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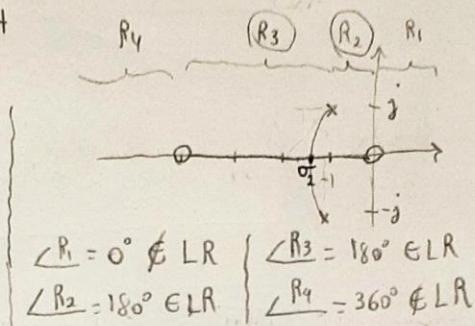
Matrícula 96708 19/08/2014 P1 Elt 331

①

$$1 + \frac{Ks(s+4)}{s^2 + 2s + 2} = 0 \rightarrow 1 + GH$$

a) Poles:  $p_1 = -1 + j$ ;  $p_2 = -1 - j$

Zeros:  $z_1 = 0$ ;  $z_2 = -4$



$$K = - \left[ \frac{s^2 + 2s + 2}{s(s+4)} \right] \Rightarrow \frac{dK}{ds} = - \frac{(2s+2)(s(s+4)) - (2s+4)(s^2 + 2s + 2)}{[s(s+4)]^2} = - \frac{2s^2 - 4s - 8}{s^2(s+4)^2}$$

$$\frac{dK}{ds} = 0 \Rightarrow 2s^2 - 4s - 8 = 0 \Rightarrow \begin{cases} s_1 = 3.236 \in R_1 \Rightarrow \text{más faz parte} \\ s_2 = -1.236 \in R_3 \Rightarrow \text{parteza LR.} \end{cases}$$

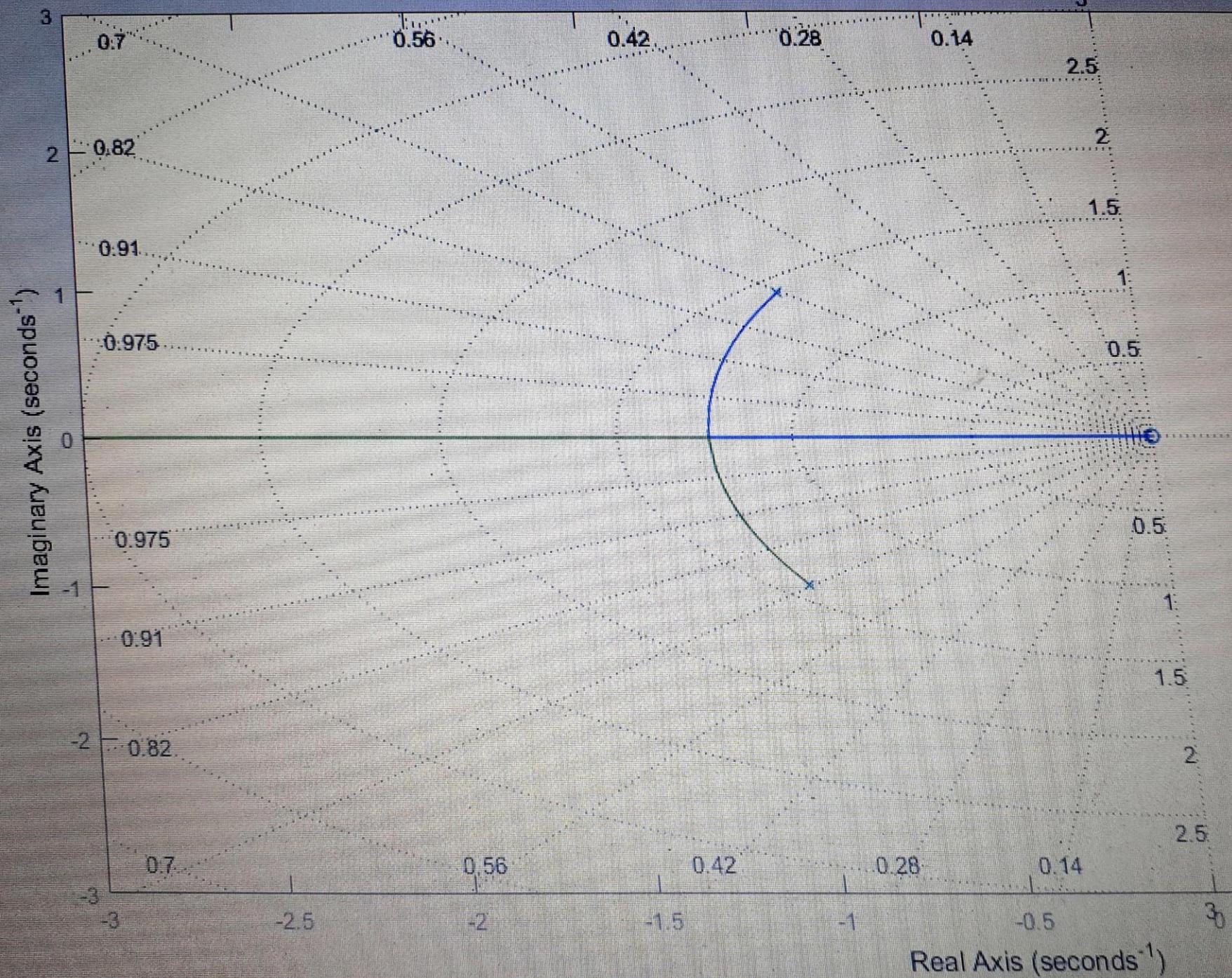
b)

