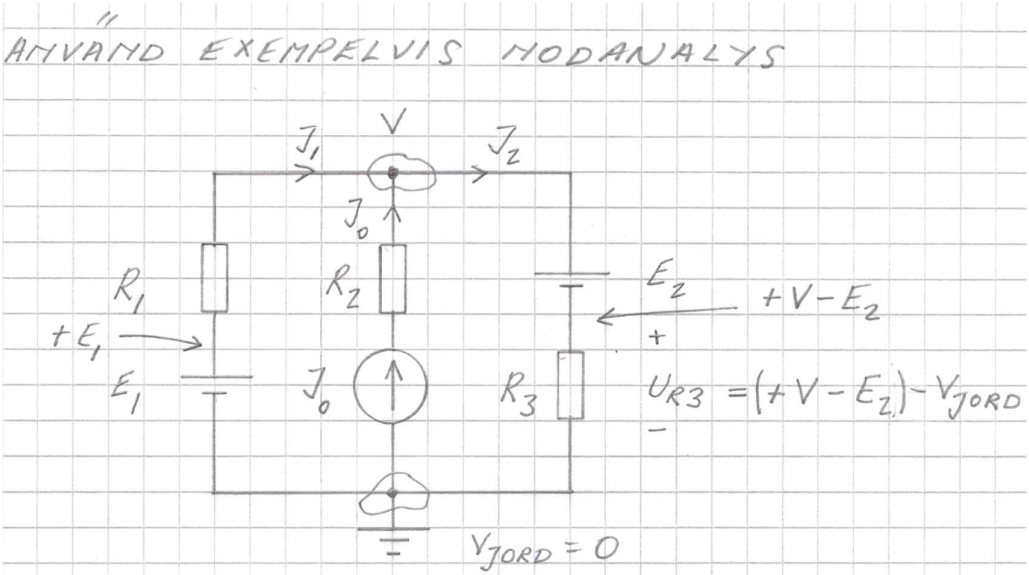
Lösningsförslag till tentamen TMEL08 Eltekniska system 2025-10-27

1. ANVÄND EXEMPELVIS NODANALYS



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

$$\frac{E_1 - V}{R_1} + J_0 - \frac{(V-E_2) - 0}{R_3} = 0$$

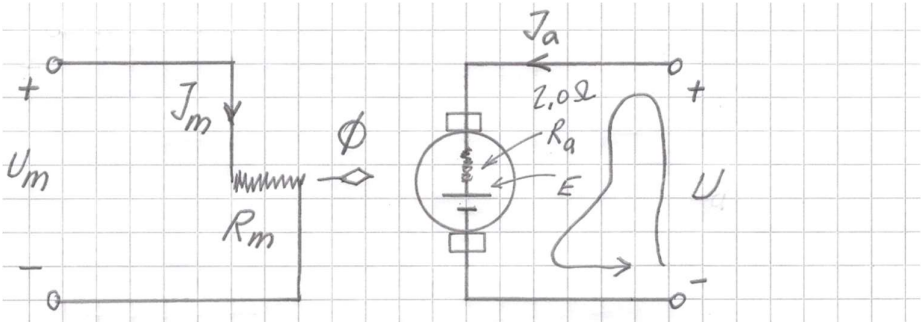
$$\frac{25 - V}{1000} + 0{,}005 - \frac{V - 10}{1000} = 0$$

$$25 - V + 5 - V + 10 = 0$$

$$V = +20\ V$$

ALLTSÅ $U_{R3} = (+20 - 10) - 0 = \underline{10\ V}$

2. Separatmagnetiserad likströmsmotor



FALL I

$U_I = 200\ V$

$J_{aI} = 10\ A$

$E_I = ?$

$n_I = 1000\ RPM$

FALL II

$U_{II} = 170\ V$

$J_{aII} = ?$

$E_{II} = ?$

$n_{II} = ?$

SAMMA MOMENT OCH MAGNETISKT FLÖDE I DE TVÅ FALLEN.

