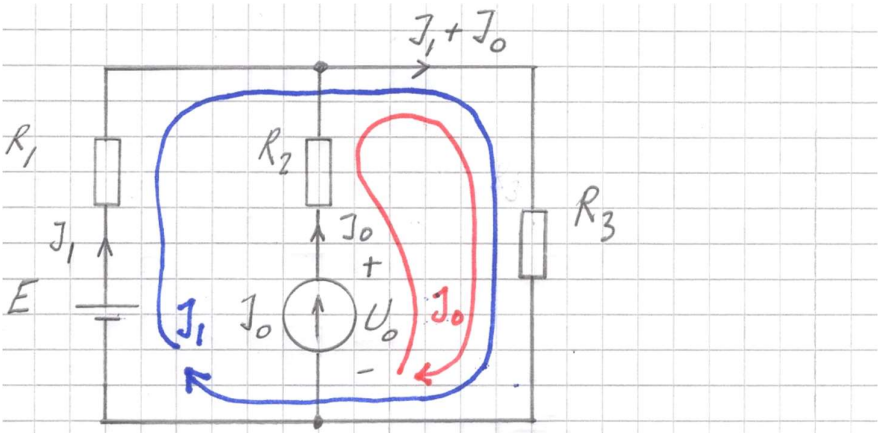
Lösningsförslag till tentamen TSFS13 Elektroteknik 2024-08-21

1.



$$+E - R_1 J_1 - R_3 (J_1 + J_0) = 0 \quad \ldots (1)$$

$$+U_0 - R_2 J_0 - R_3 (J_1 + J_0) = 0 \quad \ldots (2)$$

$(1) \rightarrow J_1 = 0$

INSÄTT $(2) \rightarrow \underline{U_0 = 20\ \text{V}}$

2a) OM KONDENSATORN ÄR BORTKOPPLAD

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

$$\underline{I} = \frac{230\sqrt{2} \cdot e^{j0^\circ}}{24 + j100\pi \cdot 0{,}10} \approx 5{,}8\sqrt{2}\, e^{-j53^\circ} \text{ A}$$

$$\underline{i(t) = 5{,}8\sqrt{2}\sin(100\pi t - 53^\circ) \text{ A}}$$

$$P = R \cdot I^2 \rightarrow P = 24 \cdot 5{,}8^2 \approx \underline{0{,}81 \text{ kW}}$$

$$Q = Q_L = \omega L \cdot I^2 \rightarrow Q = 100\pi \cdot 0{,}10 \cdot 5{,}8^2 \approx \underline{1{,}1 \text{ kVAr}}$$

2b) OM KONDENSATORN ÄR INKOPPLAD

$Q = Q_L - Q_C$ DÅ ÄR

$Q_C = \frac{U^2}{X_C} = / X_C = \frac{1}{\omega C} / = \omega C U^2$

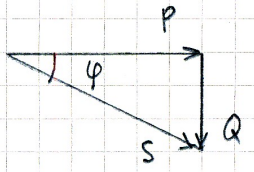
$Q_C = 314 \cdot 150 \cdot 10^{-6} \cdot 230^2 = 2{,}5$ kVAr

$Q = 1{,}1 - 2{,}5 \approx \underline{-1{,}4 \text{ kVAr}}$

STRÖMMEN GENOM R OCH L PÅVERKAS INTE OM C KOPPLAS IN DVS. P ÄR DENSAMMA SOM FÖRUT.

$\underline{P = 0{,}81 \text{ kW}}$

SKENBARA EFFEKTEN



$S = \sqrt{P^2 + Q^2} \Rightarrow S \approx 1{,}6$ kVA

$S = U \cdot J \Rightarrow 1{,}6 \cdot 10^3 = 230 \cdot J \rightarrow J = 7{,}0$ A

$\tan\varphi = \frac{Q}{P} \rightarrow \varphi \approx -60°$

$\varphi = \arg \mathcal{U} - \arg \mathcal{I} \quad -60° = 0° - \arg \mathcal{I}$

$\rightarrow \arg \mathcal{I} = 60°$

ALLTSÅ $\underline{i(t) \approx 7{,}0\sqrt{2}\sin(100\pi t + 60°) \text{ A}}$

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.

$\rightarrow U_{R2} = U_z$

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

$R_p = 0 \rightarrow$

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

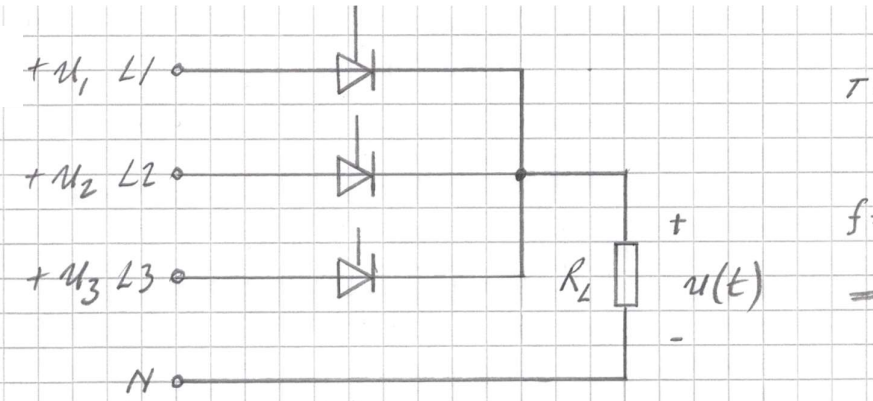
$R_p = 10\ k\Omega \Rightarrow$

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

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

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

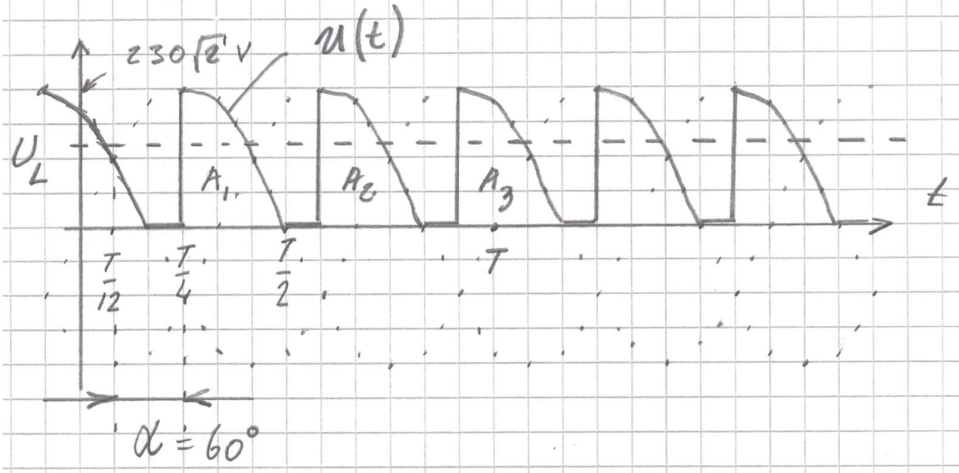
4a)



$T = \frac{1}{f}$

$f = 50\,Hz$

$\Rightarrow T = 20\,ms$



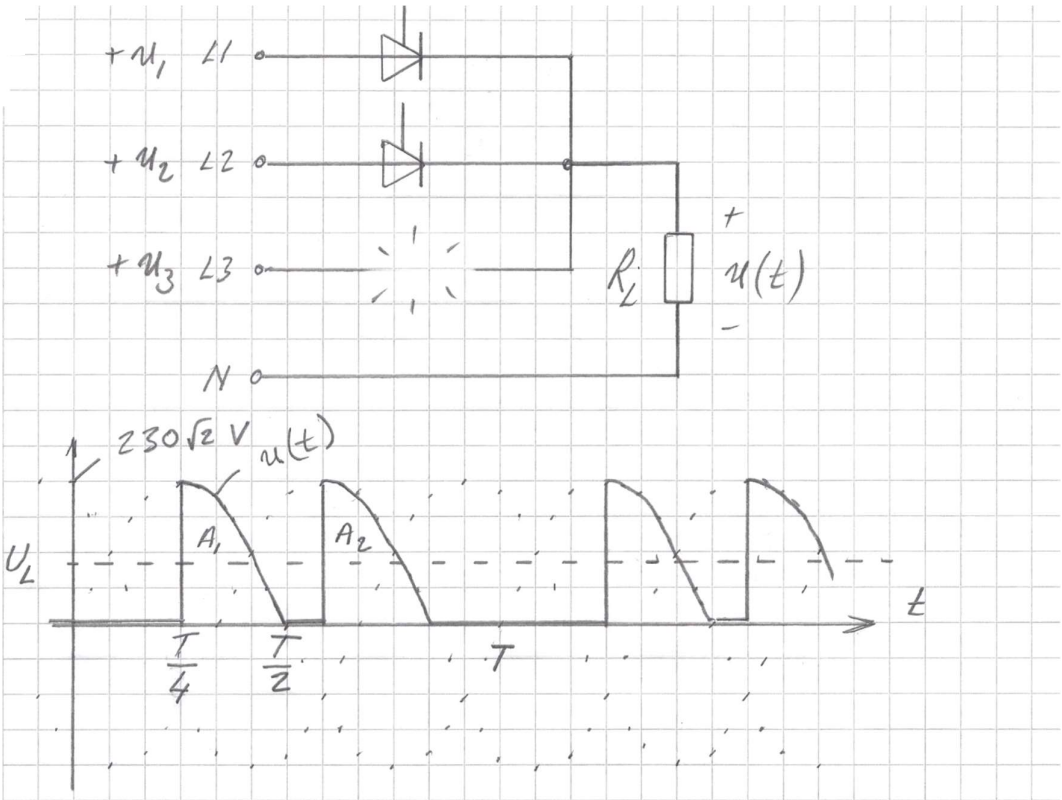
$$\underline{U_L} = \frac{1}{T}\int_0^T u(t)\,dt = \left| A_1 = A_2 = A_3 \right| =$$

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

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

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

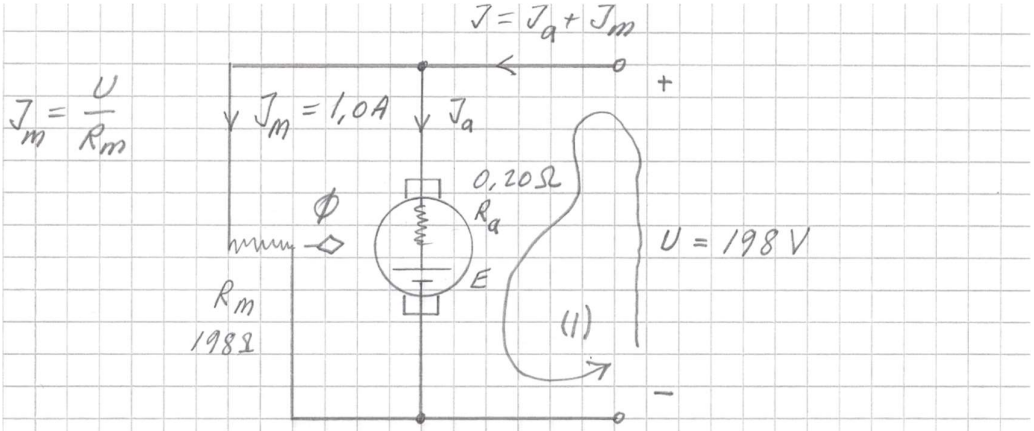
4b)



$$U_L = \frac{1}{T}\int_0^T u(t)\,dt = |A_1 = A_2| = \frac{2}{T}\int_{T/4}^{T/2} u(t)\,dt =$$

$$= \ldots \approx 104\ \text{V} \quad (103{,}5)$$

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)

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

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

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