BIE 240 Reg. tek 19/2 -2014 ①

1) a)

$$H(j\omega) = \frac{2(-3j\omega+4)}{(j\omega+1)(3j\omega+3)}$$

$$= \frac{8-6j\omega}{(1+j\omega)(3+j\omega 3)}$$

$$|H(j\omega)| = \frac{\sqrt{8^2+6^2\omega^2}}{\sqrt{1+\omega^2}\cdot\sqrt{3^2+\omega^2 3^2}}$$

$$\angle H(j\omega) = \operatorname{atan}\left(-\frac{6\omega}{8}\right) - \operatorname{atan}(\omega) - \operatorname{atan}(\omega)$$

b) polene er begge i $p_{1,2} = -1$

$$(s+1)(3s+3) = (s+1)(s+1)\cdot 3 = 0$$

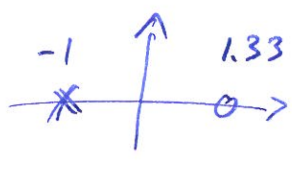
$$s_1, s_2 = -1$$

Asymptotisk stabilt

Kritisk dempet, sammenfallende poler

Nullpkt i $-3s+4=0$

$$\underline{s = \frac{4}{3}}$$



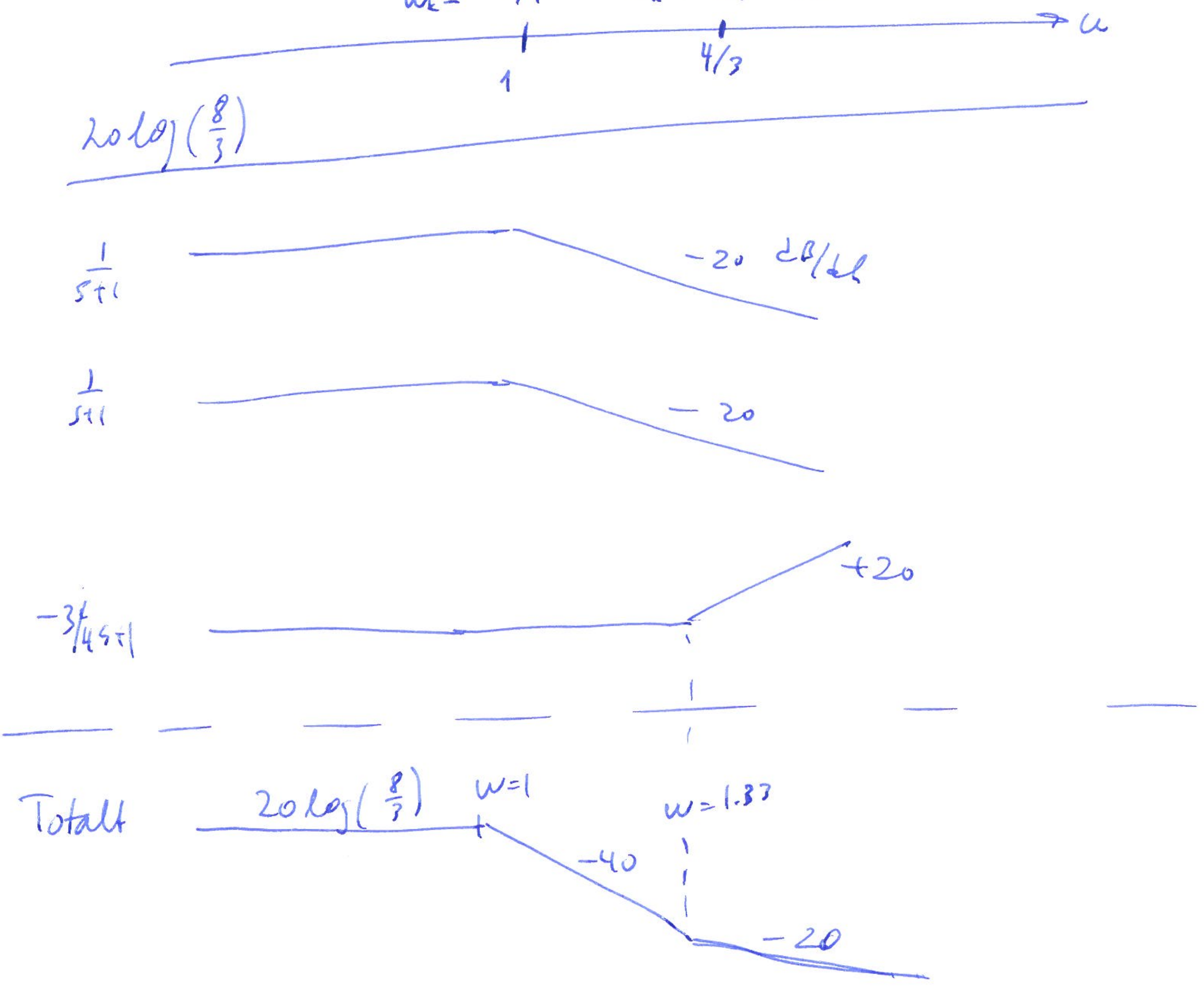
c)

