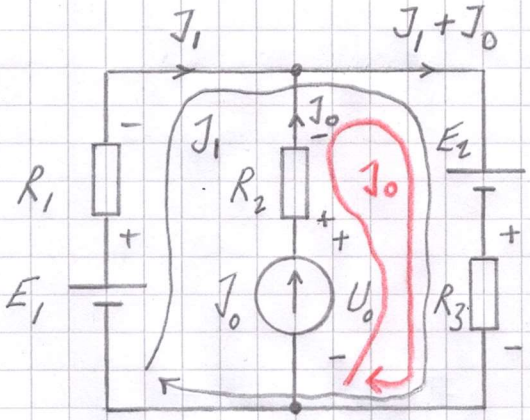
Lösningsförslag till tentamen TMEL08 Eltekniska system 2024-10-28

1.

ANVÄND EXEMPELVIS SLINGANALYS:



$$+E_1 - R_1 J_1 - E_2 - R_3(J_1 + J_0) = 0 \quad \ldots (1)$$

$$+U_0 - R_2 J_0 - E_2 - R_3(J_1 + J_0) = 0 \quad \ldots (2)$$

$$+25 - 1000\,J_1 - 10 - 1000(J_1 + 0{,}005) = 0 \quad \ldots (1)$$

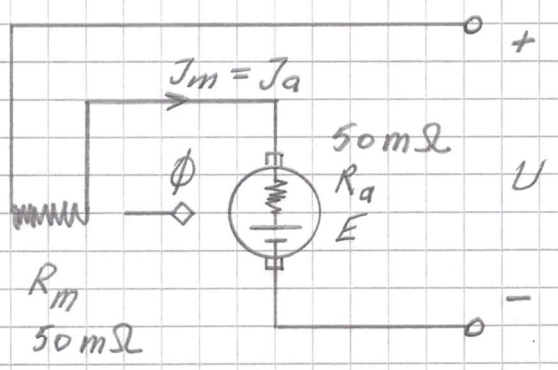
$$+U_0 - 1000 \cdot 0{,}005 - 10 - 1000(J_1 + 0{,}005) = 0 \quad \ldots (2)$$

$$(1) \rightarrow J_1 = 0{,}005 \text{ A}$$

$$(2) \Rightarrow \underline{U_0 = 25 \text{ V}}$$

2.

SERIEMOTOR



MAGNETISKT OMÄTTAD

$$\Rightarrow \phi = k I_m = k I_a$$

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

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

$$\frac{M}{4M} = \frac{k_2 \cdot k I_{aI} \cdot I_{aI}}{k_2 \cdot k I_{aII} \cdot I_{aII}}$$

$$\frac{1}{4} = \frac{I_{aI}^2}{I_{aII}^2} \Rightarrow \underline{I_{aII} = 200\,A}$$

KIRCHHOFFS SPANNINGSLAG

FALL I $\Rightarrow + U_I - R_m J_{aI} - R_a J_{aI} - E_I = 0$

FALL II $\Rightarrow + U_{II} - R_m J_{aII} - R_a J_{aII} - E_{II} = 0$

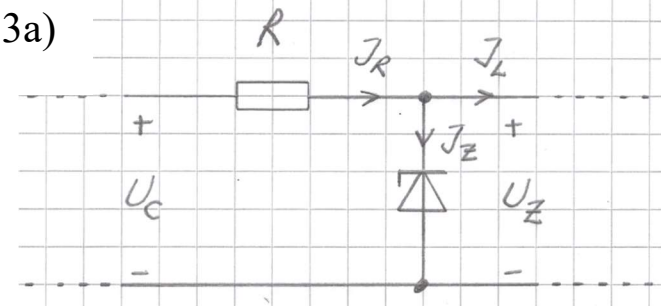
$\Rightarrow \quad E_I = 210\,V \qquad E_{II} = 200\,V$

