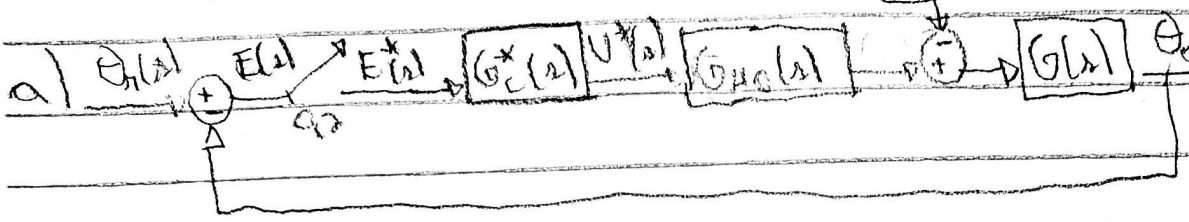
João Victor de Carvalho Mota 160177823

2) $\Theta_o(s) = G(s)\left[U(s) - 1,6 T_d(s)\right]$ $\quad G(s) = \dfrac{0,21}{s(s+1,71)}$

$G_c^*(s) = c \quad T = 0,2\,s$

a)



$T_d(s) = \dfrac{\overline{T_d}}{s} \quad \Theta_i(s) = \dfrac{\overline{\Theta_n}}{s} \quad G_c^*(t) = c \quad T = 0,2$

b) $G_1(z) = Z\left\{G_c^*(s) \cdot G_{H0}(s) \cdot G(s)\right\} = c\left(1 - z^{-1}\right) Z\left\{\dfrac{G(s)}{s}\right\} \Rightarrow$

Usando Matlab `g = tf([0,21],[1 1,71 0])`

`g1 = c2d(g,0,2,'zoh')`

Chegamos em $c \cdot \left(\dfrac{0,003759\,z + 0,003355}{z^2 - 1,71z + 0,7103}\right) = G_1(z) = \dfrac{0,003759\,cz + 0,003355\,c}{(z-1)\cdot(z - e^{-1,71 \times 0,2})}$

Como $\Theta_o(s) = G(s)\left[U^*(s) - 1,6 T_d(s)\right]$ e $U^*(s) = c\,E^*(s)$

$U^*(s) = c\left(\Theta_i^*(s) - \Theta_o^*(s)\right)$

$\Downarrow$

$\Theta_o(s) = G(s)G_{H0}(s) \cdot c \cdot \Theta_i^*(s) - G(s)G_{H0}(s) \cdot c \cdot \Theta_o^*(s) - G(s) \cdot 1,6 \cdot T_d(s)$

$\Downarrow$

$\Theta_o^*(s) = c\,G_1^*(s)\,\Theta_i^*(s) - c\,G_1^*(s)\,\Theta_o^*(s) - 1,6\,(GT_d)^*(s)$

$\Downarrow$

$\Theta(z) = \dfrac{G_1(z)\,\Theta_i(z) - 1,6\,(GT_d)(z)}{1 + G_1(z)}$

$(GT_d)(z) = Z\left\{\dfrac{0,21\,\overline{T_d}}{s^2(s+1,71)}\right\} = \overline{T_d}\,Z\left\{\dfrac{0,21}{s^2(s+1,71)}\right\}$ (fracionar) $= \overline{T_d}\left(\dfrac{TA_2(z-e^{-1,71\times0,2}) + B_2(z-1)(z-e^{-1,71\times0,2}) + C_2(z-1)^2(z-e^{-1,71\times0,2})}{(z-1)^2(z-e^{-1,71\times0,2})}\right)$, $e = e^{-1,71\times0,2}$

$0,21 = A(s+1,71) + B(s)(s+1,71) + Cs^2$

$$G_1(z)\Theta_n(z) = \frac{0,003759cz + 0,003355c}{(z-1)(z-e^{-1,71\times0,1})} \cdot \frac{z\,\overline{\Theta_n}}{(z-1)}$$

$$\Downarrow$$

$$\Theta_0(z) = \frac{0,003759cz^2\overline{\Theta_n} + 0,003355cz\overline{\Theta_n} + \overline{\overline{T_d}}\left(TAz(z-e) + Bz(z-1)(z-e) + Cz(z-1)^2(z-e)\right)1,6}{(z-1)^2(z-e^{-1,71\times0,1})}$$

$$1 + \frac{0,003759cz + 0,003355c}{(z-1)(z-e^{-1,71\times0,1})}$$

$$\Downarrow$$

$$\Theta_0(z) = \frac{0,003759cz^2\overline{\Theta_n} + 0,003355cz\overline{\Theta_n} + \overline{\overline{T_d}}\left(TAz(z-e) + Bz(z-1)(z-e) + Cz(z-1)^2(z-e)\right)1,6}{(z-1)^2(z-e^{-1,71\times0,1}) + (z-1)(0,003759cz + 0,003355c)}$$

com $A = 0,1338$ $B = -0,0718$ $C = 0,0718$ $e = e^{-1,71\times0,1}$

polinômio característico: Como $\Theta_0(z) = \frac{G_1(z)\Theta_n(z) - 1,6(GT_d)(z)}{1 + G_1(z)}$

Logo $1 + G_1(z) = 0$ (polinômio característico)

$$\Downarrow$$

$$z^2 - 1,71z + 0,7103 + 0,003759cz + 0,003355c = 0$$

$$z^2 + (0,003759c - 1,71)z + (0,7103 + 0,003355c) = 0$$

Usando critério de Jury:

$a_0 = 1$ $a_1 = 0,003759c - 1,71$ $a_2 = 0,7103 + 0,003355c$

1) $|a_2| < a_0 \Rightarrow |0,7103 + 0,003355c| < 1$

$$-1 < 0,7103 + 0,003355c < 1$$

$$-1,7103 < 0,003355c < 0,2897$$

$$509,7765 < c < 86,3487$$

2) $P(1) > 0 \Rightarrow 1 + 0,003759c - 1,71 + 0,7103 + 0,003355c > 0$

$$c > 0$$

3) $P(-1) > 0 \Rightarrow 1 - 0,003759c + 1,71 + 0,7103 + 0,003355c > 0$

$$-0,000404c > 3,42$$

$$c > -8,4653.10^3$$

4) Como n=2 não precisamos construir a tabela

daqui $86,3487 > C > 509,7765$

c) Usando $\theta(z)$ obtido anteriormente e substituindo $\theta_n = 0$ e $T_d = 1$

$$\theta_0(z) = \frac{\left(0,2Az(z-e^{-1,11\times0,2}) + Bz(z-1)(z-e^{-1,7\times0,2}) + Cz(z-1)^2(z-e^{-1,7\times0,2})\right).1,6}{(z-1)^2(z-e^{-1,11\times0,2}) + (z-1)(0,003759Cz + 0,003355C)}$$

$A = 0,1228 \quad B = -0,0718 \quad C = 0,0718$

$e_{ss} < 0,1 \text{ rad}$

Kv

$$e_{ss} = \lim_{z\to1}(1-z^{-1}).E(z) = \lim_{z\to1}\frac{(z-1)}{z}.\theta_0(z) \quad \text{pois } \theta_n = 0$$

substituindo $A = 0,1228$

$$e_{ss} = \frac{0,2A(1-e^{-1,11\times0,2}).1,6}{0,003759C + 0,003355C} = \frac{0,0071.1,6}{0,0071C} = \frac{1,6}{C}$$

$\frac{1,6}{C} < 0,1 \Rightarrow C > 16$ Daqui se for estável, erro estacionário já é $< 0,1 \text{ rad}$