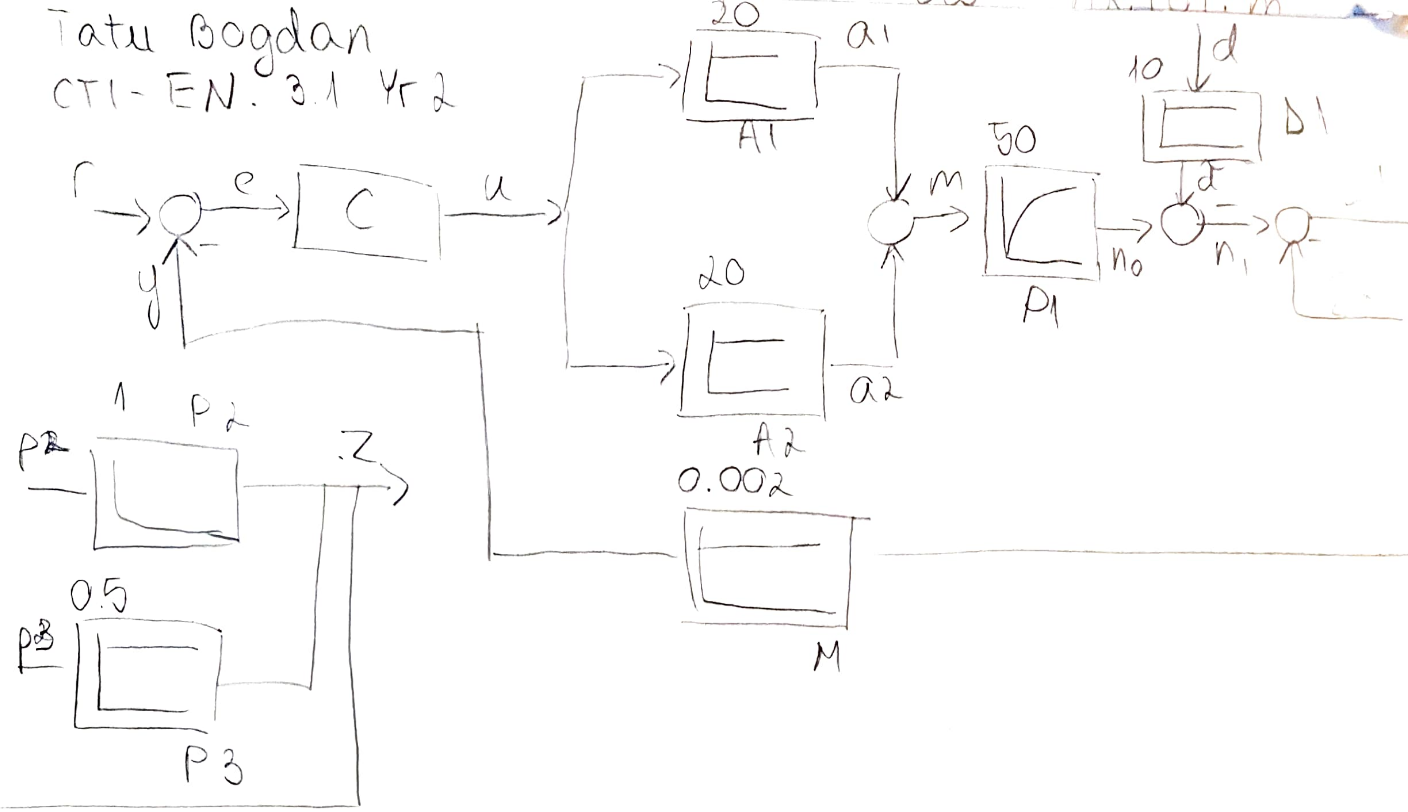
Tatu Bogdan
CTI-EN. 3.1 Yr 2



$$C(s) = K_c\left(1 + \frac{1}{T_i s}\right) = K_c + \frac{K_c}{T_i s} = \frac{K_c(1 + T_i s)}{T_i s} \Rightarrow \text{PI controll}$$

