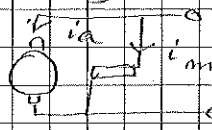
Lösning EIET10 150604

1. a)




2M

b) $e_a = u_a - R_a i_a = 400 - 0{,}705 \cdot 89 = 337\ V$

$\Psi = \frac{e}{\omega} = \frac{337}{2\pi \cdot 819/60} = 3{,}9\ Vs$

$T_n = \frac{P_n}{\omega_n} = \frac{29000}{2\pi \cdot 819/60} = 338\ Nm$

c) $P_{magn} = P_{fn} = 1200\ W$

$P_{cu} = R_a i_a^2 = 0{,}705 \cdot 89^2 = 5{,}584\ kW$

$P_{fe} + P_{friktion} = P_{eldyn} - P_{ut} = e_a i_a - P_{ut} =$

$= 337 \cdot 89 - 29000 = 1020\ W$

$\sum P_{förlust} = P_{in} - P_{ut} = u_a \cdot i_a + P_{magn} - P_{ut} =$

$= 400 \cdot 89 + 1200 - 29000 = 7800\ W$

Alt: $\sum P_{förlust} = P_{in} - P_{ut} = \frac{P_{ut}}{\eta} - P_{ut} =$

$= \frac{29000}{0{,}788} - 29000 = 8275\ W$

d) 1. Nominell magnetisering, styr med rotorspänning

$0 \le n \le 819\ rpm$ då $0 \le U \le 400\ V$

2. Nominell rotorspänning, styr med magnetiseringen

$819 \le n \le 2456$ då $i_{f\,min} \le i_f \le i_{f,nom}$

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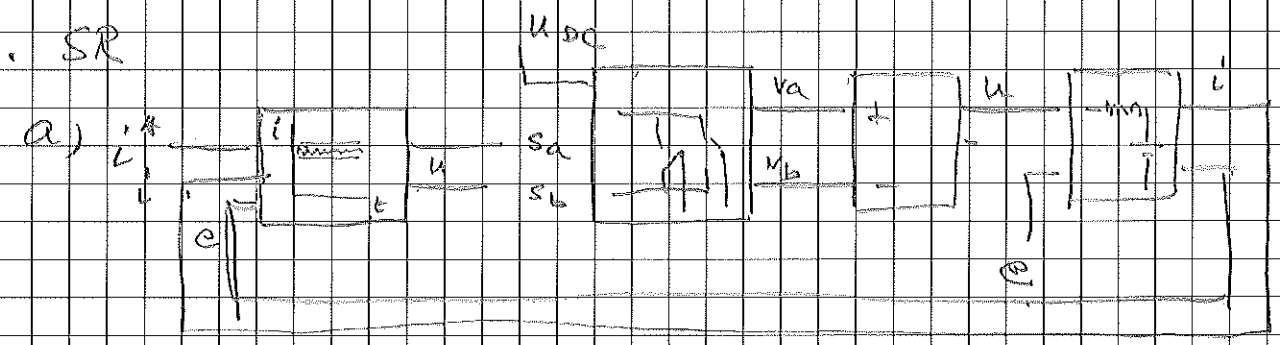
2. SR

a) 


b) PI strömreg med dead beat

$$u^* = \left(\frac{L_a}{T_s} + \frac{R_a}{2}\right)\left((i^* - i) + \frac{\frac{T_s}{T_1}}{\frac{L_a}{R_a} + \frac{T_s}{2}} \sum (i^* - i)\right) + \psi \cdot \omega =$$

7 - del 1 - del

$$= K_p (i^* - i) + \frac{T_s}{T_1} \cdot \sum (i^* - i) + \psi \cdot \omega$$

där $K_p = \frac{9{,}05\ m}{1\ m} + \frac{0{,}705}{2} = 9{,}4$

$$\frac{T_s}{T_1} = \frac{1\ m}{\underbrace{9{,}05\ m}_{0{,}705} + \underbrace{1\ m}_{2}} = 0{,}075 \quad ; \quad T_1 = 13{,}3\ m$$

c) $u^*(1) = 9{,}4 \left((89 - 0) + 0{,}075 \sum(\ )\right) + 0 = 836\ V \rightarrow 400\ V$

$di = \frac{dt}{L}(u - e) \Rightarrow i(1) = 44\ A \quad T(1) = \psi \cdot i(1) = 3{,}93 \cdot 44 = 175\ Nm$

$\omega(1) = \frac{T(1) \cdot dt}{J} = \frac{175\ m}{0{,}5} = 0{,}35\ rad/s \quad e(1) = \psi \cdot \omega(1) = 1{,}4\ V$