a) $M = k_2 \Phi J_{aI}$ } $\Rightarrow J_{aII} = J_{aI} = \underline{10A}$

$M = k_2 \Phi J_{aII}$ }

b) KIRCHHOFFS SPÄNNINGSLAG →

$+U_I - R_a J_{aI} - E_I = 0 \rightarrow E_I = \underline{180\ V}$

$+U_{II} - R_a J_{aII} - E_{II} = 0 \rightarrow E_{II} = \underline{150\ V}$

c) $\frac{E_I}{E_{II}} = \frac{k_1 \Phi n_I}{k_1 \Phi n_{II}} \rightarrow n_{II} = \underline{833\ RPM}$

3a)

"ÖVRE LÄGET" ⇒

$$U_z = U_{ut} \cdot \frac{R_3 + R_4}{R_2 + R_3 + R_4}$$

$$5{,}6 = 6{,}6 \cdot \frac{R_3 + R_4}{30000 + R_3 + R_4} \rightarrow$$

$$R_3 + R_4 = 168000\ \Omega$$

"NEDRE LÄGET" ⇒

$$U_z = U_{ut} \cdot \frac{R_4}{R_2 + R_3 + R_4}$$

$$5{,}6 = 13{,}2 \cdot \frac{R_4}{30000 + 168000} \rightarrow$$

$$R_4 = 84\ \text{k}\Omega \rightarrow R_3 = 84\ \text{k}\Omega$$

SPÄNNINGEN "AR NOLL MELLAN PLUS- OCH MINUSINGÅNGEN PÅ OPERATIONSFÖRSTÄRKAREN."

3b) $U_{OP} - U_{BE} = U_{ut} \rightarrow U_{OP} = U_{ut} + U_{BE}$

$U_{BE} \approx 0{,}70\ V$

$U_{ut} = 6{,}6\ V \rightarrow U_{OP} = 7{,}3\ V$

$U_{ut} = 13{,}2\ V \rightarrow U_{OP} = 13{,}9\ V$

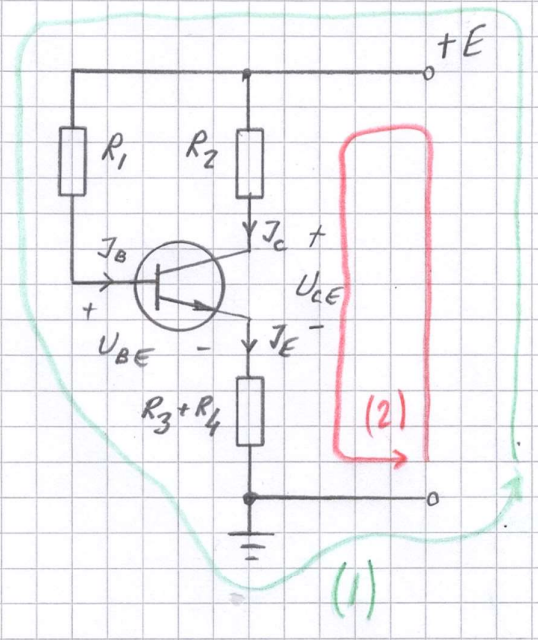
3c) $J_{R1} = J_Z$ TY STRÖMMEN IN TILL OP'NS PLUSINGÅNG ÄR NOLL.

$$R_1 = \frac{U_{R1}}{J_{R1}} = \frac{U_{in} - U_Z}{J_Z}$$

$$R_1 = \frac{15 - 5{,}6}{0{,}030} = 313\ \Omega$$

VÄLJ R_1 STRAX UNDER $313\ \Omega$

3d) LIKSTRÖMSSCHEMA



$I_C = h_{FE} \cdot I_B$

$I_E = I_B + I_C = (1 + h_{FE})\, I_B$

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

$\Rightarrow I_B = 39{,}8\ \mu A \qquad I_C = 8{,}0\ mA \ (7{,}96) \qquad I_E = 8{,}0\ mA \ (8{,}00)$