1. $$H_{zr}(s) = \left.\frac{Z(s)}{r(s)}\right|_{d(s)=0}$$

$$= \frac{H_c \cdot (H_{A1} + H_{A2}) \cdot H_{P1} \cdot \dfrac{H_{P2}}{1 + H_{P2} \cdot H_{P3}}}{1 + H_c (H_{A1} + H_{A2}) \cdot H_{P1} \cdot \dfrac{H_{P2}}{1 + H_{P2} \cdot H_{P3}} \cdot H_M}$$

$$= \frac{H_c (H_{A1} + H_{A2}) \cdot H_{P1} \cdot \dfrac{H_{P2}}{\cancel{1 + H_{P2} \cdot H_{P3}}}}{\dfrac{1 + H_{P2} \cdot H_{P3} + H_c (H_{A1} + H_{A2}) \cdot H_{P1} \cdot H_{P2} \cdot H_M}{\cancel{1 + H_{P2} \cdot H_{P3}}}}$$

$$= \frac{H_c (H_{A1} + H_{A2}) \cdot H_{P1} \cdot H_{P2}}{1 + H_{P2} \cdot H_{P3} + H_c (H_{A1} + H_{A2}) \cdot H_{P1} \cdot H_{P2} \cdot H_M}$$

$K_c > 0$

for H_{zd} no

$$= \frac{\frac{K_c + K_c T_i s}{T_i s} \cdot (20+20) \cdot \frac{50}{2s+1} \cdot \frac{1}{s}}{1 + \frac{1}{s} \cdot 0.5 + \frac{K_c + K_c T_i s}{T_i s} \cdot (20+20) \cdot \frac{50}{2s+1} \cdot \frac{1}{s} \cdot 0.002}$$

$$= \frac{\frac{(K_c + K_c \cdot T_i s) \cdot 40 \cdot 50}{T_i s \cdot (2s+1) \cdot s}}{1 + \frac{0.5}{s} + \frac{(K_c + K_c T_i s)(40) \cdot 50 \cdot 0.002}{T_i s (2s+1) \cdot s}}$$

$$= \frac{\frac{K_c (1 + T_i s) \cdot 2000}{\cancel{T_i s \cdot (2s+1) \cdot s}}}{\frac{T_i s (2s+1) s + 0.5(2s+1) T_i s + K_c (1 + T_i s) \cdot 4}{\cancel{T_i s (2s+1) s}}}$$

$$= \frac{K_c (1 + T_i s) \cdot 2000}{2 T_i s^3 + T_i s^2 + T_i s^2 + 0.5 T_i s + 4K_c + 4K_c T_i s}$$

for $K_c = 1$ and $T_i = 2.5$

$$\Rightarrow H_{z\text{-}r}(s) = \frac{2000(2.5s+1)}{5s^3 + \cancel{2.5s^2}\ 5s^2 + 11.25s + 4}$$

$$H_{zd}(s) = -H_{D1} \cdot \frac{\frac{H_{P2}}{1 + H_{P3} H_{P2}}}{1 - \frac{H_{P2}}{1 + H_{P3} H_{P2}} \cdot H_M \cdot (-1) \cdot H_C \cdot (H_{A1} + H_{A2}) \cdot H_{P1}}$$

$$= -H_{D1} \cdot \frac{\frac{H_{P2}}{\cancel{1 + H_{P2} \cdot H_{P3}}}}{\frac{1 + H_{P2} H_{P3} + H_{P2} \cdot H_M \cdot H_C \cdot (H_{A1} + H_{A2}) \cdot H_{P1}}{\cancel{1 + H_{P3} H_{P2}}}}$$

$$= -\frac{H_{P2} \cdot H_{D1}}{1 + H_{P2} \cdot H_{P3} + H_{P2} \cdot H_M \cdot H_C \cdot (H_{A1} + H_{A2}) \cdot H_{P1}}$$

bottom is same as $H_{z\text{-}r}(s)$

$$= -\frac{\frac{1}{0.5s}\cdot 10}{\dfrac{T_i s^2(2s+1)+0.5T_i s(2s+1)+K_c(1+T_i s)\cdot 4}{T_i s(2s+1)}}$$