$u^*(2) = 9{,}4\left((89 - 44) + 0{,}075 \cdot 89\right) + 3{,}93 \cdot 0{,}35 = 487\ V \rightarrow 400\ V$

$di(2) = \frac{1\ m}{9{,}05\ m}(400 - 1{,}4) = 44\ A \quad i(2) = i(1) + di(2) = 88\ A$

$T(2) = 346\ Nm \quad d\omega(2) = \frac{dt}{J} \cdot T(2) = \frac{1\ m}{0{,}5} \cdot 346 = 0{,}69\ rad/s$

$\omega(2) = \omega(1) + d\omega(2) = 1{,}04\ rad/s \quad e(2) = \psi \cdot \omega(2) = 4{,}1\ V$

$u^*(3) = 9{,}4\left((89 - 86) + 0{,}075\,(89 + 45)\right) + 3{,}93 \cdot 1{,}04 = 104\ V$

$di(3) = \frac{1\ m}{9{,}05\ m}(104 - 4{,}1) = 11\ A \quad i(3) = 99\ A$

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3) SM

a) $T = \vec{\psi}_m \times \vec{i}_s = \psi_{max} \cdot i_{sy}$ (tvärströmsregel)

$i_{fas\,max} = \sqrt{2}\cdot 10\ A \Rightarrow$

$\vec{i}_{xp} = \sqrt{\frac{3}{2}} \cdot \hat{i}_{fas} \cdot e^{j\omega t} = 12{,}3 \cdot e^{j\omega t}$

$\vec{i}_{xy} = 0 + j\,12{,}3$

$\vec{\psi}_{m\,xp} = \sqrt{\frac{3}{2}} \cdot \hat{\psi}_{m\,fas} e^{j\omega t}$

$\vec{\psi}_{m\,xy} = \sqrt{\frac{3}{2}} \cdot \hat{\psi}_{m\,fas} \cdot j0 = 2{,}45 + j\cdot 0$

$T = 2{,}45 \cdot 12{,}3 = 42\ Nm$

b) $U_{dc} = 660V = \hat{U}_n \Rightarrow U_{n\,max} = \frac{660}{\sqrt{2}} = 467V$

c) $\frac{d}{dt}\left(\vec{\psi}_{m\,xp} + L_s \vec{i}_{s\,xp}\right) = \vec{e}_{s\,xp} = \vec{u}_{s\,xp} - R_s \vec{i}_{s\,xp}$

$\frac{d}{dt}\vec{\psi}_{m\,xp} = \vec{e}_{s\,xp} = \vec{u}_{s\,xp}$

$j\omega \vec{\psi}_{m\,xp} = \vec{u}_{s\,xp}$

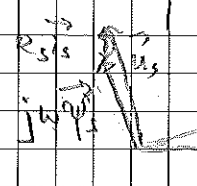
$\omega\,|\vec{\psi}_m| = |\vec{u}_s|$

$|\vec{u}_s|_{max} = \sqrt{\frac{3}{2}} \cdot U_{s\,rms} = \sqrt{\frac{3}{2}} \cdot \frac{1}{\sqrt{3}} \cdot \frac{660}{\sqrt{2}} = 330\ V$

$\omega_{el} = \frac{330}{2{,}45} = 135\ rad/s \Rightarrow \omega_{max} = 67\ rad/s = 640\ rpm$

d) $n_{max} = 500\ rpm$ $n_{el} = 1000\ rpm$ $\omega_{el} = 105\ rad/s$

$T_{max} = 50\ Nm$ $T_{el} = 25\ Nm$ $i_{sy} = \frac{25}{2{,}45} = 10{,}2\ A$




$L_s \vec{i}_s = 0 + j\,3m \cdot 10{,}2 = j\,0{,}03$

$\vec{\psi}_s = 2{,}45 + j\,0{,}03$

$j\omega\vec{\psi}_s = (-0{,}03 + j\,2{,}45)\cdot 105 =$

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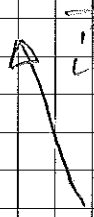
3 d) Inkl.

$$j\omega\vec{\psi}_s = -3{,}21 + j\,257.$$

$$\vec{u}_s = R_s\vec{i}_s + j\omega\vec{\psi}_s = j\cdot 0{,}2\cdot 10{,}2 - 3{,}21 + j\,257 =$$

$$= -3{,}2 + j\,259\ \text{V}$$

e) Strömmen ska ha en momentgivande komponent i y-led och en magnetiserande i neg. x-led



