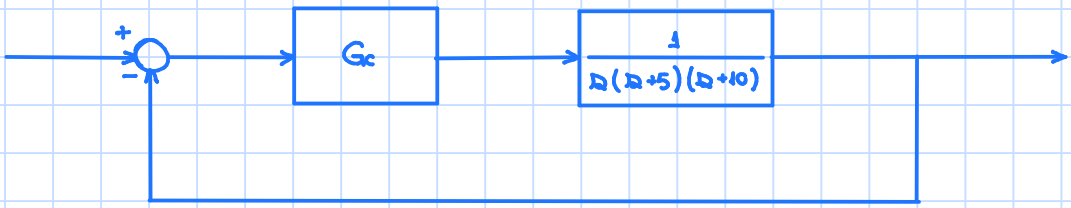
PAULO AKIRA FIGUTI ENABE 9083027 ATIVIDADE 3

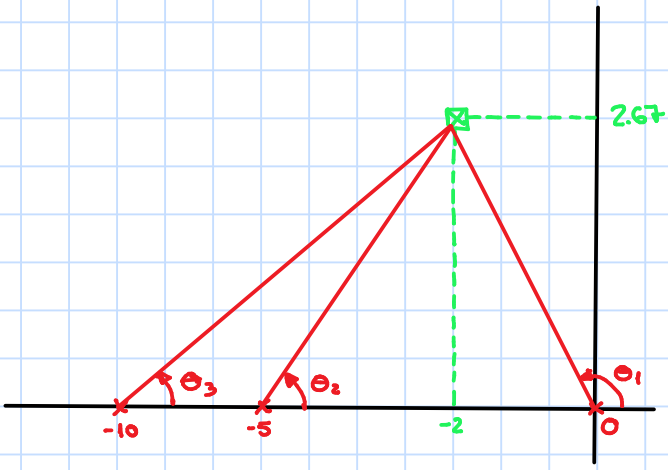



Projetar um compensador de avanço-atraso para $K_v = 10$, $\zeta = 0.6$, tempo de estabilização (2%) menor que 2s.

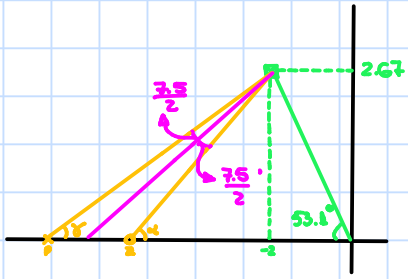
Solução:

i) Polos desejados: $t_s^{2\%} = 2 \Rightarrow \frac{4}{0.6\omega_n} = 2 \Rightarrow 0.6\omega_n = 2 \Rightarrow \omega_n = 3.33\ rad/s \quad \therefore s_{1,2} = -2 \pm 2.67$

ii) Projeto do compensador de avanço




$$\left.\begin{aligned}\theta_1 &= 127^\circ\\ \theta_2 &= 42^\circ\\ \theta_3 &= 18.5^\circ\end{aligned}\right\}\ \text{Avanço de } 7.5^\circ$$




$$\alpha = \frac{180^\circ + 7.5^\circ - 53.1^\circ}{2} = 67.2^\circ \Rightarrow z = -2 - \frac{2.67}{tg\,67.2^\circ} = -3.1$$

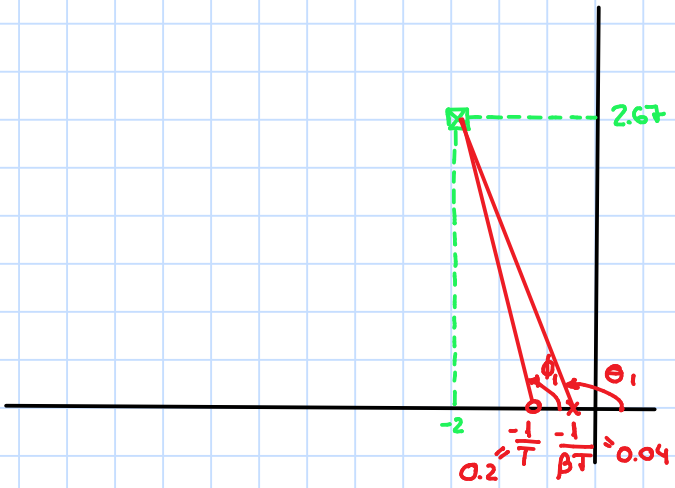
$$\gamma = \frac{180^\circ - 7.5^\circ - 53.1^\circ}{2} = 59.7 \quad \Rightarrow p = -2 - \frac{2.67}{tg\,59.7^\circ} = -3.5$$