$$Q = s^2 + 2s + 2 + Ks^2 + Ks4 = s^2(1+K) + s(2+4K) + 2 = 0$$

$$s = \frac{-(2+4K) \pm \sqrt{(2+4K)^2 - 4 \times 2 \times (1+K)^2}}{2(1+K)} \Rightarrow \Delta = 0 \Rightarrow 4 + 16K + 16K^2 - 8 - 8K = 0 \\ 16K^2 + 8K - 4 = 0$$

$$K_1 = 0.309 // K_2 = -0.809$$

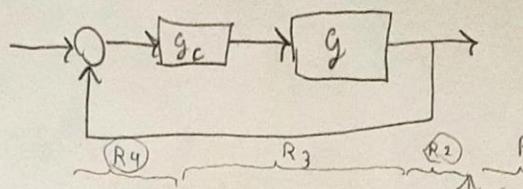
### Gráfico do Lugar das Raízes



Wertzen Alves 96708

②

$$G(s) = \frac{30}{s(s^3 + 6s + 5)}$$



- $R_1 \notin LR$
- $R_2 \in LR$
- $R_3 \notin LR$
- $R_4 \in LR$

a)  $p_1 = 0; p_2 = -1; p_3 = -5$

$\beta_1, \beta_2, \beta_3$  no infinito

$$1 + GH = 0$$

$$K = -\left[ \frac{s^3 + 6s^2 + 5s}{30} \right] \Rightarrow \frac{dK}{ds} = -\left[ \frac{3s^2 + 12s + 5}{30} \right] = 0 \Rightarrow 3s^2 + 12s + 5 = 0 \quad \begin{cases} \alpha_1 = -0.472 \in R_2 \\ \alpha_2 = -3.528 \in R_3 \end{cases}$$

$$s^3 + 6s^2 + 5s + 30K = 0 \quad \notin LR$$

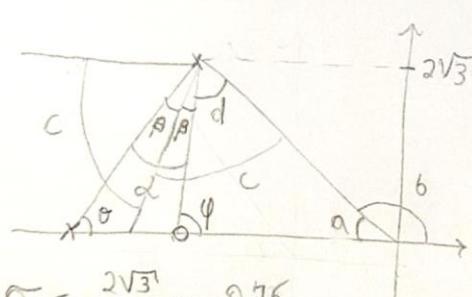
$$\begin{bmatrix} 1 & 5 \\ 6 & 30K \\ 30-30K & 0 \end{bmatrix} \quad \begin{array}{l} 30K > 0 \Rightarrow K > 0 \\ 30-30K > 0 \Rightarrow K < 1 \end{array} \quad \left\{ \begin{array}{l} -6w^2 + 30K = 0 \\ -w^3 + 5w = 0 \end{array} \right. \Rightarrow \left\{ \begin{array}{l} w = \sqrt{5} \\ K = 1 \end{array} \right.$$

$$K_{lim} = 1$$

b) Esta é omelada em seguida.