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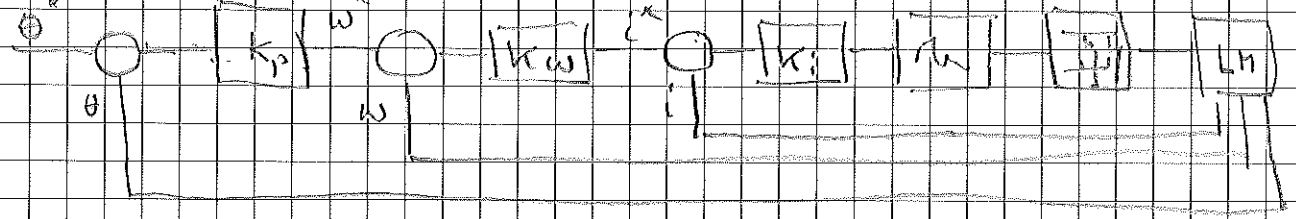
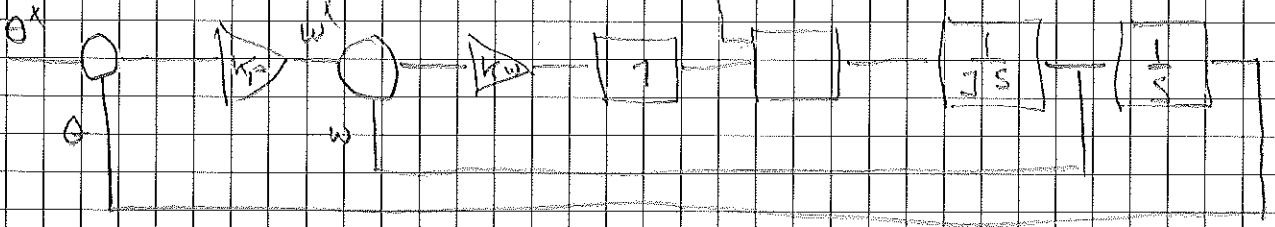
4.

Aksen posisjonsregulert:

a)




Lukket:




b) $G(s) = \frac{1}{J \cdot s} \cdot \frac{1}{s} \cdot K_p \cdot K_\omega$

$$\frac{G}{1+G} = \frac{\frac{K_p K_\omega}{Js^2}}{1 + \frac{K_p K_\omega}{Js^2}} = \frac{K_p K_\omega}{Js^2 + K_p K_\omega} = \frac{K_p \cdot K_\omega}{J} \cdot \frac{1}{s^2 + \frac{K_p K_\omega}{J}}$$

c) Poler: $s = (\pm) \sqrt{\frac{K_p K_\omega}{J}} = -\frac{1}{2}$

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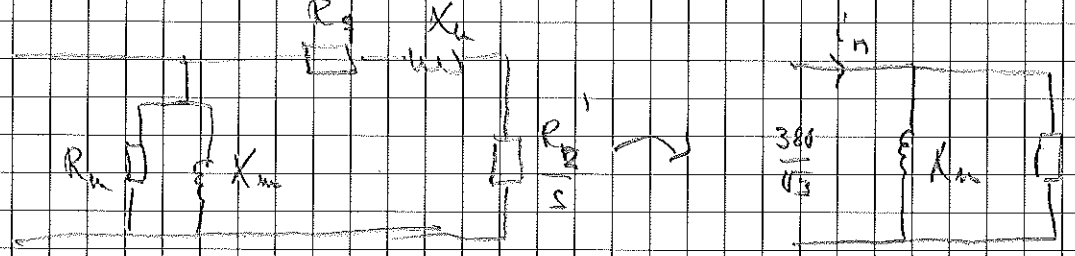
5

a) $n_n = 1390$ rpm $\Rightarrow$ $p = 4$

$n_n = 710$ rpm $\Rightarrow$ $p = 8$

b)