Finner først $H(s)$ på standard form.

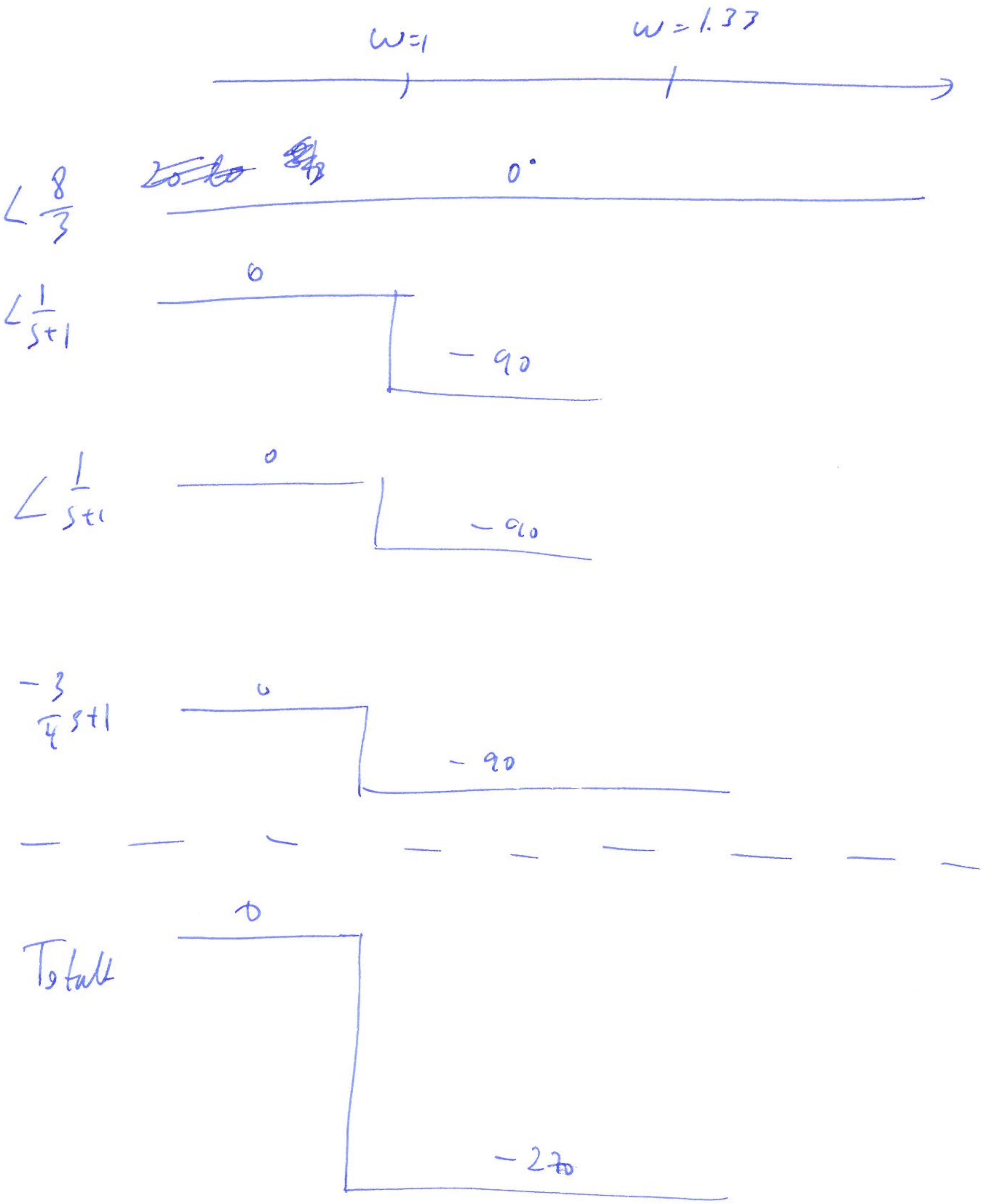
$$H(s) = \frac{4 \cdot 2\left(-\frac{3}{4}s+1\right)}{(s+1)(s+1)\cdot 3}$$

