frac{K}{s^2 + 2s + K} \quad \cdot e^{\frac{-5\pi}{\sqrt{1-5^2}}} = 0,2$$

$$\xi = 0,246$$

$$T_{\Delta} 5\% = \frac{3}{\xi \omega_n} = 3,5 \text{ sec}$$

$$\cdot 2\xi \omega_n = 2 \Rightarrow \omega_n = \frac{1}{\xi} = \omega_n = 2,2$$

$$K = \omega_n^2 = 4,8$$

$\Rightarrow$  Ganhos estáticos unitários  
independente de  $K$