c)  $\xi = 0.5 \quad \omega_n = 4 \text{ rad/s} \quad K_v = \text{mantém}$

$$P' = -\xi \omega \pm j \omega \sqrt{1 - \xi^2} = -2 \pm j 2\sqrt{3}$$



$$\sigma_3 = \frac{2\sqrt{3}}{\tau_g(\theta)} = -0.76$$

$$\beta = -2 - \sigma_3 = -1.24$$

$$\sigma_p = \frac{2\sqrt{3}}{\tau_g(\theta)} = 10.92$$

$$\beta = -2 - \sigma_p = -12.92$$

Anângulo de Força

$$\angle g(s)p_1 = 84.791^\circ$$

$$\alpha = 84.79^\circ \Rightarrow \beta = 42.40^\circ$$

$$\alpha = \arccos \cos(\beta) = 60^\circ$$

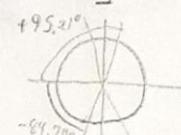
$$b = 180 - \alpha = 120^\circ$$

$$c = b/2 = 60^\circ$$

$$d = c - \beta = 17.61^\circ$$

$$\theta = 180^\circ - \alpha - \beta = 102.39^\circ$$

$$\theta = \theta - d = 17.60^\circ$$

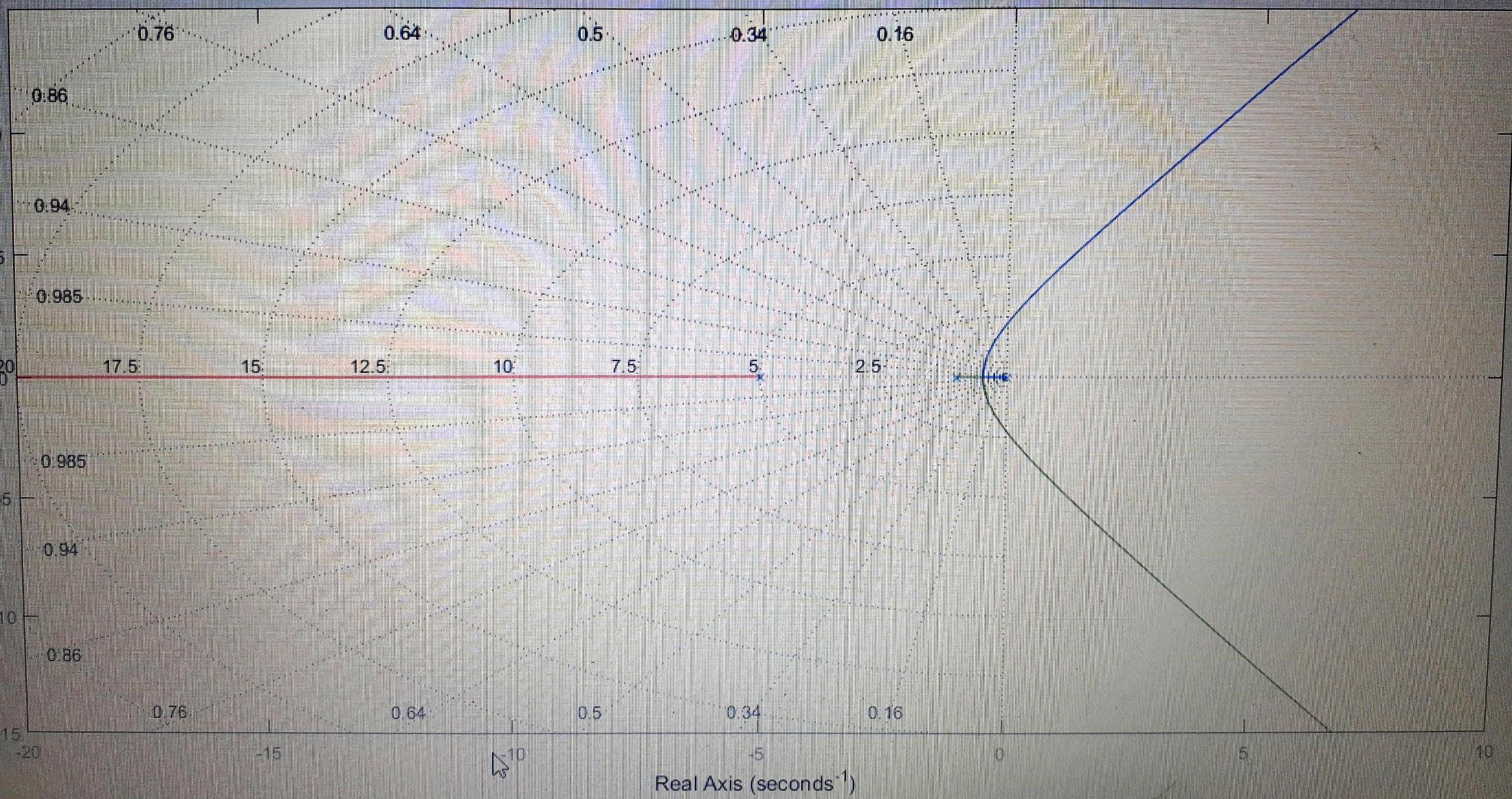


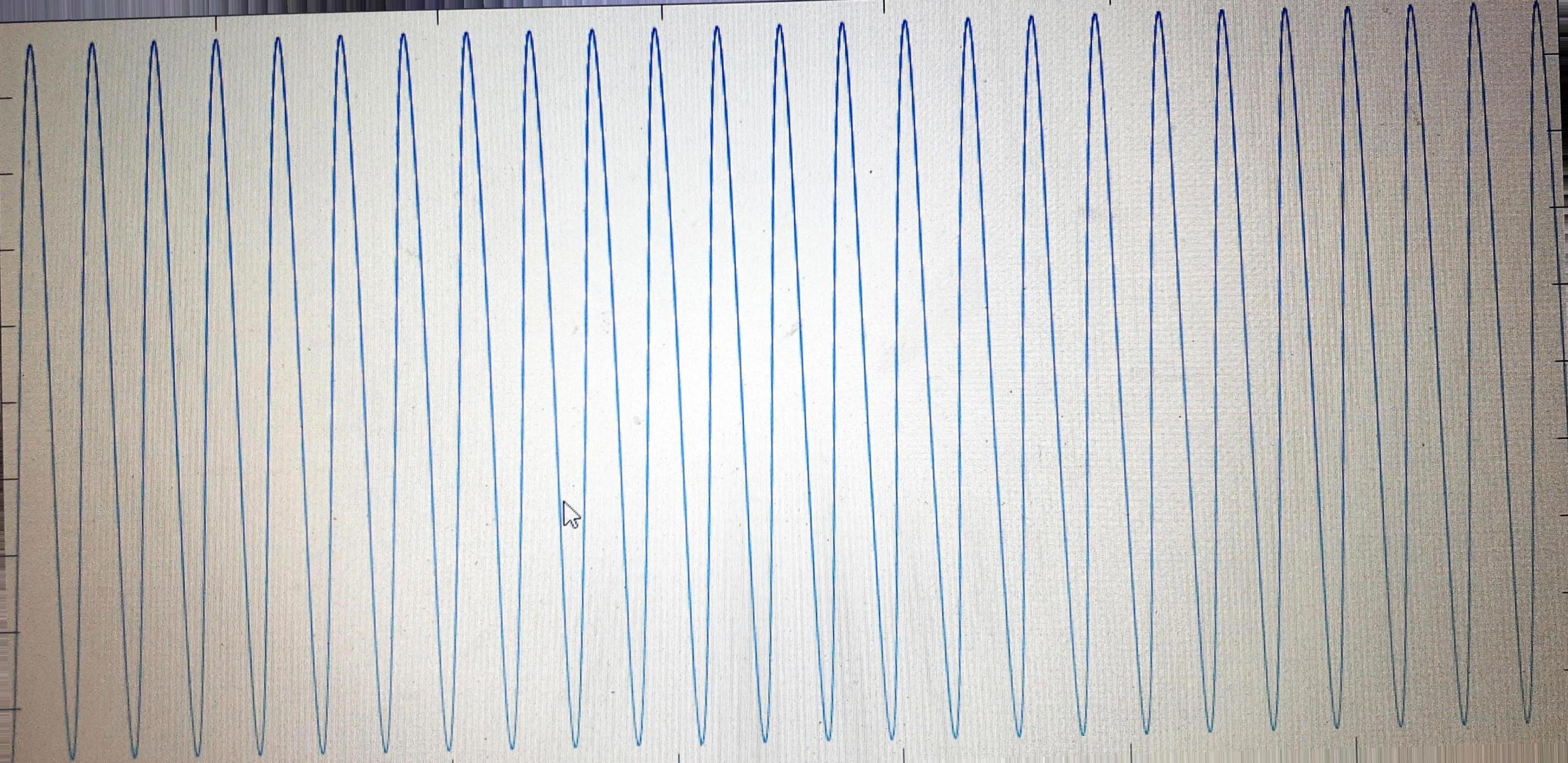
$$G_C = 7.12 \frac{(s+1.24)}{(s+12.92)}$$