$$= \frac{\frac{8}{3}\left(-\frac{3}{4}s+1\right)}{(s+1)(s+1)}$$

$\omega_k = 1/1 \qquad \omega_k = \frac{1}{3/4} = 4/3$



c (cont'd)



$\omega = 1$
$\omega = 1.33$
$\angle \frac{8}{3}$
$0°$
$\angle \frac{1}{s+1}$
0
-90
$\angle \frac{1}{s+1}$
0
-90
$\frac{-3}{4}s+1$
0
-90
Totall
0
-270

d) $u(t) = 0.5$

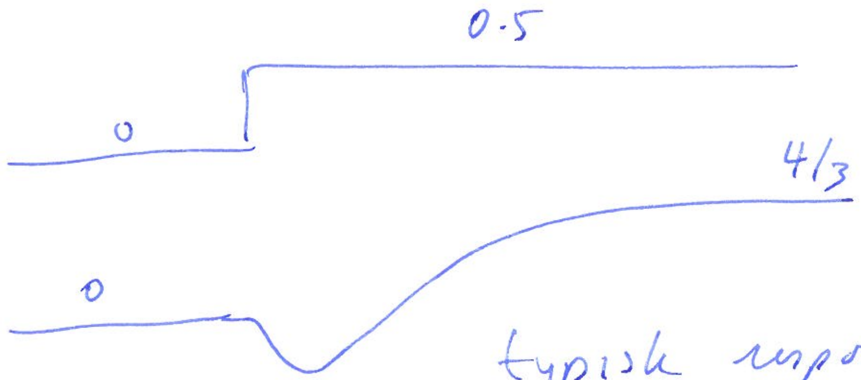
$U(s) \downarrow$

Benytter sluttverditeorem:

$$\lim_{t\to\infty} y(t) = \lim_{s\to 0} s\cdot y(s) = \lim_{s\to 0} s\cdot H(s)\cdot \frac{0.5}{s}$$

$$= H(0)\cdot 0.5$$

$$= \frac{8}{3}\cdot 0.5 = \underline{\underline{\frac{4}{3}}}$$



typisk respons for system med nullpunkt i h.h.p.

Oppg 2)