Pelo Critério de Módulo: $\left| K_c \left(\frac{\frac{s}{3.1}+1}{\frac{s}{3.5}+1}\right)\left(\frac{1}{s(s+5)(s+10)}\right)\right|_{s=-2+2.67} = 1 \Rightarrow K_c = 106.1 \quad \therefore \boxed{G_{c1}(s) = 106.1\left(\frac{\frac{s}{3.1}+1}{\frac{s}{3.5}+1}\right)}$

iii) Projeto do compensador de atraso

Calculo do $K_v$: $\lim_{s\to 0} s \cdot G_{c1} \cdot G = \lim_{s\to 0} \cancel{s}\, 106.1\left(\frac{\frac{s}{3.1}+1}{\frac{s}{3.5}+1}\right)\left(\frac{1}{\cancel{s}(s+5)(s+10)}\right) \approx 2.1$

O $K_v$ é aproximadamente 5 vezes menor do que no requisito de projeto. Logo, $K = \beta = 5$



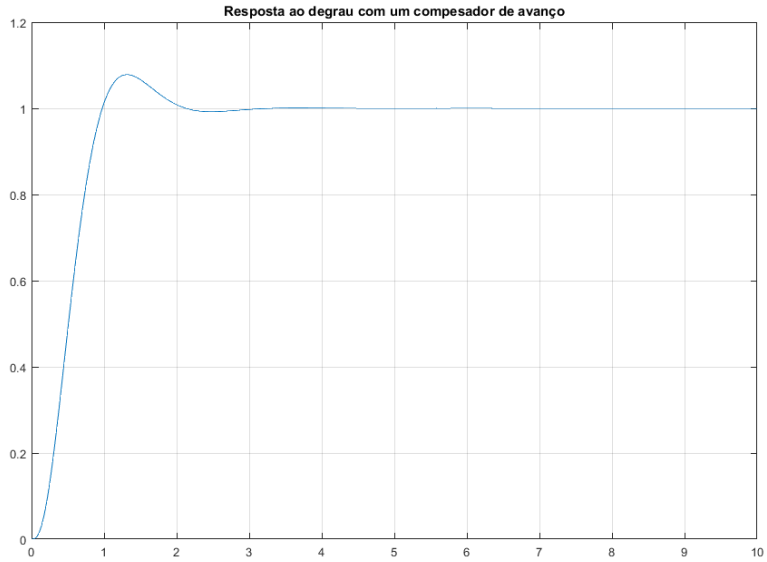

Estimativa para T: $\frac{1}{T} = \frac{2}{10} \Rightarrow T = 5$

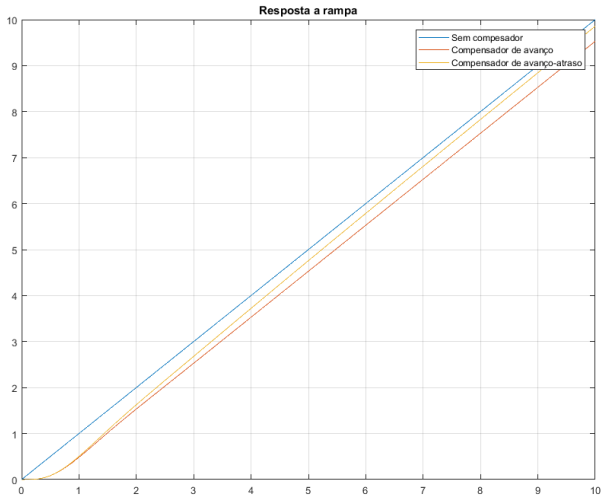
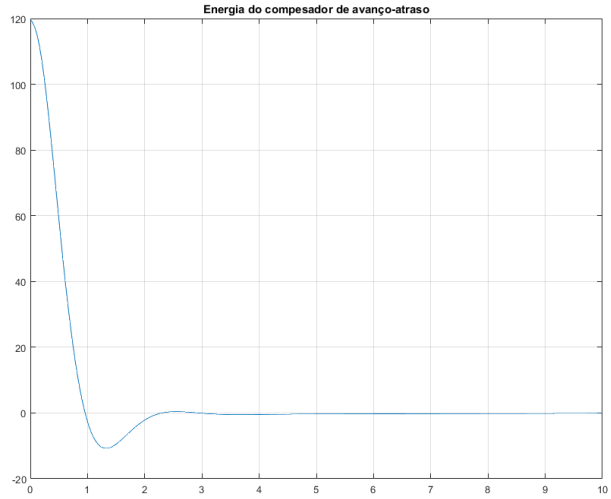
$$\left.\begin{aligned}\theta_1 &= 127.4^\circ\\ \phi_1 &= 129.5^\circ\end{aligned}\right\}\ |\phi_1 - \theta_1| = 2.1^\circ \text{ ok!}$$

$$\therefore \boxed{G_{c2}(s) = 5\left(\frac{5s+1}{25s+1}\right)}$$

iv) O controlador de avanço-atraso é dado por:

$$G_c(s) = G_{c1}(s) \cdot G_{c2}(s) = 106.1 \left( \frac{\frac{s}{3.1}+1}{\frac{s}{3.5}+1} \right) 5 \left( \frac{5s+1}{25s+1} \right) \rightarrow \boxed{G_c(s) = \frac{9287 s^2 + 30650 s + 5798}{77.5 s^2 + 274.4 s + 10.85}}$$

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