LÖSNINGSFÖRSLAG

TILL

TENTAMEN

REGLERTEKNIK 060826

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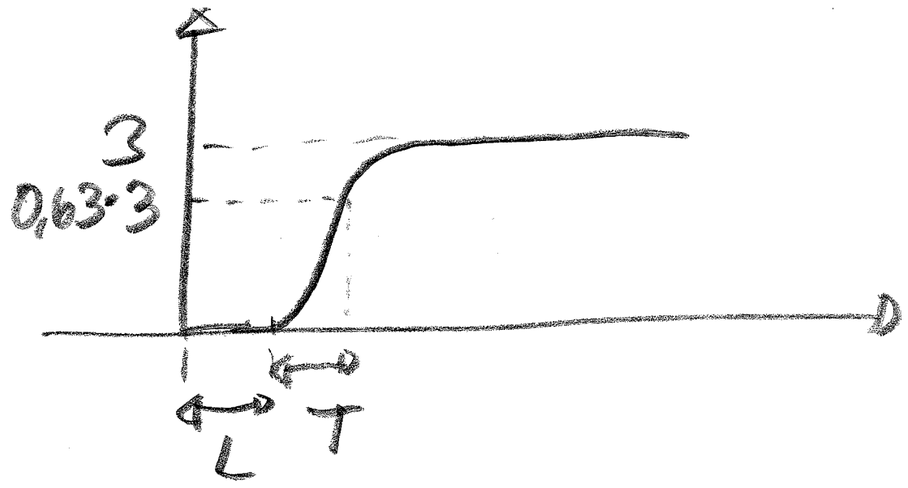
1. a - h : Se kursbok

2.



L = 4 sek

L+T = 8 sek

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3. Avläsning ger: $\begin{cases} t_p = 1\,\text{sek} \\ M = \frac{0{,}035}{0{,}1} = 0{,}35 \end{cases}$

$$M = e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}} = 0{,}35 \Rightarrow \left(-\ln(0{,}35)\right)^2 \cdot (1-\zeta^2) = (\zeta\pi)^2$$

$$1{,}0498\,(1-\zeta^2) = \zeta^2 \cdot \pi^2 \Rightarrow \pm\left(\frac{1{,}0498}{\pi^2 - 1{,}0498}\right) = \zeta \simeq 0{,}345$$

$$t_p \simeq \frac{\pi}{\omega_0\sqrt{1-\zeta^2}} \Rightarrow \omega_0 = \frac{\pi}{t_p\sqrt{1-\zeta^2}} \simeq 3{,}35$$

$$G(s) = \frac{K\cdot\omega_0^2}{s^2 + 2\zeta\omega_0 s + \omega_0^2} \simeq \frac{0{,}1\cdot 3{,}35^2}{s^2 + 2\cdot 0{,}345\cdot 3{,}35 s + 3{,}35^2}$$

4. $G(s) = \frac{K}{(1+sT_1)(1+sT_2)}$

Ser ut som en tänkbar överföringsfunktion

$K = 12{,}5\,dB \simeq 4{,}2$ ggr

Det syns tydligt i faskurvan 2 "knyckar" i denna.

$$\begin{cases} \frac{1}{T_1} \simeq 0{,}01 \Rightarrow T_1 = 100 \\ \frac{1}{T_2} \simeq 1 \Rightarrow T_2 = 1 \end{cases}$$

$$G(s) \simeq \frac{4{,}2}{(1+s100)(1+s)}$$

Stämmer bra överens med amplitudkurvans HF-lutning $-40\,dB/dekad$.

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5. $H(s) = \frac{4}{s+2} = \frac{2}{0{,}5s+1} \longrightarrow H_p(z) = \frac{K(1-e^{-h/T})z^{-1}}{(1-e^{-h/T}z^{-1})} \simeq$

grad P = 1
grad C = 0, grad D = 0

$$\simeq \frac{2\cdot(1-e^{-1})z^{-1}}{(1-e^{-1}z^{-1})} \simeq \frac{1{,}26\,z^{-1}}{1-0{,}37\,z^{-1}} = \frac{B}{A}$$

