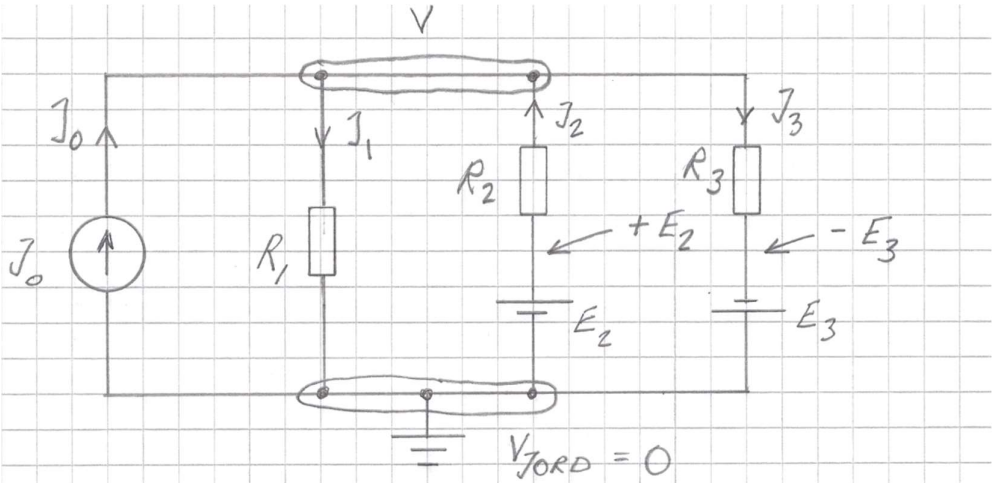
Lösningsförslag till tentamen TSFS13 Elektroteknik 2024-05-30

1. Nodanalys:



$$J_2 = \frac{E_2 - V}{R_2} \quad \ldots (1)$$

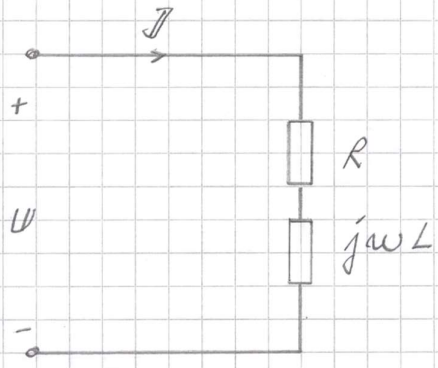
$$J_0 - J_1 + J_2 - J_3 = 0 \Rightarrow$$

$$J_0 - \frac{V-0}{R_1} + \frac{E_2 - V}{R_2} - \frac{V-(-E_3)}{R_3} = 0$$

$$\Rightarrow V = +2{,}25\ V$$

INS i (1) $\rightarrow$ $\underline{J_2 = 3{,}0\ A}$

2a)



$u(t) = 230\sqrt{2}\sin(100\pi t + 0°)\,V \rightsquigarrow \underline{U} = 230\sqrt{2}\,e^{j0°}\,V$

$$\underline{J} = \frac{\underline{U}}{R + j\omega L} \Rightarrow$$

$$\underline{J} = \frac{230\sqrt{2}\,e^{j0°}}{24{,}0 + j100\pi \cdot 0{,}0513} =$$

$$= \frac{230\sqrt{2}\,e^{j0°}}{\sqrt{24^2 + 18^2}\,e^{j\arctan\frac{18}{24}}} = 7{,}67\sqrt{2}\,e^{-j37°}\,A$$

$\rightsquigarrow \underline{i(t) = 7{,}67\sqrt{2}\sin(100\pi t - 37°)\,A}$

2b)

$$J = \frac{\hat{J}}{\sqrt{2}} = 7{,}67\,A$$

$P = R \cdot J^2 \rightarrow \underline{P = 1{,}41\,kW}$

$Q = X_L J^2 = \omega L J^2 \Rightarrow \underline{Q = 1{,}06\,kVAr}$

(Q = Q_L DÅ C ÄR BORTKOPPLAD)

$S = \sqrt{P^2 + Q^2} \Rightarrow \underline{S = 1{,}76\,kVA}$

ALTERNATIVT SÄTT ATT RÄKNA :

$P = UI\cos\varphi$ $\qquad$ $\varphi = \arg U - \arg I = 37°$

$Q = U \cdot I \sin\varphi$ $\qquad$ $\uparrow \quad \uparrow$

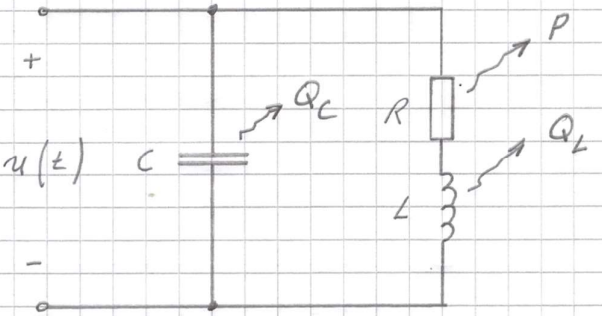
$0° \quad -37°$

$S = U \cdot I$

$\uparrow \quad \uparrow$

$230\,V \quad 7{,}67\,A$

2c)



$Q = Q_L - Q_C$

$Q = 0 \Longrightarrow Q_C = Q_L$

$$Q_C = \frac{U^2}{X_C} = \left| X_C = \frac{1}{\omega C} \right| = U^2 \omega C$$

$1{,}06 \cdot 10^3 = 230^2 \cdot 100\pi \cdot C \Rightarrow \underline{C = 63{,}7\,\mu F}$

2d) $Q = 0 \rightarrow S = P$ och $\cos\varphi = 1 \rightarrow \varphi = 0°$ $(\arg I = \arg U)$

$S = U \cdot I \rightarrow 1{,}41 \cdot 10^3 = 230 \cdot I \rightarrow I = 6{,}13\,A$

$\Longrightarrow i(t) = 6{,}13\sqrt{2}\sin(100\pi t)\ A$

3a) $U_{ut} = U_Z - U_{BE} \rightarrow \underline{\underline{U_{ut} = 5{,}5\ V}}$

$U_{CE} = U_{in} - U_{ut} \Rightarrow \underline{\underline{U_{CE} = 6{,}5\ V}}$

3b) Spänningsfallet mellan plus- och minusingången på OP:n är noll.

$\rightarrow U_{R2} = U_Z$

$$U_{R2} = U_{ut} \cdot \frac{R_2}{R_1 + R_p + R_2}$$

$R_p = 0 \rightarrow$

$$3{,}3 = U_{ut} \cdot \frac{2400}{7500 + 0 + 2400} \Rightarrow U_{ut} \approx 14\ V \quad (13{,}6\ V)$$

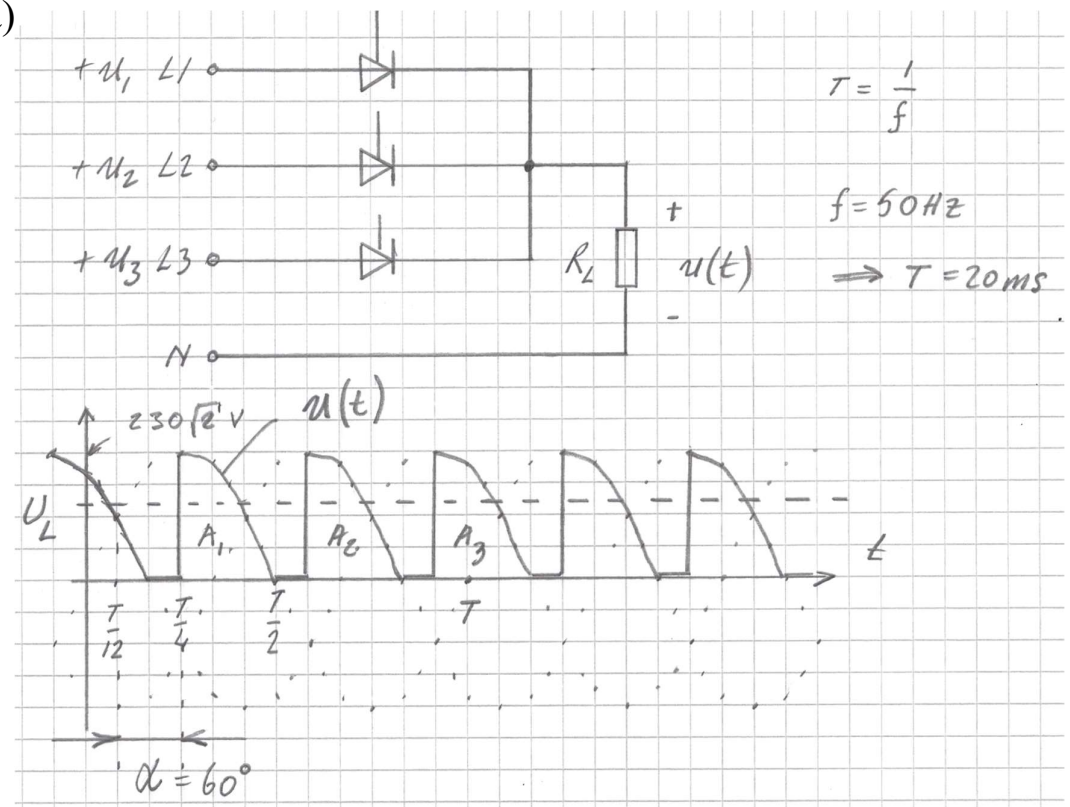
$R_p = 10\ k\Omega \Rightarrow$

$$3{,}3 = U_{ut} \cdot \frac{2400}{7500 + 10000 + 2400} \Rightarrow U_{ut} \approx 27V \quad (27{,}4\ V)$$

ALLTSÅ $\underline{\underline{14V \lesssim U_{ut} \lesssim 27V}}$

3c) $U_{ref} = U_{ut} \cdot \frac{R_1}{R_1 + R_2} \rightarrow \underline{\underline{R_2 \approx 2{,}1\ k\Omega}}$ $(2089{,}8\ \Omega)$

4a)



$$\underline{U_L} = \frac{1}{T}\int_0^T u(t)\,dt = \left| A_1 = A_2 = A_3 \right| =$$

$$= \frac{3}{T}\int_{T/4}^{T/2} u(t)\,dt = \frac{3}{T}\int_{T/4}^{T/2} 230\sqrt{2}\sin(\omega t)\,dt =$$

$$= \left| T = \frac{2\pi}{\omega} \right| = \frac{3\omega}{2\pi}\cdot 230\sqrt{2}\left[\frac{-\cos(\omega t)}{\omega}\right]_{\frac{\pi}{2\omega}}^{\frac{\pi}{\omega}} =$$

$$= 155{,}3\left[-\cos\pi + \cos\frac{\pi}{2}\right] = \underline{155\ V}\ (155{,}3)$$

4b)

$\alpha = 150^\circ \Rightarrow U_L = 0 = U_{L\,MIN}$

$\alpha = 0^\circ \rightarrow U_L = U_{L\,MAX}$

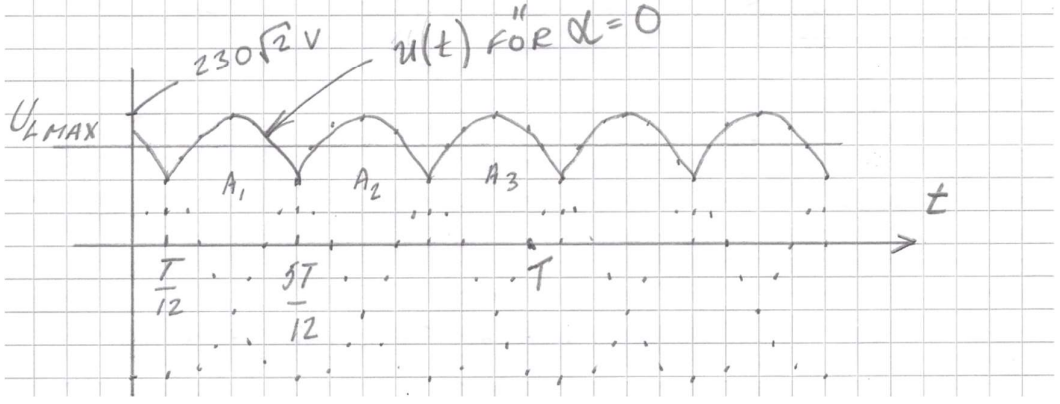
$$U_{L\,MAX} = \frac{1}{T}\int_{5T/12}^{T} u(t)\,dt = \left| A_1 = A_2 = A_3 \right| =$$

$$= \frac{3}{T}\int_{T/12}^{5T/12} u(t)\,dt = \frac{3}{T}\int_{T/12}^{5T/12} 230\sqrt{2}\sin(\omega t)\,dt =$$

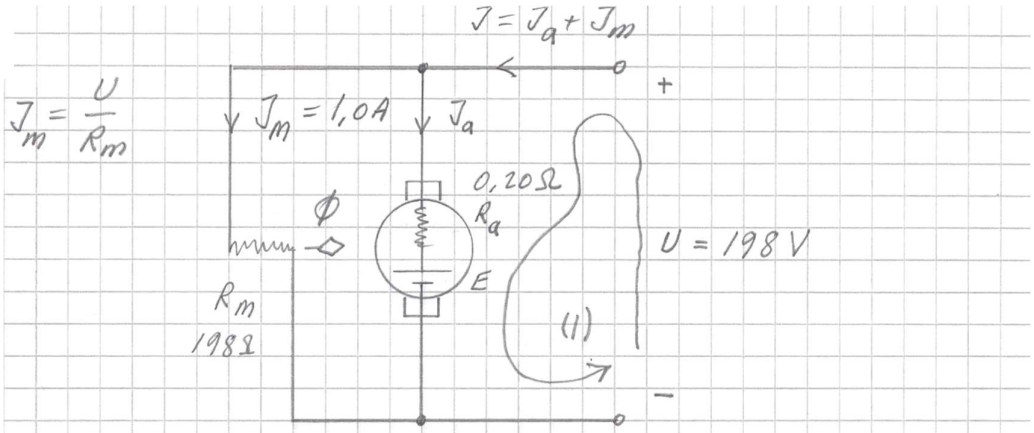
$$= \left| T = \frac{2\pi}{\omega} \right| = \frac{3\omega}{2\pi}\cdot 230\sqrt{2}\left[\frac{-\cos(\omega t)}{\omega}\right]_{\frac{\pi}{6\omega}}^{\frac{5\pi}{6\omega}} =$$

$$= 155{,}3\left[-\cos\frac{5\pi}{6} + \cos\frac{\pi}{6}\right] = 269\ V$$

ALLTSÅ $\underline{0V < U_L < 269\ V}$



5.



FALL I (TOMGÅNG) FALL II (BELASTNING)

$J_{aI} = 4{,}0\,A$ $J_{aII} = 49\,A$

$n_I = 985\,RPM$ $n_{II} = ?$

$\Phi_I = \Phi$ $\Phi_{II} = 0{,}97\,\Phi$

$\eta = ?$

$M_a = ?$

$$+U - R_a J_a - E = 0 \quad \ldots (1)$$

FALL I $\Rightarrow$ $+198 - 0{,}20 \cdot 4{,}0 - E_I = 0 \Rightarrow E_I = 197{,}2\,V$

FALL II $\Rightarrow$ $+198 - 0{,}20 \cdot 49 - E_{II} = 0 \Rightarrow E_{II} = 188{,}2\,V$

$$\frac{E_I}{E_{II}} = \frac{\cancel{k}\,\cancel{\Phi} n_I}{\cancel{k} \cdot 0{,}97 \cancel{\Phi} n_{II}} \Rightarrow \frac{197{,}2}{188{,}2} = \frac{985}{0{,}97\,n_{II}}$$

$$\Rightarrow \underline{\underline{n_{II} = 969\,RPM}}$$

$$\eta = \frac{P_{2a}}{P_1} = \frac{P_1 - P_F}{P_1} \quad \ldots (2)$$

P_1 = TILLFÖRD EFFEKT

P_{2a} = AVGIVEN EFFEKT PÅ UTGÅENDE MOTORAXEL

P_F = FÖRLUSTER

$P_F = P_{FM} + P_{FB} + P_{FO}$ ... (3)

P_{FM} = FÖRLUST I MAGNETISERINGSLINDNINGEN

P_{FB} = BELASTNINGSFÖRLUST I ANKARET

P_{FO} = FRIKTION OCH VENTILATION

$P_1 = U J_{II} \rightarrow P_1 = 198 \cdot 50 = 9900\,W$

$P_{FM} = R_m \cdot J_m^2 \rightarrow P_{FM} = 198\,W$

$P_{FB} = R_a \cdot J_{aII}^2 \rightarrow P_{FB} = 0,20 \cdot 49^2 = 480,2\,W$

$P_{FO} = E_I \cdot J_{aI} \Rightarrow P_{FO} = 197,2 \cdot 4,0 = 788,8\,W$

$(3) \Rightarrow P_F = 1467\,W$

$(2) \Rightarrow \underline{\eta = 0,85\ (85\%)}$

$P_{2a} = M_a \cdot \frac{2\pi n_{II}}{60}$ .... (4)

$P_{2a} = P_1 - P_F \rightarrow P_{2a} = 8433\,W$

$(4) \Rightarrow 8433 = M_a \cdot \frac{2\pi \cdot 969}{60}$

$\Rightarrow \underline{M_a = 83\,Nm}$