a) Bare negative tilbakekopl $\Leftrightarrow$ asymptotisk stabilt

b) $\dot{x}_1 = 2(u - 4x_1 - x_2)$

$$\underline{\dot{x}_1 = -8x_1 - 2x_2 + 2u}$$

$$\dot{x}_2 = \frac{1}{2}(2 \cdot x_1 - 2x_2)$$

$$\underline{\dot{x}_2 = x_1 - x_2}$$

$$\underline{y = x_2}$$

c) $A = \begin{bmatrix} -8 & -2 \\ 1 & -1 \end{bmatrix}$

$$B = \begin{bmatrix} 2 \\ 0 \end{bmatrix}$$

$$C = \begin{bmatrix} 0 & 1 \end{bmatrix}$$

d) ~~[illegible]~~ Blokkdiagram manipulasjon

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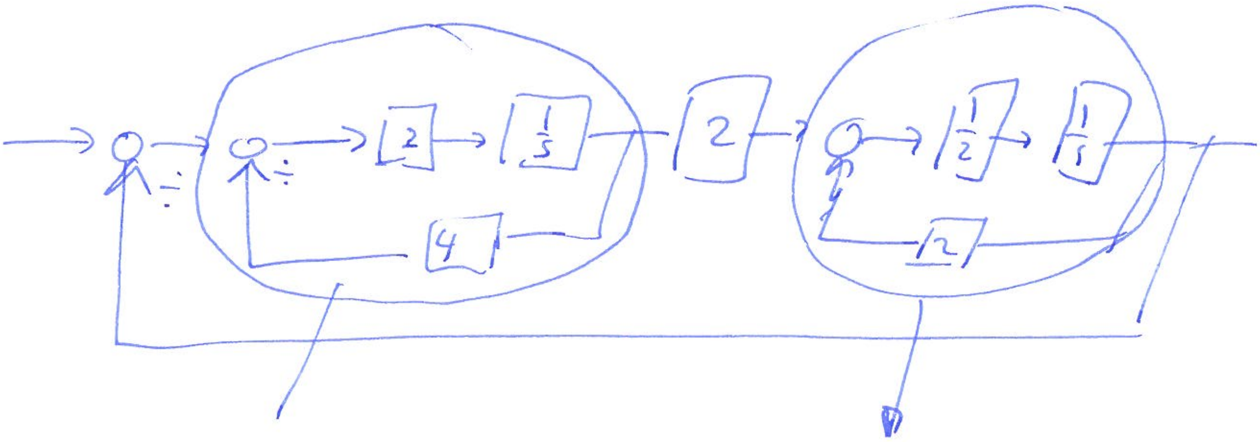
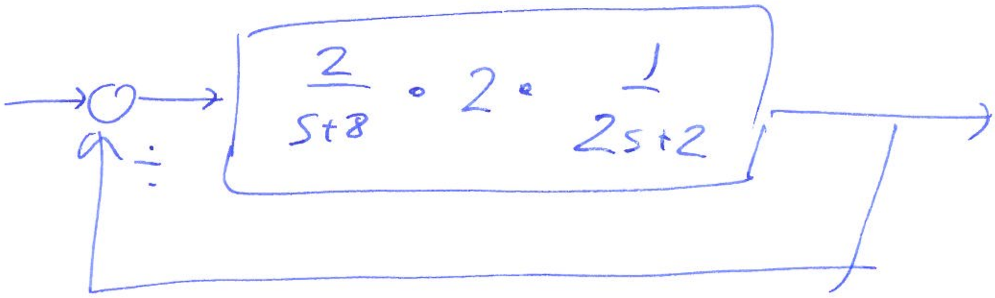


$$\frac{\frac{2}{s}}{1+\frac{2}{s}\cdot 4} = \frac{2}{s+8} \qquad \frac{\frac{1}{2s}}{1+\frac{1}{2s}\cdot 2} = \frac{1}{2s+2}$$



$$H(s) = \frac{\frac{4}{(s+8)(2s+2)}}{1+\frac{4}{(s+8)(2s+2)}\cdot 1}$$

$$= \frac{4}{(s+8)(2s+2)+4} = \underline{\underline{\frac{4}{2s^2+18s+20}}}$$

e) Polene

$$2s^2 + 18s + 20 = 0$$

$$s_{1,2} = \frac{-18 \pm \sqrt{18^2 - 4 \cdot 2 \cdot 20}}{2 \cdot 2}$$

$$= \frac{-18 \pm \sqrt{324 - 160}}{4}$$

$$= \frac{-18 \pm 12.8}{4}$$

$$s_1 = \div 7.7 \quad s_2 = \div 1.3$$

Begge er i v.h.p $\Rightarrow$ asymp. stab.