$$K_C = \frac{1}{\left| \frac{(s+1.24)}{(s+12.92)} \cdot \frac{30}{s^3 + 6s + 5} \right|_{p'}} = \frac{1}{0.14} \approx 7.12$$



### Gráfico do Lugar das Raízes





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④

$$a) \quad g = \frac{10}{s(s+2)(s+5)}$$

$$\rho_1 = 0 \quad \rho_2 = -2 \quad \rho_3 = -5 \quad LR = [-2, 0] \cup [-\infty, -5]$$

$z_1, z_2, z_3$  no infinito

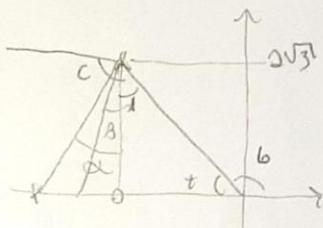
$$K = -\frac{s(s+2)(s+5)}{10} \Rightarrow \frac{dK}{ds} = -\frac{3s^2 + 14s + 10}{10} = 0 \Rightarrow \boxed{\sigma_1 = -0.88} \\ \boxed{\sigma_2 = -3.79}$$

$$Q = s^3 + 7s^2 + 10s + 10K = 0 \\ \begin{cases} -w^3 + 10w = 0 \Rightarrow w = \sqrt[3]{10} \\ -7w^2 + 10K = 0 \Rightarrow K = \frac{7}{w} \end{cases}$$

$$g) \quad \xi w_m = 2 \Rightarrow \xi = 0.5$$

$$\Delta g(s)_{\rho_1} = 100,89 \Rightarrow \alpha = 79,11^\circ \quad \beta = 39,56^\circ$$

$$w_m \sqrt{1-\xi^2} = 2\sqrt{3} \Rightarrow w_m = 4$$



$$g_C = \frac{K_C \left( s + \frac{1}{T_1} \right) \left( s + \frac{1}{T_2} \right)}{\left( s + \frac{1}{T_1} \right) \left( s + \frac{1}{T_2} \right)}$$

$$\alpha = \arccos(\xi) = 60^\circ$$

$$\beta = 120^\circ$$

$$\gamma = 120^\circ / 2 = 60^\circ$$

$$d = C^2 B = 20,44$$

$$\phi = 180^\circ - \alpha - d = 99,56^\circ$$

$$\theta = 20,45^\circ$$

$$T_2 = 10 \Rightarrow \beta_2 = 0.1 \quad \beta_2 = 0.01$$

$$A = \left| \frac{s + 0.1}{s + 0.01} \right|_{\rho_1} = 0.99 \approx 1 \text{ OK} \quad \Delta A = -1,10 \text{ OK}$$

$$g_C = g \frac{(s + 1.42)}{(s + 11.29)} \frac{(s + 0.1)}{(s + 0.01)}$$

$$C = 2\% \Rightarrow K_V' = 50$$

$$K_V' = \lim_{s \rightarrow 0} \left[ s g_C g \right] \Rightarrow 50 = \left[ K_C \cdot \frac{5 + 1.42}{s + 11.29} \cdot \frac{10}{s(s+2)(s+5)} \right] \Rightarrow K_C = 384,62$$