$P = AC + BD$

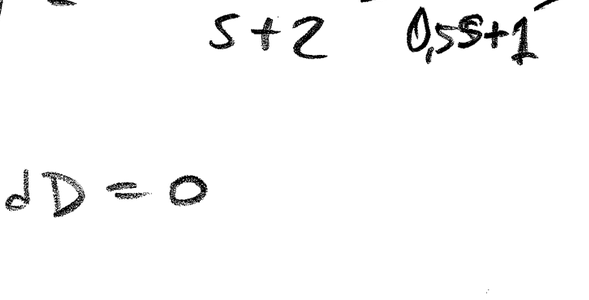
$1 = (1-0{,}37z^{-1})\cdot 1 + 1{,}26z^{-1}\cdot d_0$

$d_0 \simeq 0{,}29 \qquad K_r = \frac{P(1)}{B(1)} = \frac{1}{1{,}26} \simeq 0{,}79$

$$\frac{Y}{R} = \frac{K_r \cdot B}{P} = \frac{0{,}79\cdot 1{,}26z^{-1}}{1} = z^{-1} \qquad y(k) = r(k-1)$$

a)

k	y	r
0	0	0
1	1	1
2	1	1
3	1	1
4	1	1
⋮	1	1
⋮	1	1



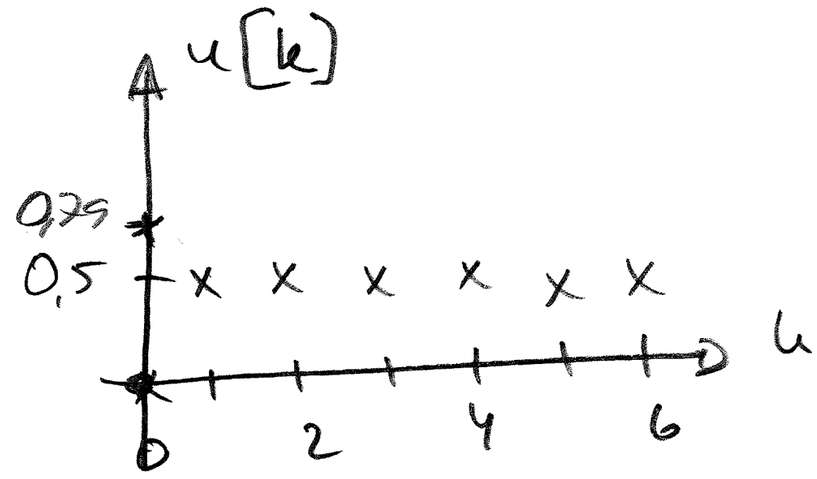
b) $\left(R(k)\cdot K_r - D(z)\cdot Y(z)\right)\frac{1}{C(z)} = U(z) \Rightarrow u[k] = 0{,}79\cdot r[k] - 0{,}29\,y(k)$

forts.

5 forts

b)

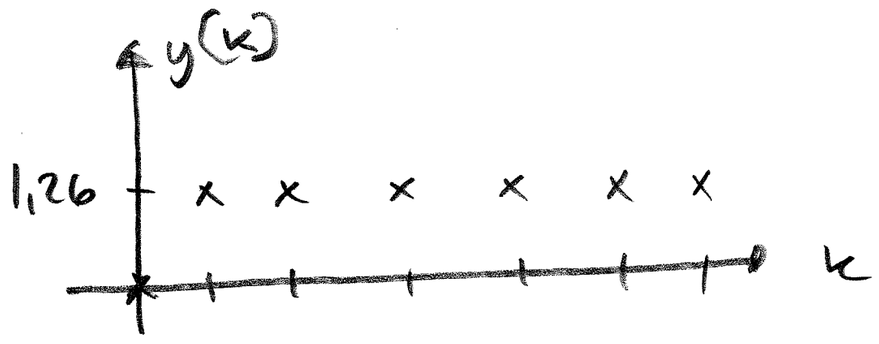
k	u[k]	y[k]	r[k]
0	0,79	0	1
1	0,5	1	1
2	0,5	1	1
3	0,5	1	1
4	0,5	1	1
	⋮	⋮	⋮



c)

$$\frac{Y}{V} = \frac{\frac{B}{A}}{1 + \frac{B}{A}\cdot\frac{D}{C}} = \frac{BC}{P} = \frac{1{,}26\,z^{-1}}{1}$$

$$y[k] = 1{,}26 \cdot v[k-1]$$



klarer inte störstorningar ⇒ kvarstående fel.