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

$$\frac{E_I}{E_{II}} = \frac{k_1 k J_{aI} n_I}{k_1 k J_{aII} n_{II}}$$

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

3a)



$$R = \frac{U_C - U_Z}{J_R} \qquad \text{"DÄR"} \quad J_R = J_Z + J_L$$

$$R_{MIN} = \frac{U_C - U_Z}{J_{R_{MAX}}} \qquad J_{R_{MAX}} = J_{Z_{MAX}} \quad \text{"DÅ"} \; J_L = 0 \; (R_L \text{ BORTKOPPLAD})$$

$$P_{Z_{MAX}} = U_Z \, J_{Z_{MAX}} \Rightarrow J_{Z_{MAX}} = 0{,}833 \text{ A}$$

$P_{Z_{MAX}}$: ↑ 10 W; U_Z: ↑ 12 V

$$\Rightarrow R_{MIN} = \frac{32 - 12}{0{,}833} = 24 \; \Omega$$

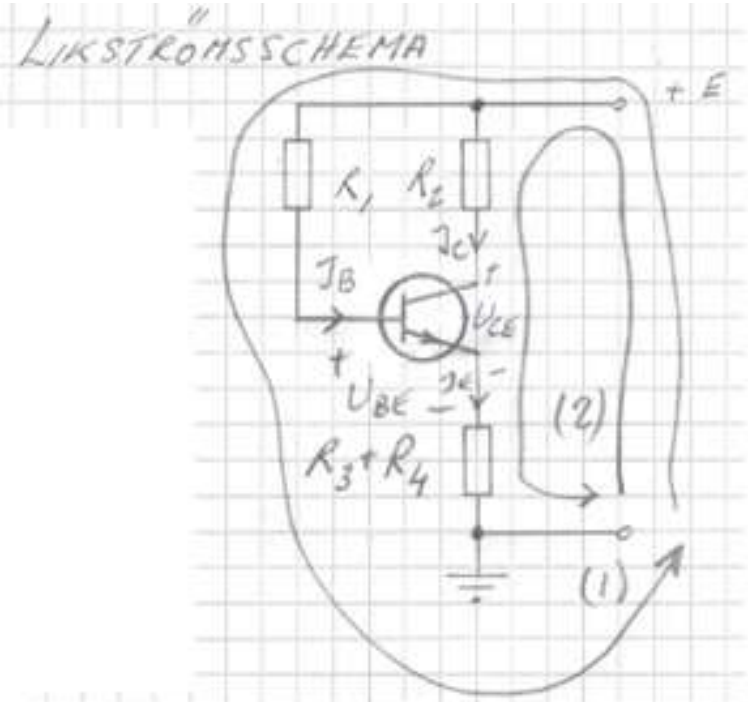
$$R_{MAX} = \frac{U_C - U_Z}{J_{R_{MIN}}} \qquad J_{R_{MIN}} = J_{Z_{MIN}} + J_{L_{MAX}}$$

$J_{Z_{MIN}}$: ↑ 100 mA; $J_{L_{MAX}}$: ↑ 500 mA

$$\Rightarrow R_{MAX} = \frac{32 - 12}{0{,}600} = 33 \; \Omega$$

ALLTSÅ "VÄLJ" $\underline{24 \; \Omega < R < 33 \; \Omega}$

3b)



$$h_{FE} = \frac{I_C}{I_B} \Rightarrow I_B = 20\,\mu A$$

$$I_E = I_B + I_C \rightarrow I_E = 4020\,\mu A$$

$$+E - R_1 I_B - U_{BE} - (R_3 + R_4) I_E = 0 \ldots (1)$$

$$(1) \rightarrow R_1 \approx 0{,}49\,M\Omega$$

$$+E - R_2 I_C - U_{CE} - (R_3 + R_4) I_E = 0 \ldots (2)$$

$$(2) \rightarrow U_{CE} = 6{,}4\,V$$

4a)