$$= -\frac{5T_i s(2s+1)}{T_i s^2(2s+1)+0.5T_i s(2s+1)+K_c(1+T_i s)4}$$

$$= -\frac{10T_i s^2+5T_i s}{2T_i s^3+2T_i s^2+0.5T_i s+4K_c+4K_c T_i s}$$

for $K_c = 1$ and $T_i = 2.5$

$$\Rightarrow H_{z-d}(s) = -\frac{12.5s(2s+1)}{5s^3+5s^2+11.25s+4}$$

3. $H_{2-r}(s) = \dfrac{\dots}{5s^3+5s^2+11.25k_c s+4k_c}$ $\quad k_c>0$

$T_i=2.5$

$\Delta(s) = \underset{>0}{5s^3}+\underset{>0}{5s^2}+\underset{>0 \Rightarrow k_c>0}{11.25k_c s}+\underset{>0\Rightarrow k_c>0}{4k_c}$ - same for H_{2d}

$$H = \begin{pmatrix} 5 & 4k_c & 0 \\ 5 & 11.25k_c & 0 \\ 0 & 5 & 4k_c \end{pmatrix}$$

1. $\det H_1 > 0 \Leftrightarrow 5>0$ ✓

$\det H_2 > 0 \Leftrightarrow 36.25 k_c > 0 \Leftrightarrow k_c>0$

$\det H_3 > 0 \Leftrightarrow 4k_c \cdot \det H_2 > 0 \Leftrightarrow 4k_c^2 \cdot 36.25 > 0$

$\Leftrightarrow k_c^2 > 0 \Leftrightarrow |k_c| > 0 \Leftrightarrow k_c \in (-\infty,0)\cup(0,\infty)$ / $\Rightarrow$ $k_c>0$

$k_c>0 \Rightarrow$ system stable

2. $k_c = 1 \overset{3}{\Longrightarrow}$ system stable

4. $r_\infty = 5$

$d_\infty = 80$

$D1 \to P \overset{FVT}{\Longrightarrow} \tilde{d}_\infty = H_{D1}(0)\cdot d_\infty = 10\cdot 80 = 800$

$H_C \to PI \Rightarrow e_\infty = 0$

$e_\infty = r_\infty - y_\infty \Big/ \Rightarrow y_\infty = e_\infty - r_\infty = 5$

$H_M \to P \overset{FVT}{\Longrightarrow} y_\infty = H_M(0)\cdot z_\infty \Rightarrow z_\infty = \dfrac{y_\infty}{H_M(0)} = \dfrac{5}{0.002}$

$= 2500$

$H_{P3} \to P \overset{FVT}{\Longrightarrow} p_{3\infty} = H_{P3}(0)\cdot z_\infty = 0.5\cdot 2500 = 1250$

$H_{P2} \to I \Rightarrow p_{2\infty} = 0$

$p_{2\infty} = n'_\infty - p_{3\infty} \Rightarrow n_{1\infty} = \cancel{p_{2}}_\infty + p_{3\infty} = 1250$

$n_{1\infty} = n_{0\infty} - \tilde{d}_\infty \Rightarrow n_{0\infty} = n_{1\infty} + \tilde{d}_\infty = 2050$

$P1 \to PT1 \overset{FVT}{\Rightarrow} n_{\infty} = H_{P1}(0) \cdot m_{\infty} \Rightarrow m_{\infty} = \dfrac{n_{\infty}}{H_{P1}(0)} = 41$

$m_{\infty} = a_{1\infty} + a_{2\infty}$

$A1, A2 \to P \overset{FVT}{\Rightarrow} a_{1\infty} = H_{A1}(0) \cdot u_{\infty} = 20u_{\infty}$

$a_{2\infty} = H_{A2}(0) \cdot u_{\infty} = 20u_{\infty}$

$\Rightarrow m_{\infty} = 40u_{\infty} \Rightarrow u_{\infty} = \dfrac{m_{\infty}}{40} = \dfrac{41}{40}$

5. $K_r = H_{zr}(0) = \dfrac{2000 k_c}{4K_c} = \dfrac{500 \cancel{k_c}}{\cancel{k_c}} = 500$

$K_d = H_{zd}(0) = 0$

$z_{\infty} = 500 r_{\infty} + 0 \cdot d_{\infty} = 2500$ ✓

$\gamma = H_{zd} = 0$

$H_0(s) = \dfrac{0.5}{s} + \dfrac{k_c(1+2.5s)\cdot 4}{2.5s^2(2s+1)}$

$=$ .... don't have time