6.

a)

$$q[k] = q[k-1] + e[k] \qquad \text{I-del (summation av fel)}$$

$$u[k] = \underbrace{3 * e[k]}_{\text{P-del}} + \underbrace{3 \cdot q[k]}_{\text{I-del}}$$

Ur P-delen fås direkt förstärkningen ⇒ $K = 3$

ur I-delen fås: $3 = \frac{K}{T_i}\cdot h = \frac{3 \cdot 0{,}2}{T_i}$

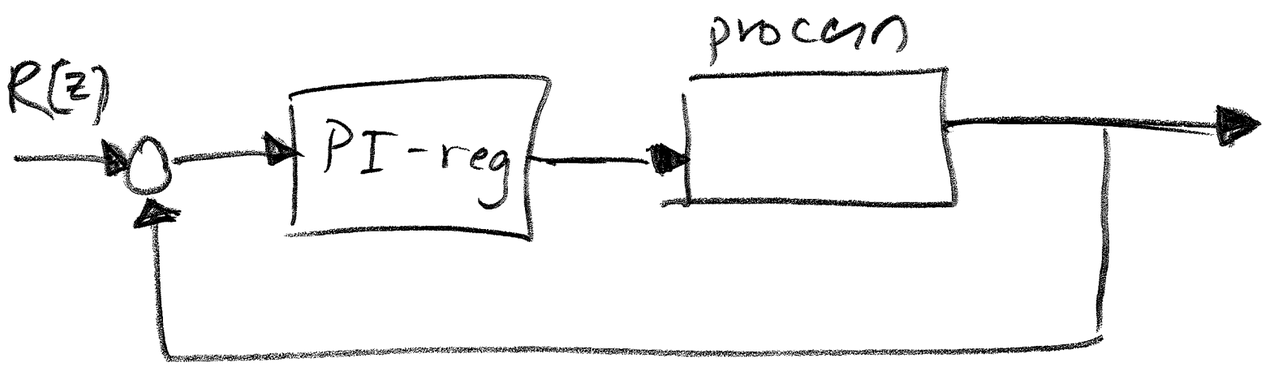
$\Rightarrow T_i = 0{,}2$ sek.

b)

$$u[k] = 3 * e[k] + 3\ q[k] + \underbrace{\frac{K \cdot T_d}{h}}_{0{,}75} \cdot \left(e[k] - e[k-1]\right)$$

där $T_d = \frac{1}{4}\cdot T_i = 0{,}05$ sek

7.



$$\begin{cases} h = 0{,}2 \text{ sek} \\ T = 1 \text{ sek} \end{cases}$$

Process: $\frac{1}{s+1} \longrightarrow H_p(z) = \frac{1 \cdot (1 - e^{-h/T}) z^{-1}}{1 - e^{-h/T} z^{-1}} \approx \frac{0{,}18\, z^{-1}}{1 - 0{,}82 z^{-1}}$

PI-reg:

$$K\left(1 + \frac{h}{T_i} \frac{1}{1 - z^{-1}}\right) = K\left(\frac{T_i(1 - z^{-1}) + h}{T_i (1 - z^{-1})}\right) =$$

$$= 3\left(\frac{0{,}2(1 - z^{-1}) + 92}{0{,}2 (1 - z^{-1})}\right) = 3\left(\frac{2 - z^{-1}}{1 - z^{-1}}\right)$$

$$G_R \cdot G_p = \frac{0{,}18\, z^{-1}}{1 - 0{,}82\, z^{-1}} \cdot \frac{3(2 - z^{-1})}{1 - z^{-1}} = \frac{0{,}54}{(z - 0{,}82)} \cdot \frac{2z - 1}{(z - 1)}$$

$$\frac{Y}{R} = H(z) = \frac{G_R \cdot G_p}{1 + G_R \cdot G_p} = \frac{\frac{0{,}54 \cdot (2z - 1)}{(z - 0{,}82)(z - 1)}}{1 + \frac{0{,}54 (2z - 1)}{(z - 0{,}82)(z - 1)}} = \frac{0{,}54 (2z - 1)}{(z - 0{,}82)(z - 1) + 0{,}54 (2z - 1)} \Rightarrow$$

$H(1) = 1$ dvs konstant regleringen fingerar utan kvarstående fel.