$$\frac{N_1}{N_2} = \frac{\hat{U}_1}{\hat{U}_2}$$

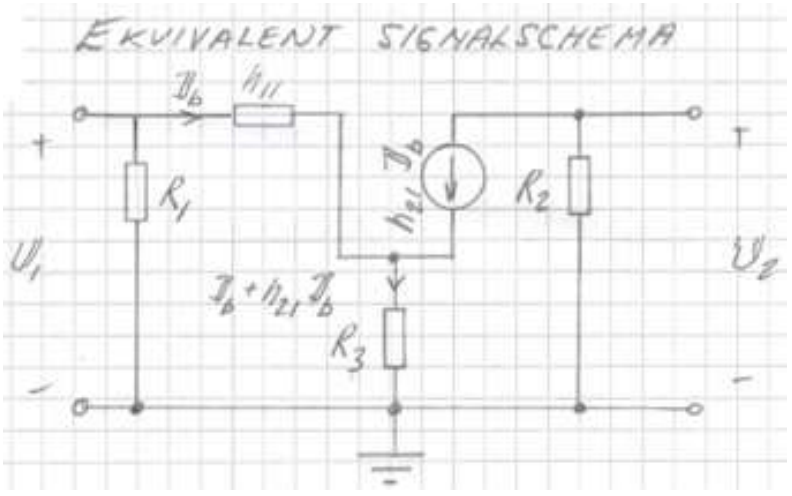
$$\hat{U}_2 = U_C + 2 \cdot U_{D100} = 33{,}4\ V$$

U_C: $32\ V$, U_{D100}: $0{,}70\ V$

$$\hat{U}_1 = 230\sqrt{2}\ V \Rightarrow$$

$$\frac{N_1}{N_2} = \frac{230\sqrt{2}}{33{,}4} \approx 9{,}7$$

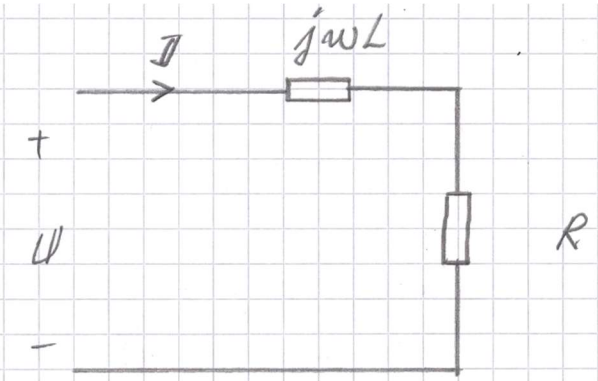
4b)



$$A = \frac{U_2}{U_1} = \frac{-h_{21} I_b R_2}{R_3 (I_b + h_{21} I_b) + h_{11} I_b}$$

$|A| = 50 \Rightarrow R_3 = 10\ \Omega \Rightarrow R_4 = 380\ \Omega$

5a)



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

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

$$\underline{I} = \frac{230\sqrt{2}\,e^{j0°}}{24{,}0 + j\,100\pi \cdot 0{,}0573} =$$

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

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

5b)

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

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

(Q_L)

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

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

ALTERNATIVT SÄTT ATT RÄKNA:

$P = U \cdot J \cdot \cos\varphi$

$(Q_L)\quad Q = U \cdot J \cdot \sin\varphi$

$S = U \cdot J$

$\varphi = \arg U - \arg J = 37°$

$\uparrow \quad \uparrow$

$0° \quad -37°$

$U = \frac{\hat{U}}{\sqrt{2}} = 230\ V$

5c)

$Q = Q_L - Q_C$

$Q = 0 \rightarrow Q_C = Q_L$

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

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

5d)