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

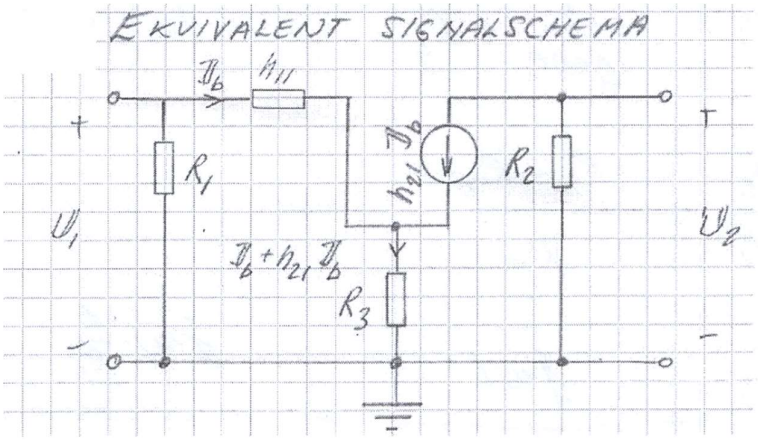
$\rightarrow U_{CE} \approx 9{,}1\ V$

4a)

$$\frac{N_1}{N_2} = \frac{\hat{U}_1}{\hat{U}_2} \quad \text{DÄR} \quad \hat{U}_2 = U_C + 2 \cdot 0{,}70 \text{ V}$$

$$\Rightarrow \quad \frac{N_1}{N_2} = \frac{230\sqrt{2}}{15 + 1{,}4} \approx 20 \; (19{,}8)$$

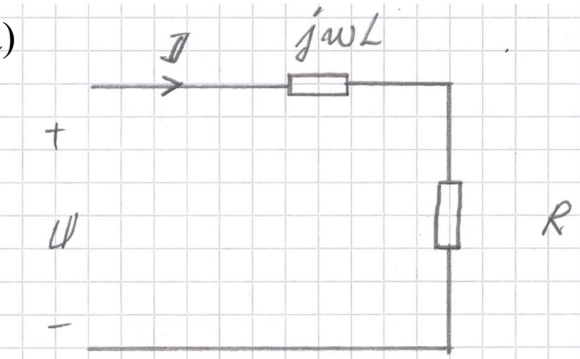
4b)



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

$$|A| = 50 \Rightarrow R_3 = 20\ \Omega \Rightarrow R_4 \approx 0{,}36\ \text{k}\Omega$$

5a)



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

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

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

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

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

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:

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

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

$S = U \cdot J$

$\varphi = \arg \underline{U} - \arg \underline{J} = 37°$

$\uparrow \quad \uparrow$

$0° \quad -37°$

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

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 $\cos\varphi = 1 \rightarrow \varphi = 0°$

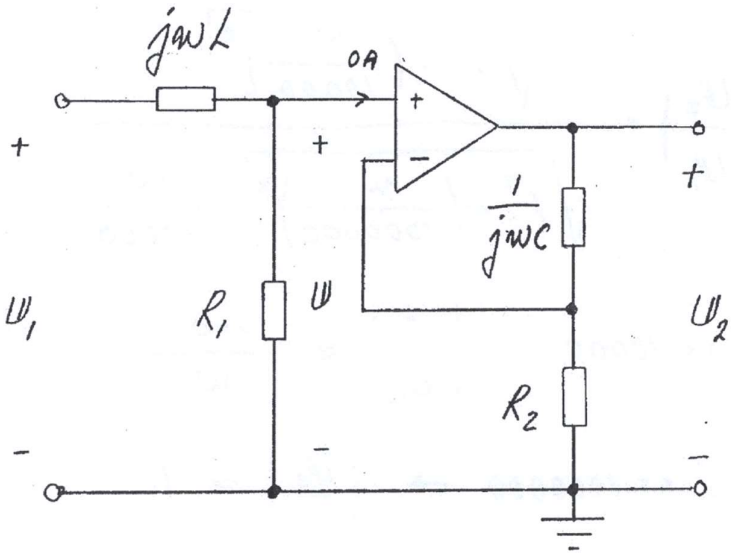
$S = U \cdot J \rightarrow 1{,}41 \cdot 10^3 = 230 \cdot J$

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

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

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

6.