Stemmer med 2a)

Overdempet system, $\xi > 1$, pga

to reelle poler. Kan vises.

Oppg 3

a) $$\frac{dE(t)}{dt} = \sum Q_{inn}(t) - \sum Q_{ut}(t)$$

b) $$E(t) = m \cdot c_p \cdot T(t)$$

$$Q_{inn}(t) = P(t)$$

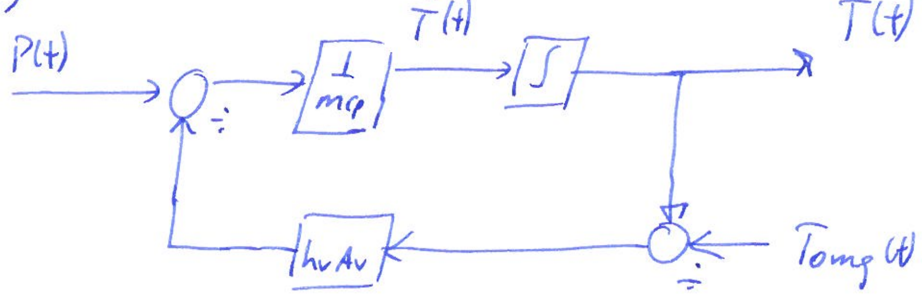
$$Q_{ut}(t) = h_v \cdot A_v (T(t) - T_{omg}(t))$$

$$m \cdot c_p \cdot \frac{dT(t)}{dt} = P(t) - h_v A_v (T(t) - T_{omg}(t))$$

$$\frac{dT(t)}{dt} = \frac{1}{m \cdot c_p} \left(P(t) - h_v A_v (T(t) - T_{omg}(t)) \right)$$

antar konstant m, c_p, $h_v \cdot A_v$

c)



d) $$s \cdot T(s) = \frac{1}{mc}\left(P(s) - h_v A_v\left(T(s) - T_{omg}(s)\right)\right)$$

$$\left(s + \frac{h_v A_v}{mc}\right) T(s) = \frac{1}{mc} P(s) + \frac{h_v A_v}{mc} T_{omg}(s)$$

Finner $H_p(s)$ når $T_{omg}(s) = 0$

$$H_p(s) = \frac{T(s)}{P(s)} = \frac{1/mc}{s + \frac{h_v A_v}{mc}}$$

$$= \frac{1}{m \cdot c \cdot s + h_v A_v}$$

$$= \frac{1/h_v A_v}{\frac{mc}{h_v A_v} s + 1}$$

e) $H_v(s)$ finner vi når $P(s) = 0$

$$H_v(s) = \cancel{\frac{T_{omg}(t)}{P}} \; \frac{T(s)}{T_{omg}(s)}$$

$$= \frac{\frac{h_v A_v}{mc}}{s + \frac{h_v A_v}{mc}} = \frac{1}{\frac{mc}{h_v A_v} s + 1}$$

f) • 1 orden begge to

• $K = 1/h_v A_v$, $T = \frac{mc}{h_v A_v}$

• $K_v = 1$, $T_v = \frac{mc}{h_v A_v}$

Sammenheng mellom temperatur i forstyrrelse $T_{omg}(t)$ og utgang $T(t)$. Samme benevning.

$$\underbrace{T_{omg} = 10\,^\circ C,\ P(t) = 0 \implies T(t) = 10\,^\circ C}_{K_v = 1}$$

g) $H_o(s) = H_r(s) \cdot H_p(s) \cdot H_m(s)$

$$= K_p \cdot \frac{1/h_v A_v}{\frac{mc}{h_v A_v}s+1} \cdot \underbrace{\frac{1}{30s+1}}_{H_m(s)}$$