$Q = 0 \rightarrow S = P$ OCH $\cos\varphi = 1 \rightarrow \varphi = 0°$

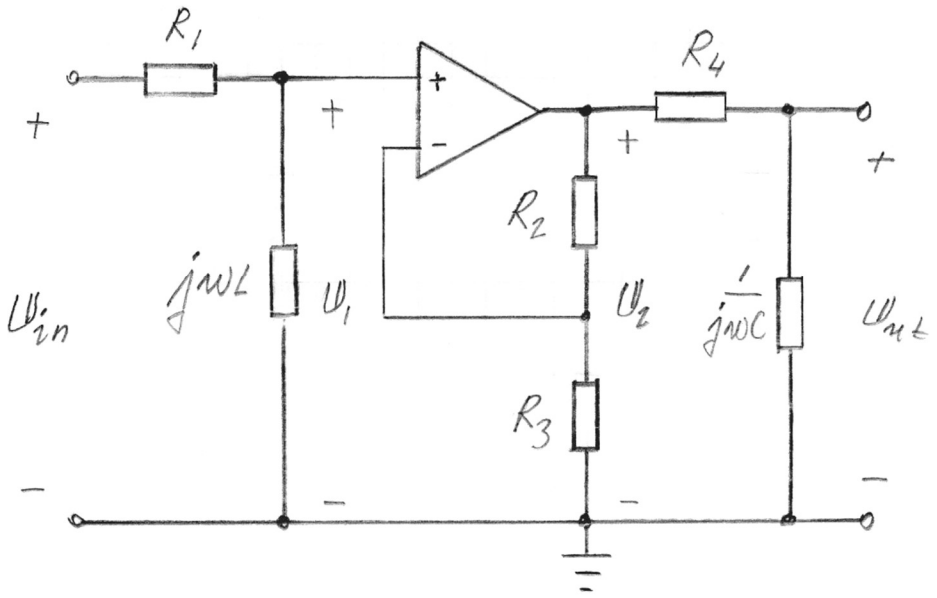
$S = U \cdot J \rightarrow 1{,}41 \cdot 10^3 = 230 \cdot J$

$\rightarrow J = 6{,}13\ A \quad \hat{J} = 6{,}13\sqrt{2}\ A$

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

($\varphi = 0°$ INNEBÄR ATT $\arg J = \arg U$)

6.



$$\frac{U_{out}}{U_{in}} = \frac{U_{out}}{U_2} \cdot \frac{U_2}{U_1} \cdot \frac{U_1}{U_{in}}$$

$$\frac{U_{out}}{U_2} = \frac{\frac{1}{jwC}}{\frac{1}{jwC} + R_4} = \frac{1}{1 + jwCR_4}$$

$$\frac{U_2}{U_1} = \frac{R_2 + R_3}{R_3}$$

$$\frac{U_1}{U_{in}} = \frac{jwL}{R_1 + jwL} = \frac{jw \cdot \frac{L}{R_1}}{1 + jw \cdot \frac{L}{R_1}}$$

$$\Rightarrow \quad \frac{U_{out}}{U_{in}} = \frac{j\frac{w}{100}}{1 + j\frac{w}{100}} \cdot 2{,}5 \cdot \frac{1}{1 + j\frac{w}{10000}}$$

$$\left|\frac{U_{ut}}{U_{in}}\right| = 2{,}5 \cdot \frac{\frac{w}{100}}{\sqrt{1^2+\left(\frac{w}{100}\right)^2}\sqrt{1^2+\left(\frac{w}{10000}\right)^2}}$$

$$w << 100\ \frac{RAD}{s} \rightarrow \left|\frac{U_{ut}}{U_{in}}\right| \approx 2{,}5 \cdot \frac{w}{100}$$

$$100\ \frac{RAD}{s} << w << 10000\ \frac{RAD}{s} \rightarrow \left|\frac{U_{ut}}{U_{in}}\right| \approx 2{,}5$$

$$w >> 10000\ \frac{RAD}{s} \Rightarrow \left|\frac{U_{ut}}{U_{in}}\right| \approx 2{,}5 \cdot \frac{10000}{w}$$

BODEDIAGRAM (AMPLITUDKURVA)