

16/3/09

Control

Summer 2007

Q 1a. $M(s) = K_P (1 + \frac{1}{T_I} s + T_D s) E(s)$

$$C(s) = \frac{M}{E} = K_P (1 + \frac{1}{T_I} s + T_D s)$$

$$= K_P (T_D s^2 + s + \frac{1}{T_I})$$

$$= \frac{s}{T_D K_P (s^2 + \frac{1}{T_D} s + \frac{1}{4 T_D^2})}$$

$$T_D = \frac{T_I}{4}$$

$$= -\frac{1}{2 T_D} \text{ twice}$$

$$C(s) = \frac{K_c (s + \frac{1}{2 T_D})^2}{s}$$

MPZ: pole @ $s=0$ $\xrightarrow{e^{sT} \text{ sample time}}$ pole @ $z = e^{0T} = 1$
 zero @ $s = -\frac{1}{2 T_D}$ \rightarrow zero @ $z = e^{-\frac{1}{2 T_D} T}$

$$D(z) = \frac{K_d (z - e^{-\frac{1}{2 T_D} T})^2}{z(z-1)}$$

$$C(s) = \frac{K_c (s + \frac{1}{2 T_D})^2}{s}$$

FROM
HINT

$$\lim_{s \rightarrow 0} s \frac{K_c (s + \frac{1}{2 T_D})^2}{s} = K_c \frac{1}{4 T_D^2}$$



$$\lim_{z \rightarrow 1} (z-1) \frac{K_d (z - e^{-\frac{1}{2 T_D} T})^2}{z-1} = K_d (1 - e^{-\frac{1}{2 T_D} T})^2$$

$$K_d = \frac{K_c \frac{1}{4 T_D^2}}{(1 - e^{-\frac{1}{2 T_D} T})^2}$$

$$\frac{M}{E} = D(z) = \frac{K_d (z^2 - 2 e^{-\frac{1}{2 T_D} T} z + e^{-2 \frac{1}{2 T_D} T})}{z^2 - z}$$

$$(z^2 - z) M = K_d (z^2 - 2 e^{-\frac{1}{2 T_D} T} z + e^{-2 \frac{1}{2 T_D} T}) E$$

2017/18

$$(2) \quad \frac{1}{s} \left(\frac{1}{s} + \frac{1}{s} + 1 \right) K_0 = (2) M \quad \text{at } 0$$

$$\left(\frac{1}{s} + \frac{1}{s} + 1 \right) K_0 = \frac{1}{s} = (2) C$$

$$\left(\frac{1}{s} + \frac{1}{s} + 1 \right) K_0 =$$

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$$\frac{1}{s} \left(\frac{1}{s} + \frac{1}{s} + 1 \right) K_0 = (2) C$$

and square

$$\frac{1}{s} \left(\frac{1}{s} + \frac{1}{s} + 1 \right) K_0 = (2) C \quad \text{at } 0$$

$$\frac{1}{s} \left(\frac{1}{s} + \frac{1}{s} + 1 \right) K_0 = (2) C$$

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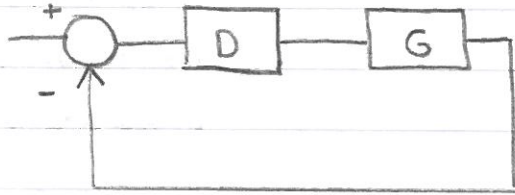
$$\underbrace{(1-z^{-1})}_{1z^{-1}} M(z) = K_d E(z) - 2K_d e^{-z^T} z^{-1} E(z) + K_d e^{-2z^T} z^{-2} E(z)$$

$$m(k) = m(k-1) + \underbrace{K_d e(k)}_{\alpha} - \underbrace{2K_d e^{-z^T} e(k-1)}_{\beta} + \underbrace{K_d e^{-2z^T} e(k-2)}_{\gamma}$$

$$(b). M(z) = K z^{-1} E(z) + 0.8 z^{-1} M(z)$$

$$(1 - 0.8 z^{-1}) M = K z^{-1} E$$

$$\frac{M}{E} = \frac{K z^{-1}}{1 - 0.8 z^{-1}} = \frac{K}{z - 0.8} \rightarrow \text{pole @ } z = 0.8$$



$$G(z) = \mathcal{Z} \left\{ \frac{1 - e^{-sT}}{s} \cdot \frac{2}{1 + 2s} \cdot 2 \right\} \Rightarrow (1 - z^{-1}) \mathcal{Z} \left\{ \frac{4}{s(1 + 2s)} \right\}$$

$$\text{Tables } \mathcal{Z} \left\{ \frac{1}{s(s+a)} \right\} = \frac{1}{a} \frac{(1 - e^{-aT}) z^{-1}}{(1 - z^{-1})(1 - e^{-aT} z^{-1})}$$

$$\frac{4}{s(1+2s)} \rightarrow \frac{2}{s(s+\frac{1}{2})} = 2 \times \frac{1}{s(s+\frac{1}{2})}$$

$$a = 0.5 \quad T = 1$$

$$G(z) = 2 \times \frac{1}{0.5} \frac{(1 - e^{-0.5}) z^{-1}}{(1 - z^{-1})(1 - e^{-0.5} z^{-1})} \times (1 - z^{-1})$$

$$= \frac{1.57 z^{-1}}{1 - 0.606 z^{-1}} \Rightarrow \frac{1.57}{z - 0.606} \rightarrow \text{pole @ } z = 0.606$$

Initial design



As this increases
- bending decreases
- W is increasing

Peak overload 30%
2 = 0.32
200 0.85 ± 5.0 = 2

1.25K
1.25K = 1.25K
1.25K = 1.25K

1.25K = 1
1.25K = 1.25K