Polerna till karakt. ekv. $z^2 - 1{,}82z + 0{,}82 + 1{,}08z - 0{,}54 = 0$

$z^2 - 0{,}74z + 0{,}28 = 0$

$z = 0{,}37 \pm \sqrt{0{,}37 - 0{,}28}$

stabilt.

Resultatet ovan ger ett litet pi!

8.

Kretsöverföringen: $G_R \cdot G_p = 8\left(1+\frac{1}{100s}\right) \cdot \frac{2e^{-s}}{(1+20s)(1+10s)}$

$$= 8\left(\frac{100s+1}{100s}\right) \cdot \frac{2e^{-s}}{(1+20s)(1+10s)}$$

$$|G_R \cdot G_p| = 16 \cdot \frac{\sqrt{(100\omega)^2+1}}{100\omega\sqrt{1+400\omega^2}\sqrt{1+100\omega^2}}$$

$$\arg\{G_R \cdot G_p\} = -90^\circ + \arctan(100\omega) - \omega \cdot \frac{180}{\pi} - \arctan(20\omega) - \arctan(10\omega)$$

ω	$\arg\{G_R \cdot G_p\}$	$\lvert G_R \cdot G_p \rvert$
0,1	-120°	5,1
0,2	-154°	1,74
0,27	-167°	1,01
0,3	-171°	0,83
0,5	-193°	0,31
1	-229°	0,08
0,37	-180°	0,56

2)

→ $\varphi_m \approx 13^\circ$

→ $A_m \approx \frac{1}{0,56} \approx 1,8$ ggr

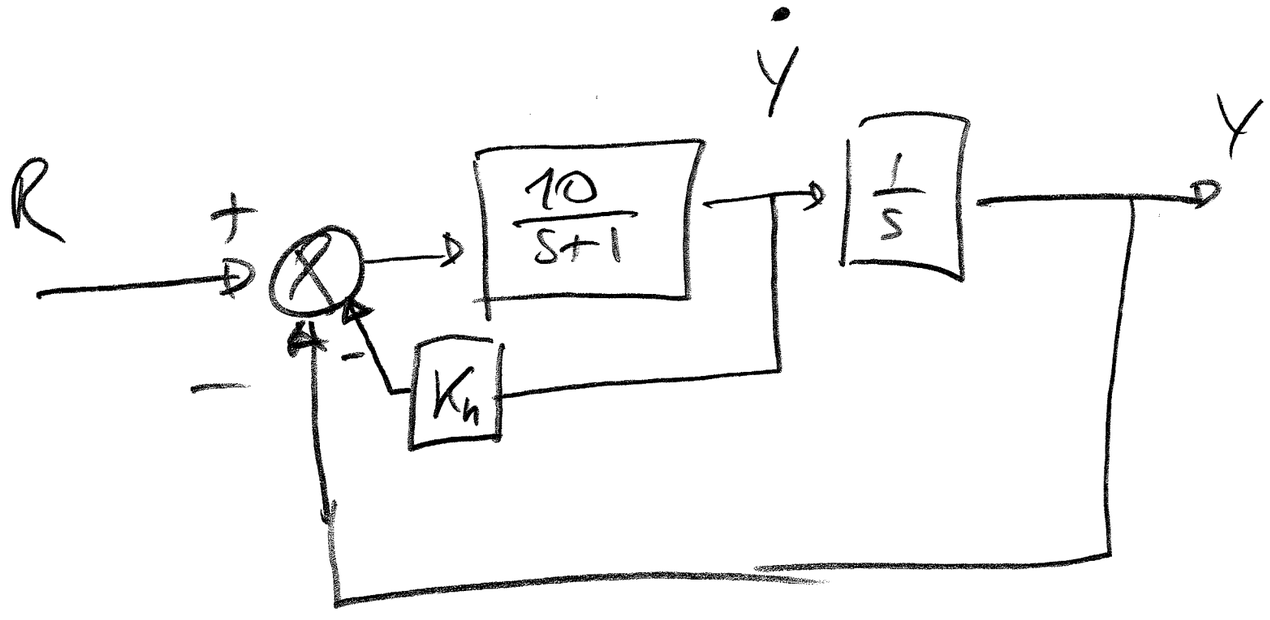
b) Kvarstående fel. vid harmonisk = 0

—" — —" — vid enhetsramp $= \frac{1}{|G_R \cdot G_p(0)|}$

$$e_{ss} = \frac{1}{K_1} = \frac{1}{0,16} \approx 6,25$$

$$G_R \cdot G_p(0) = \frac{16/100}{s} = \frac{K_1}{s}$$

9.

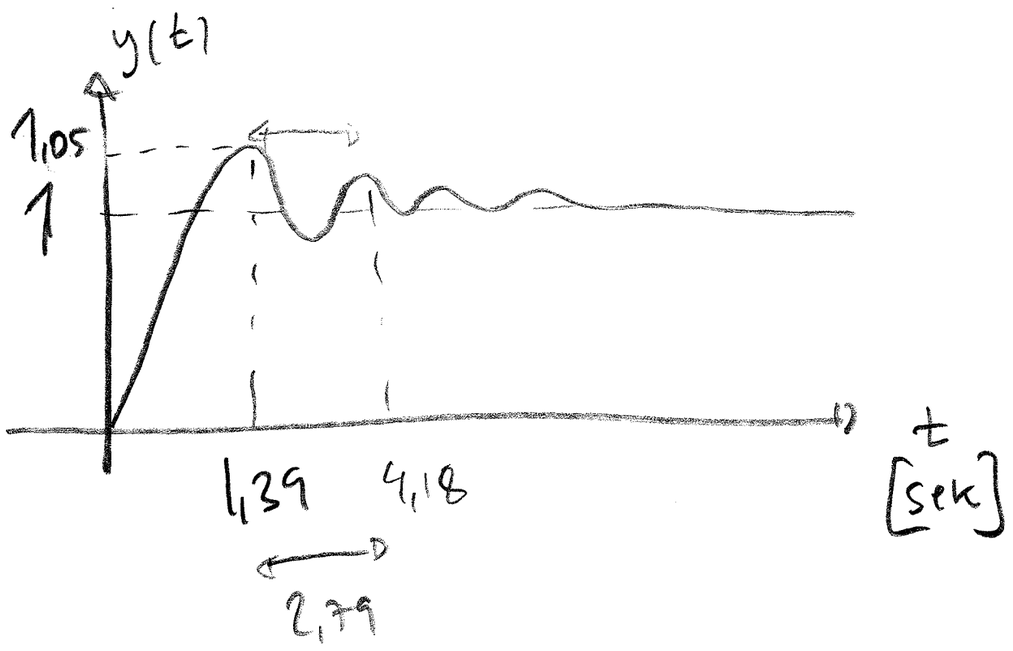


$$\frac{Y}{R} = \frac{\left(\frac{\frac{10}{s+1}}{1+\frac{10K_h}{s+1}}\right)\cdot\frac{1}{s}}{1+\frac{\frac{10}{s+1}}{1+\frac{10K_h}{s+1}}\cdot\frac{1}{s}} = \frac{\frac{10}{s+1+10K_h}\cdot\frac{1}{s}}{1+\frac{10}{s+1+10K_h}\cdot\frac{1}{s}} = \frac{10}{s^2+s+10K_h\cdot s+10}$$

Ifr med : $\frac{K\cdot\omega_0^2}{s^2+2\varphi\cdot\omega_0 s+\omega_0^2}$

$$\Rightarrow \begin{cases} K=1 \\ \omega_0=\sqrt{10} \\ 1+10K_h = 2\cdot\varphi\cdot\omega_0 \end{cases}$$

$$K_h = \frac{2\cdot\varphi\cdot\omega_0 - 1}{10} \approx 0{,}34$$



$$M \approx e^{-\frac{\varphi\pi}{\sqrt{1-\varphi^2}}} \approx 0{,}046$$

$$t_p \approx \frac{\pi}{\omega_0\sqrt{1-\varphi^2}} \approx 1{,}39$$

$$t_s \approx 1{,}81 \text{ sek} \left(\approx \frac{4}{\varphi\cdot\omega_0}\right)$$

$$\omega_d = \omega_0\cdot\sqrt{1-\varphi^2} \approx 2{,}25 \text{ red/s}$$

$$\frac{2\pi}{T_d} = 2{,}25 \Rightarrow T_d = 2{,}79$$