$$U = U_1 \cdot \frac{R_1}{R_1 + j\omega L} = U_1 \cdot \frac{1}{1 + j\omega \frac{L}{R_1}} \quad \ldots (1)$$

$$U_2 = U \cdot \frac{\frac{1}{j\omega C} + R_2}{R_2} = U \cdot \frac{1 + j\omega C R_2}{j\omega C R_2} \quad \ldots (2)$$

(1) ΚΑΙ (2) $\Rightarrow$

$$\frac{U_2}{U_1} = \frac{1 + j\omega C R_2}{\left(1 + j\omega \frac{L}{R_1}\right) j\omega C R_2} \Rightarrow$$

$$\left|\frac{U_2}{U_1}\right| = \frac{\sqrt{1^2 + (\omega C R_2)^2}}{\sqrt{1^2 + \left(\omega \cdot \frac{L}{R_1}\right)^2} \cdot \omega C R_2} \Rightarrow$$

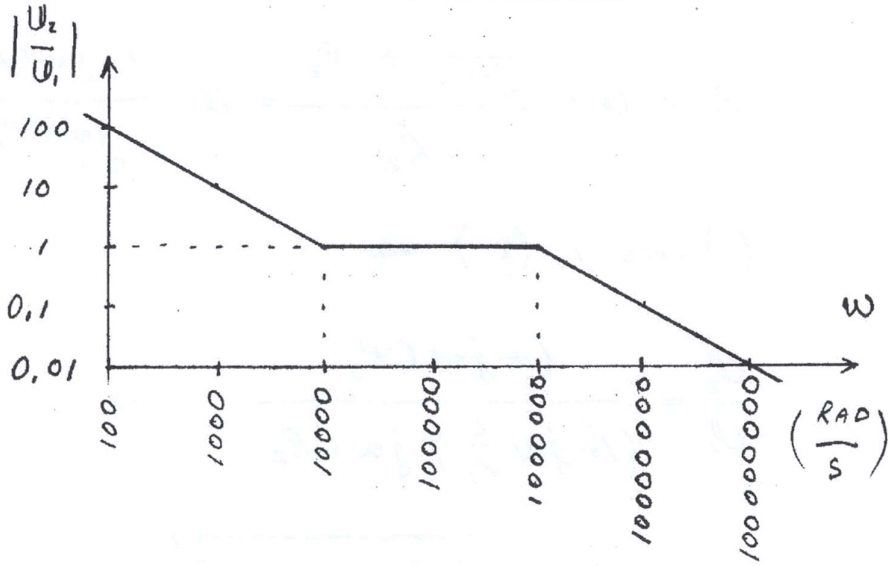
$$\left|\frac{U_2}{U_1}\right| = \frac{\sqrt{1^2 + \left(\frac{w}{10000}\right)^2}}{\sqrt{1^2 + \left(\frac{w}{1000000}\right)^2} \cdot \frac{w}{10000}}$$

$$w << 10000 \rightarrow \left|\frac{U_2}{U_1}\right| \approx \frac{10000}{w}$$

$$10000 << w << 1000000 \rightarrow \left|\frac{U_2}{U_1}\right| \approx 1$$

$$w >> 1000000 \rightarrow \left|\frac{U_2}{U_1}\right| \approx \frac{1000000}{w}$$

AMPLITUDKURVAN:



$$\arg U_2 - \arg U_1 = \arg\left(\frac{U_2}{U_1}\right) =$$

$$= \arg\left(\frac{1+jwCR_2}{\left(1+jw\frac{L}{R_1}\right)jwCR_2}\right) =$$

$$= \underbrace{\arg\left(1+jwCR_2\right)}_{\arctan(wCR_2)} - \underbrace{\arg\left(1+jw\cdot\frac{L}{R_1}\right)}_{\arctan\left(\frac{wL}{R_1}\right)} - \underbrace{\arg\left(jwCR_2\right)}_{90^\circ}$$

$w\ (^{RAD}/_{S})$	$\arg U_2 - \arg U_1$
100	-89°
1000	-84°
10000	-46°
100000	-11°
1000000	-46°
10000000	-84°
100000000	-89°

FASKURVAN: