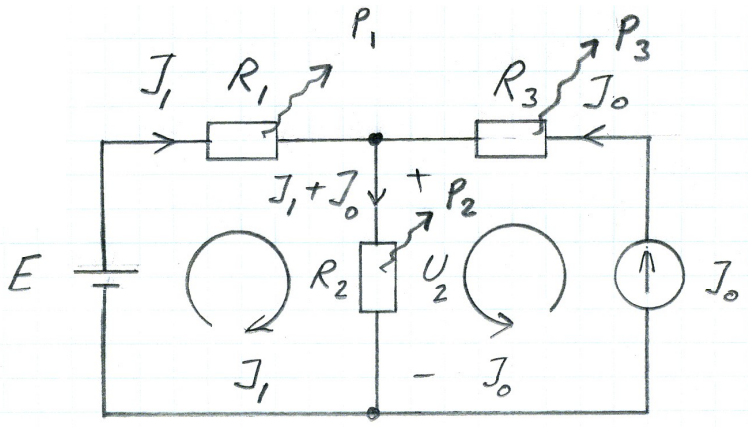
Lösningsförslag till tentamen TSFS13 Elektroteknik 2025-01-08

1. *Lösning med slinganalys*



a) $+E - R_1 J_1 - R_2 (J_1 + J_0) = 0 \rightarrow$

$+15 - 3{,}0 J_1 - 3{,}0 (J_1 + 1{,}0) = 0 \rightarrow J_1 = 2{,}0\ A$

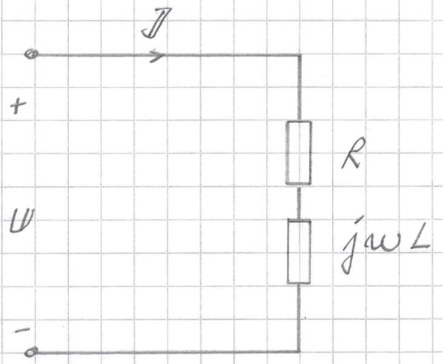
$U_2 = R_2 (J_1 + J_0) \rightarrow \underline{U_2 = 9{,}0\ V}$

b) $P_1 = R_1 \cdot J_1^{\,2} \rightarrow \underline{P_1 = 12\ W}$

$P_2 = R_2 \cdot (J_1 + J_0)^2 \rightarrow \underline{P_2 = 27\ W}$

$P_3 = R_3 J_0^{\,2} \rightarrow \underline{P_3 = 3{,}0\ W}$

2a)



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

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

$$\underline{J} = \frac{230\sqrt{2}\,e^{j0°}}{24{,}0 + j100\pi \cdot 0{,}0573} =$$

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

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

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 :

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

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

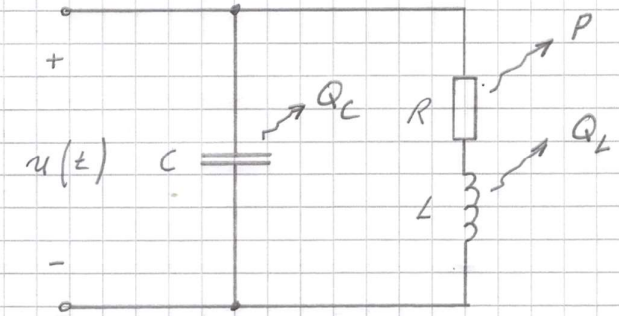
$0° \quad -37°$

$S = U \cdot I$

$\uparrow \quad \uparrow$

230V 7,67 A

2c)



$Q = Q_L - Q_C$

$Q = 0 \Rightarrow Q_C = Q_L$

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

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

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

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

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

3a) $U_{ut} = U_Z - U_{BE} \Rightarrow \underline{\underline{U_{ut} = 4{,}9\ V}}$

$U_{CE} = U_{in} - U_{ut} \Rightarrow \underline{\underline{U_{CE} = 7{,}1\ V}}$

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

$\Rightarrow U_{R2} = U_Z$

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

$R_p = 0 \Rightarrow$

$$5{,}6 = U_{ut} \cdot \frac{2400}{7500 + 0 + 2400} \Rightarrow U_{ut} \approx 23\ V$$

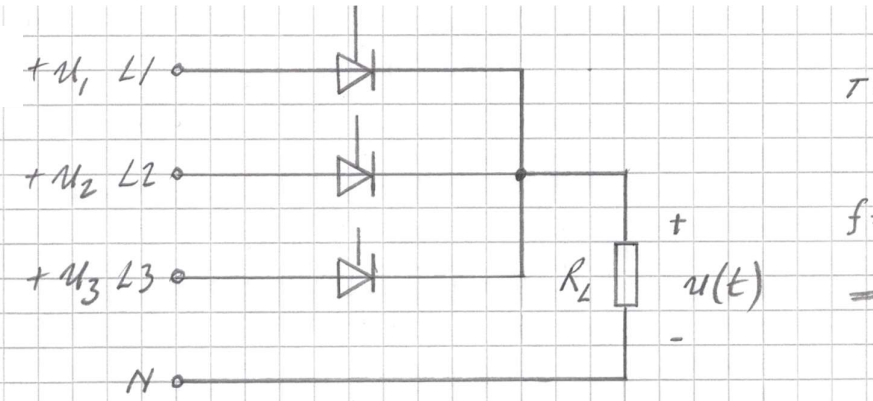
$R_p = 10\ k\Omega \Rightarrow$

$$5{,}6 = U_{ut} \cdot \frac{2400}{7500 + 10000 + 2400} \Rightarrow U_{ut} \approx 46\ V$$

ALLTSÅ $\underline{\underline{23\ V \lesssim U_{ut} \lesssim 46\ V}}$

3c) $U_{ref} = U_{ut} \cdot \frac{R_1}{R_1 + R_2} \Rightarrow \underline{\underline{R_2 \approx 2{,}7\ k\Omega}}$

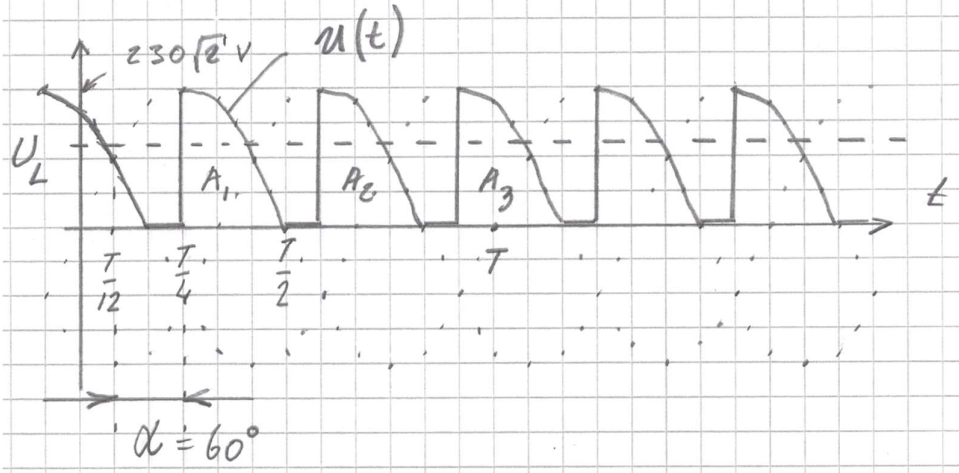
4a)



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

$f = 50\,Hz$

$\Rightarrow T = 20\,ms$



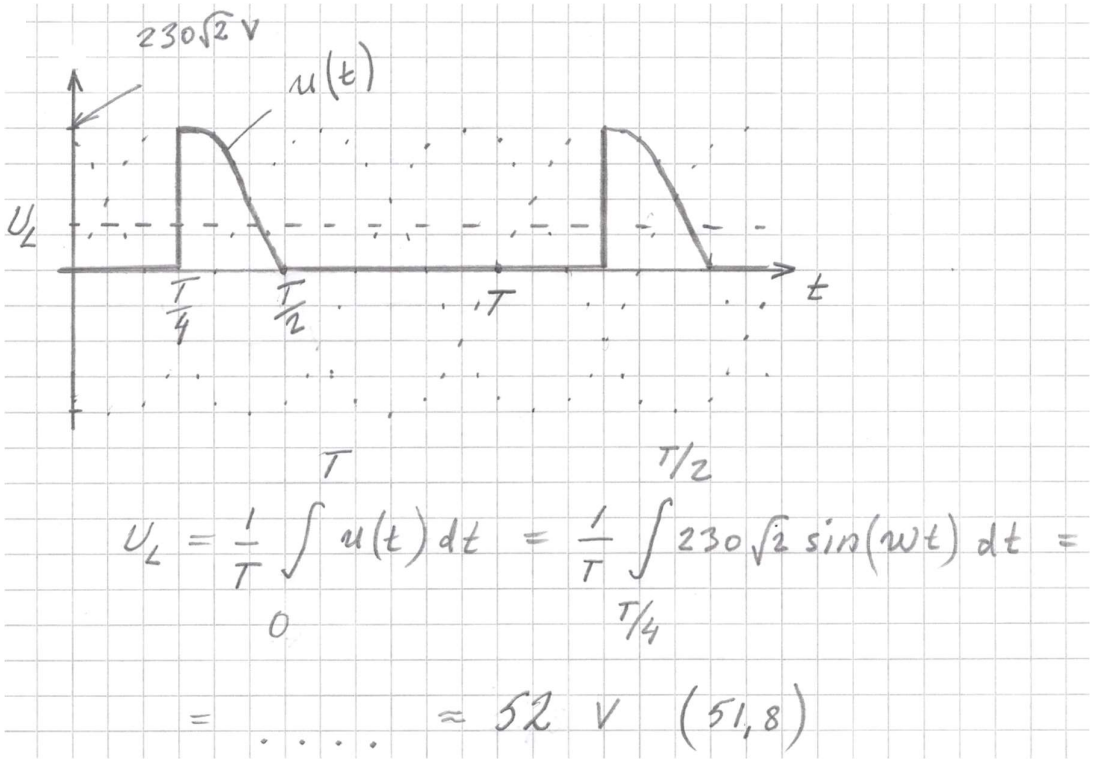
$$\underline{U_L} = \frac{1}{T}\int_0^T u(t)\,dt = \left| A_1 = A_2 = A_3 \right| =$$

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

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

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

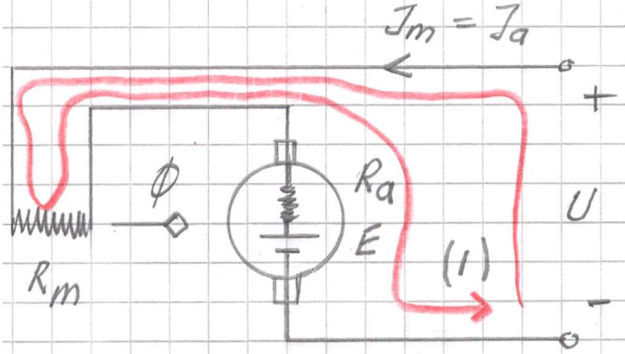
4b)



$$U_L = \frac{1}{T}\int_0^T u(t)\,dt = \frac{1}{T}\int_{T/4}^{T/2} 230\sqrt{2}\sin(\omega t)\,dt =$$

$$= \ldots\ldots \approx 52\ V \quad (51{,}8)$$

5. SERIEMOTOR



MAGNETISKT OMÄTTAD → $\Phi = k_3 I_m = k_3 I_a$

FALL I	FALL II
$U_I = 220\,V$	$U_{II} = 220\,V$
$M_I = M$	$M_{II} = 4M$
$n_I = 1000\,RPM$	$n_{II} = ?$
$I_{aI} = 100\,A$	$I_{aII} = ?$

$$\frac{M_I}{M_{II}} = \frac{k_2 I_{aI} \Phi_I}{k_2 I_{aII} \Phi_{II}}$$

$$\frac{M_I}{M_{II}} = \frac{k_2 I_{aI} \cdot k_3 I_{aI}}{k_2 I_{aII} \cdot k_3 I_{aII}}$$

$$\frac{M}{4M} = \frac{\cancel{k_2 k_3} I_{aI}^2}{\cancel{k_2 k_3} I_{aII}^2} \rightarrow I_{aII} = 200\,A$$

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

FALL I $\Rightarrow$ $+220 - 0{,}050 \cdot 100 - 0{,}050 \cdot 100 - E_I = 0$

FALL II $\Rightarrow$ $+220 - 0{,}050 \cdot 200 - 0{,}050 \cdot 200 - E_{II} = 0$

$\Longrightarrow$ $E_I = 210\ V$ $\quad E_{II} = 200\ V$

$$\frac{E_I}{E_{II}} = \frac{k_1 \Phi_I n_I}{k_1 \Phi_{II} n_{II}}$$

$$\frac{E_I}{E_{II}} = \frac{\cancel{k_1 k_2} J_{aI} n_I}{\cancel{k_1 k_2} J_{aII} n_{II}} \Rightarrow \underline{\underline{n_{II} = 476\ RPM}}$$