$T_m = 30$ sek

$$\omega_b = \frac{1}{30} = 0.033$$

$$M(s) = \frac{H_o(s)}{1+H_o(s)} = \frac{\frac{t}{n}}{1+\frac{t}{n}} = \frac{t}{n+t}$$

$$= \frac{K_p \cdot \frac{1}{h_v A_v} \cdot 1}{\left(\frac{mc}{h_v A_v}s+1\right)(30s+1) + K_p \cdot \frac{1}{h_v A_v} \cdot 1}$$

$$N(s) = \frac{1}{1+H_o(s)} = \frac{1}{1+\frac{t}{n}} = \frac{n}{n+t}$$

$$= \frac{\left(\frac{mc}{h_v A_v}s+1\right)(30s+1)}{\left(\frac{mc}{h_v A_v}s+1\right)(30s+1) + \frac{1}{h_v A_v} \cdot K_p \cdot 1}$$

h) Følgeegenskapene er ikke så gode med P-reg.
Regulatoren klarer ikke å følge settpunktet. Dette fordi det ikke er en integrator i sløyfa.
Reguleringsavviket blir:

$$e(s) = N(s) \cdot y_{ref}(s)$$

$$\lim_{t \to \infty} e(t) = \lim_{s \to 0} s \cdot e(s)$$

$$= \lim_{s \to 0} \cancel{s} \cdot N(s) \cdot \frac{T_{ref}}{\cancel{s}}$$

$$= N(0) \cdot T_{ref}$$

$$= \frac{1}{1 + \frac{K_p}{h_v A_v}} \cdot T_{ref}$$

$$= \frac{h_v A_v}{h_v A_v + K_p} \cdot T_{ref}$$

(13)

i)

$$e(s) = N(s)\, y_r(s)$$

$$\lim_{t\to\infty} e(t) = \lim_{s\to 0} s \cdot e(s)$$

$$= \lim_{s\to 0} s \cdot N(s) \cdot y_r(s)$$

$$= \lim_{s\to 0} \cancel{s} \cdot N(s) \cdot \frac{1}{\cancel{s}}$$

$$= \lim_{s\to 0} \frac{1}{1 + H_0(s)}$$

$$= \frac{1}{1 + H_0(0)}$$

hvor $H_0(0)$ er $\approx \div 4$ dB som er

$$X = 10^{\div 4/20} = 0.63$$

$$\lim_{t\to\infty} e(t) = \frac{1}{1+0.63} = \underline{\underline{0.61}}$$

Fra oppg h) forventes:

$$\lim_{t\to\infty} e(t) = \frac{h_v A_v}{h_v A_v + K_p} \cdot \text{Fin}$$

$$= \frac{0.004}{0.004 + 0.0025} \cdot 1$$

$$= \underline{0.615}$$

Stemmer bra

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j) ① Kan la $K_p \to \infty$, men dette er bare teoretisk interessant. ② Benytt PI reg.

Eller, ved å la $h_v A_v \to 0$ (mer og mer isolasjon) $\frac{h_v A_v}{h_v A_v + k_p} \to 0$

blir prosessen mer og mer en integrator, og $e(t) \to 0$, $t \to \infty$.

Får da en integrator i slørfa.

k) $K_p = 0.0025$

K_p må økes med ca 11 dB. ~~[illegible]~~ for å få $\varphi = 90°$

$$\underline{K_{p,ny}} = 0.0025 \cdot 10^{\frac{11}{20}} = \underline{\underline{0.0088}}$$

Uendelig ΔK, $\underline{\underline{\Delta K = \infty}}$

l) $$H_p(s) = \frac{1/h_v A_v}{\frac{mc}{h_v A_v} s + 1} = \frac{250}{2500 s + 1}$$

