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Exercícios aula 12/11

①

$$G(s) = \frac{s^2 + 5s + 25}{s^4 + 7,5s^3 + 76s + 720}$$

$$G(s) = \frac{25\left(1 - \left(\frac{\omega}{5}\right)^2 + \left(\frac{\omega}{5}\right)j\right)}{25\left(\frac{\omega}{5}j + 1\right) \cdot 64\left(1 - \frac{\omega^2}{64} + 0,09375j\right)}$$

$$20 \log K = 20 \log\left(\frac{5}{64}\right) = 20 \log(0,078125) = -22,14 dB$$

→ decaimento de 20dB por década

→ início do par -50°

$\omega_n = 5$ rad/s → $\omega_r = \omega_n \sqrt{1 - 2\zeta^2}$ → 5 rad/s pico

$$M_r = 20 \log\left(2\zeta\sqrt{1-\zeta^2}\right)^{-1} = 1,25 dB$$

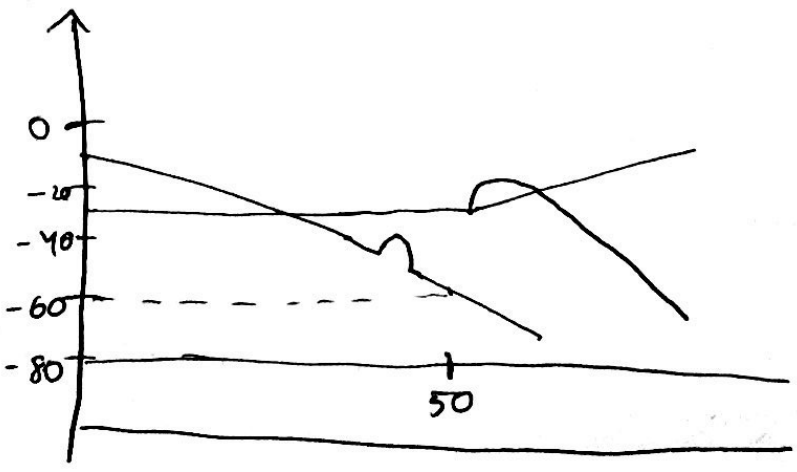
→ decaimento 20dB por ~~década~~ década

→ queda de 90° na fase

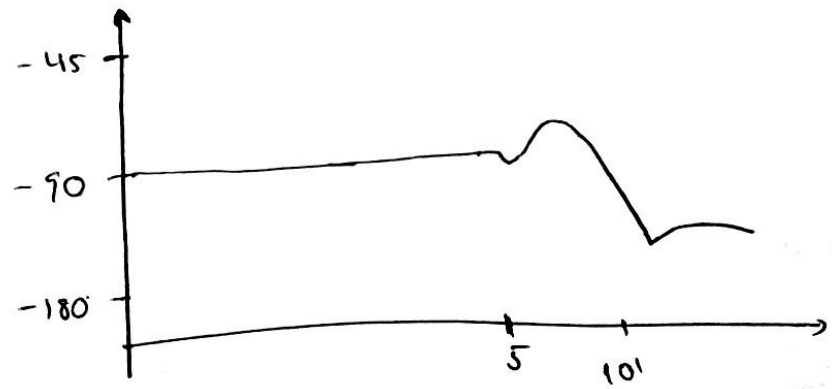
Par com polos conjugados: $\omega_n = 8$ rad/s; $\zeta = 0,15$

$$\omega_{rp} = \omega_n \sqrt{1 - 2\zeta^2} = 8\sqrt{1 - 2 \cdot 0,15^2} = 7,8 \text{ rad/s}$$

$$M_r = 20 \log\left(2\zeta\sqrt{1-\zeta^2}\right)^{-1} = 10,55 dB$$



Fase:



② $G_2(s) = \frac{6(s+1)}{s+12}$ ∴ $G_2(j\omega) = \left(\frac{\omega 5/2 + 1}{\omega j/12 + 12}\right)$

$\omega_{n-} = 2 rad/s \rightarrow$ zero

↳ aumenta de 90° depois de ω_{n-}

↳ crescimento de 20dB/década

$\omega_{np} = 12 rad/s \rightarrow$ polo

↳ diminuição de fase após 12 rad/s