$U = 380$ V $\quad P_n = 0{,}16$ kW $\quad n_n = 1390 \quad I_n = 0{,}55$ A

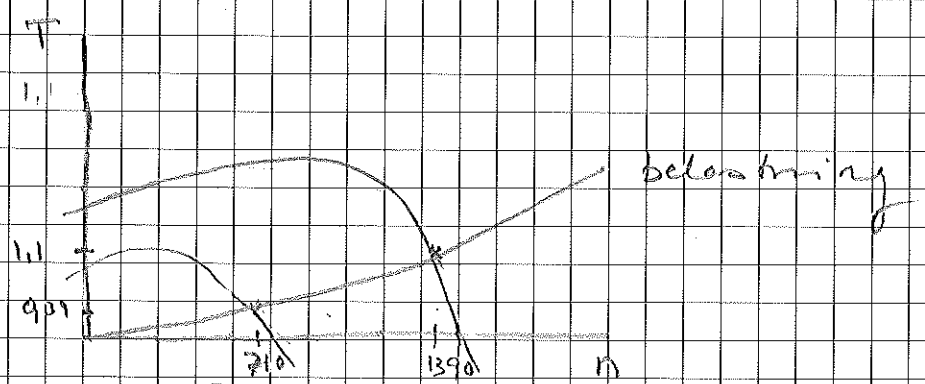
$\eta = 0{,}56 \quad \cos\varphi = 0{,}5 \Rightarrow \quad \underline{i} = 0{,}55\,(0{,}8 + j\,0{,}6) = 0{,}44 + j\,0{,}33$

$$X_m = \frac{\frac{380}{\sqrt{3}}}{0{,}33} = 666\ \Omega$$

$$\frac{R_2'}{s} = \frac{\frac{380}{\sqrt{3}}}{0{,}44} = 499{,}2\ \Omega \quad \Big\} \quad s = \frac{1500 - 1390}{1500} = 0{,}073$$

$$R_2' = 36{,}6\ \Omega$$

c)




$$T_{1390} = \frac{P_{1390}}{\omega_{1390}} = \frac{160}{\frac{1390 \cdot 2\pi}{60}} = 1{,}1\ \text{Nm}$$

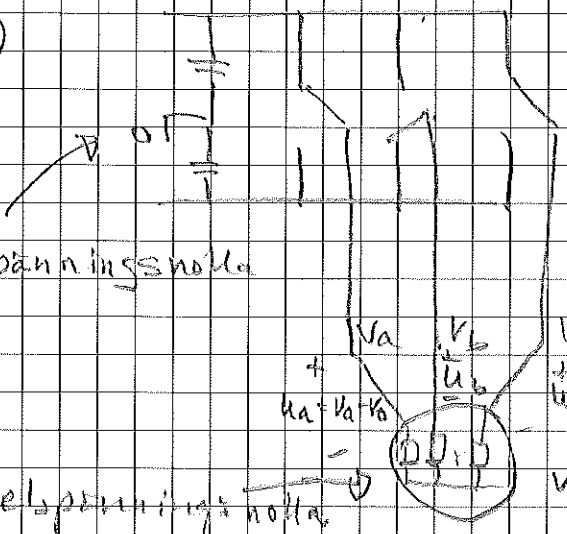
$$T_{710} = \frac{P_{710}}{\omega_{710}} = \frac{25}{710\ \ 2\pi/60} = 0{,}34\ \text{Nm}$$

# Lösning ETEF10 150804

6. $\underline{U}_{100} = \sqrt{\frac{2}{3}} \cdot 311 \cdot e^{j0} = 254 \cdot e^{j0}$ [kV]

a) med effektivvärdet som transformator

b)




$V_{a,b,c} \in \{\pm U_{dc}/2\}$

$U_{a,b,c} \in \{+\frac{U_{dc}}{3}, -\frac{U_{dc}}{3}\}$

$U_{ab}, U_{bc}, U_{ca} \in \{\pm 0, \pm U_{dc}\}$

c) $\underline{U}_{100} = K\left(U_a \cdot 1 + U_b \cdot e^{j2\pi/3} + U_c \cdot e^{j4\pi/3}\right) =$

$= K\left((V_a - V_0) \cdot 1 + (V_b - V_0) e^{j2\pi/3} + (V_c - V_0) e^{j4\pi/3}\right) =$

$= K\left(V_a \cdot 1 + V_b \cdot e^{j2\pi/3} + V_c e^{j4\pi/3} - V_0\left(1 + e^{j2\pi/3} + e^{j4\pi/3}\right)\right) =$

$= K\left(\left(S_a \cdot U_{dc} - \frac{U_{dc}}{2}\right) \cdot 1 + \left(S_b \cdot U_{dc} - \frac{U_{dc}}{2}\right) e^{j2\pi/3} + \right.$

$\left. + \left(S_c \cdot U_{dc} - \frac{U_{dc}}{2}\right) \cdot e^{j4\pi/3}\right) =$

$= K\left(S_a \cdot U_{dc} \cdot 1 + S_b \cdot U_{dc} \cdot e^{j2\pi/3} + S_c \cdot U_{dc} \cdot e^{j4\pi/3}\right)$