$$\underline{T_r = 1000 \text{ sek}}$$

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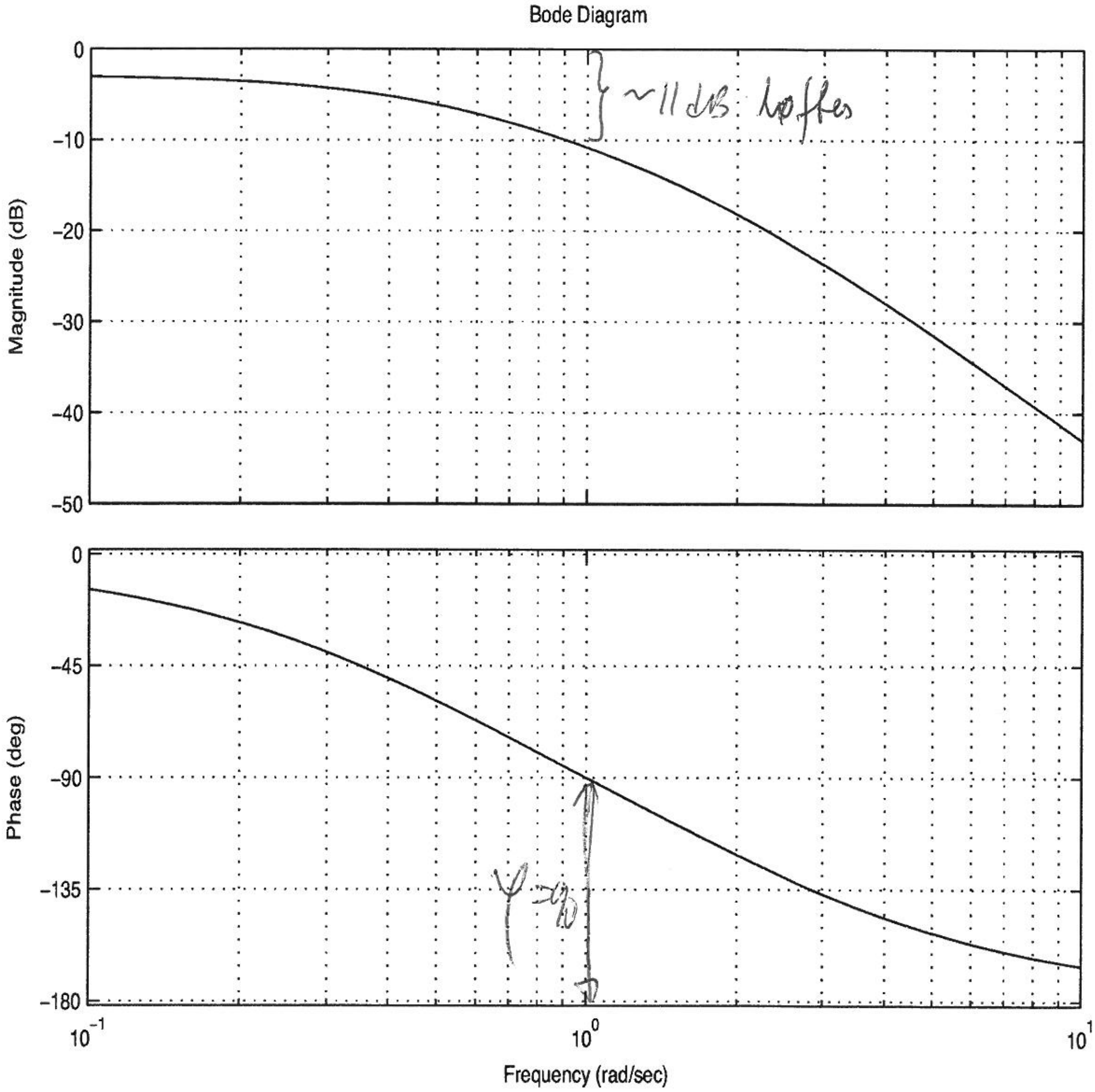
Dato: 19. februar 2014
Kandidatnr:
Sidenr:



Figur 5: Bodeplot av sløyfetransferfunksjonen $H_0(j\omega)$ i oppgave 3h).

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Velger pol/nullpkt kansellering

$$\underline{T_i = 2500}$$

$$K_p = \frac{2500}{1000 \cdot 250} = \frac{25}{2500} = \underline{0.01}$$

4)

1 – C imaginære poler
marginalt stab

2 – E reelle poler, overdempet

3 – A nullpkt i V.H.P.
oversving, starter som
1. orden

4 – B ustabilt, 2 integratorer

5 – D nullpkt i H.H.P.
inversrespons.