2] $\theta_o(s) = G(s)\left[U(s) - K_D T_d(s)\right]$ $\quad G(s) = \dfrac{0{,}07}{s(s+0{,}87)}$ $\quad K_d = 0{,}5$ $\quad T = 1$

a] $P(t) = 0 = \underbrace{\theta_i^{(1)}}_{\text{rampa}} - \theta_o(t)$ para $t \in \mathbb{R}$ maior considerando $T_d(s)$ nulo

$$G(z) = Z\left(G_{HO} \cdot G(s)\right) = \left(1 - z^{-1}\right) \cdot Z\left\{\frac{G(s)}{s}\right\} = \frac{z-1}{z} \cdot Z\left\{\frac{0{,}07}{s^2(s+0{,}87)}\right\}$$

Usando Matlab: `g = tf([0,07],[1, 0,87 0])`

`gz = c2d(g, 1, 'zoh')`

$$G(z) = \frac{0{,}026732 + 0{,}02003}{z^2 - 1{,}419z + 0{,}419} = \frac{0{,}02673(z + 0{,}7495)}{(z-1)(z-0{,}419)}$$

$m = n_p[G(z)] - n_z[G(z)] = 2 - 1 = 1 \quad K = m = 1$

$p = \max\{2, 1\} = 2$

$$M(z) = \left(m_K z^{-1} + m_{K+1} z^{-2}\right) \Rightarrow 1 - m_K z^{-1} - m_{K+1} z^{-2} = 1 - 2z^{-1} + z^{-2}$$

$$1 - m(z) = \left(1 - z^{-1}\right)^2$$

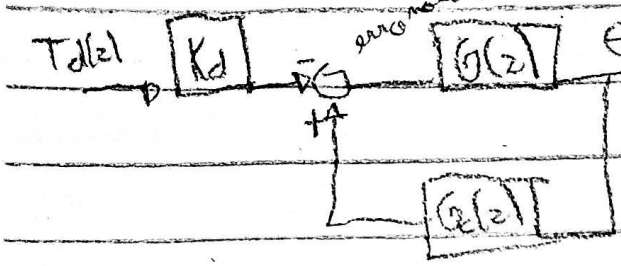
$m_K = 2 = m_1$

$m_{K+1} = -1 = m_2$

$$m(z) = 2z^{-1} - z^{-2} \cdot \frac{z^2}{z^2} = \frac{2z-1}{z^2} \qquad 1 - m(z) = 1 - 2z^{-1} + z^{-2} = \frac{z^2 - 2z + 1}{z^2}$$

$$G_c(z) = \frac{(z-1)(z-0{,}419)}{0{,}02673(z+0{,}7495)} \cdot \frac{2z-1}{(z-1)^2} = \frac{(z-0{,}419)(z-0{,}5)}{(z-1)(z+0{,}7495)} \cdot 73{,}5294$$

b) Considerando $G_c(z) = 73,5294 \frac{(z-0,419)(z-0,5)}{(z-1)(z+0,7495)}$



$Td = \frac{z}{z-1}$ $Kd = 0,5$

$$\frac{\theta_o(z)}{KdTd(z)} = \frac{G(z)}{1 + G \cdot G_c} \Rightarrow \theta_o(z) = \frac{G(z) \cdot Kd \cdot Td(z)}{1 + G(z) \cdot G_c(z)}$$

$$G(z) = \frac{0,0267(z+0,7495)}{(z-1)(z-0,419)}$$

$$\theta_o(z) = \frac{\frac{0,2672(z+0,7495)}{(z-1)(z-0,419)} \cdot 0,5 \cdot \frac{z}{(z-1)}}{1 + \frac{0,2672(z+0,7495)}{(z-1)(z-0,419)} \cdot 73,5294 \frac{(z-0,419)(z-0,5)}{(z-1)(z+0,7495)}}$$

$$\theta_o(z) = \frac{0,2672(z+0,7495) \cdot 0,5 \cdot z}{(z-1)^2(z-0,419) + 0,2672 \cdot 73,5294 \cdot (z-0,5)(z-0,419)} =$$

$$\theta_o(z) = \frac{0,1336z(z+0,7495)(\quad)}{(z-0,419)(z-0,4165)(z+18,1336)}$$

Resolvendo no Wolfram: $\theta_o(z) = 0,1336z^{-1} - 2,2z^{-2} + 40,01z^{-3} - 736,954z^{-4}$

c) $G(z) = \frac{0,0267\,2(z+0,7495)}{(z-1)(z-0,419)}$

$n = 2-1 = 1 \quad k = n = 1$

$p = 1$

$M(z) = m_1 z^{-1} \Rightarrow 1 - m_1 z^{-1} = 1 - z^{-1}$

$1 - m(z) = (1 - z^{-1}) \qquad m_1 = 1$

$m(z) = z^{-1} = \frac{1}{z} \qquad 1 - m_1 z^{-1} = \frac{z-1}{z}$

$G_c(z) = \frac{(z-1)(z-0,419)}{0,0267\,2(z+0,7495)} \cdot \frac{1}{(z-1)} = \frac{-73,5394\,.\,(z-0,419)}{(z+0,7495)}$