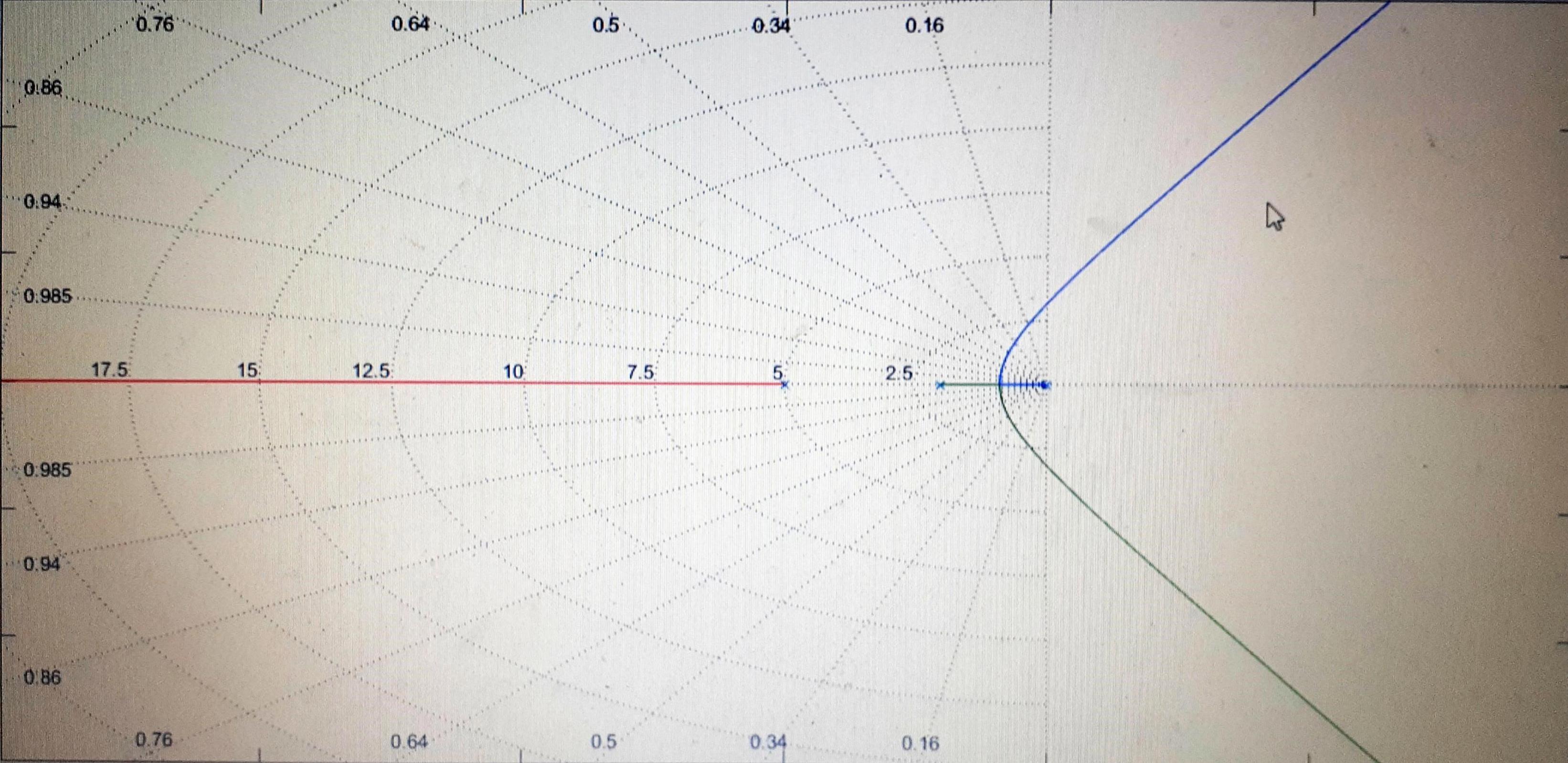
$$\begin{cases} \sigma_3 = \frac{2\sqrt{3}}{T_2(\phi)} = -0.58 \\ \gamma = -1.42 \\ \sigma_B = \frac{2\sqrt{3}}{T_2(\theta)} = 9,29 \\ \phi = -11,2^\circ \\ g_{AV} = \left| \frac{K_{AV} \frac{s + 1.42}{s + 11.29} \cdot \frac{10}{s(s+2)(s+5)}}{s + 11.29} \right| = 1 \end{cases}$$

$$\boxed{K_{AV} = 17,92}$$

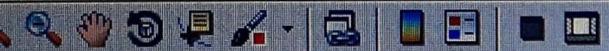
$$\left\{ \begin{array}{l} \frac{1}{T_1} = 1.42 \\ T_1 = 0.7 \end{array} \right.$$

$$\beta = T_1, \beta_2 = 7,95$$

$$\beta \approx 8$$



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### Step Response

