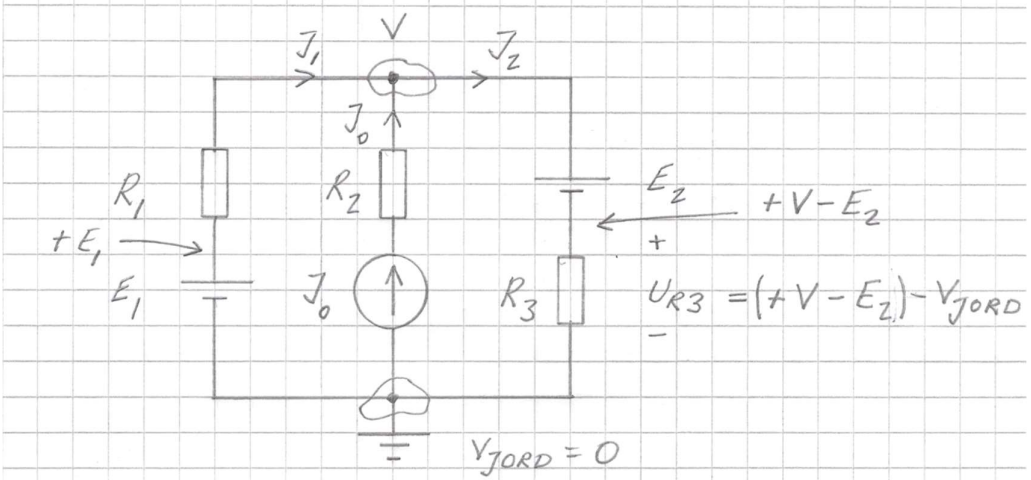
Lösningsförslag till tentamen TMEL08 Eltekniska system 2024-03-15

1. "ANVÄND EXEMPELVIS NODANALYS"



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

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

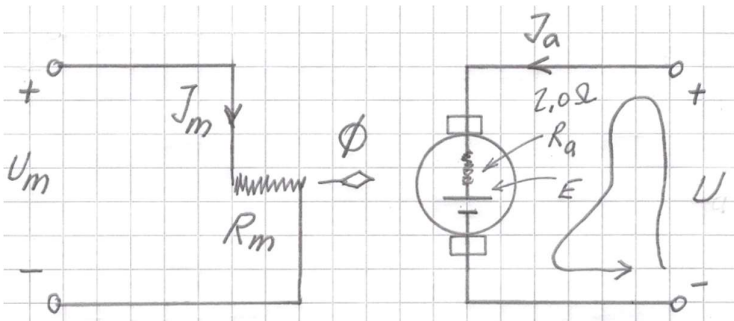
$$\frac{25 - V}{1000} + 0{,}005 - \frac{V - 10}{1000} = 0$$

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

$$V = +20\ V$$

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

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

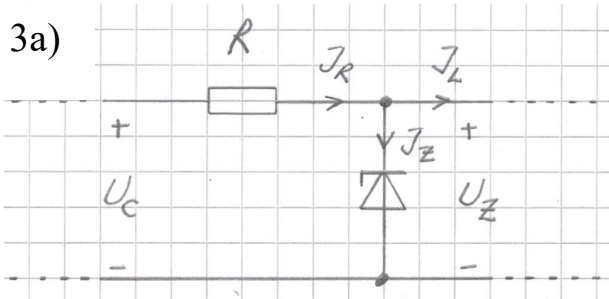
b) KIRCHHOFFS SPÄNNINGSLAG $\rightarrow$

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

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

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

3a)



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

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

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

($P_{Z_{MAX}}$: 10W, U_Z: 12V)

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

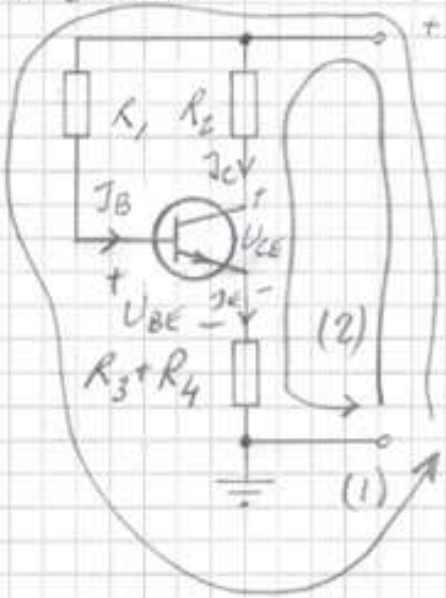
$$R_{MAX} = \frac{U_C - U_Z}{J_{R_{MIN}}} \qquad J_{R_{MIN}} = J_{Z_{MIN}} + J_{L_{MAX}}$$

($J_{Z_{MIN}}$: 100mA, $J_{L_{MAX}}$: 500 mA)

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

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

3b) LIKSTRÖMSSCHEMA



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

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

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

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

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

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

4a)

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

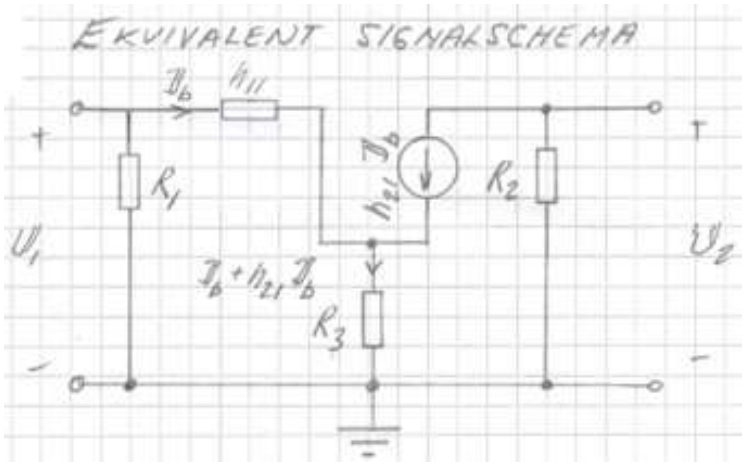
$$\hat{U}_2 = U_C + 2 \cdot U_{D100} = 33{,}4\ \text{V}$$

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

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

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

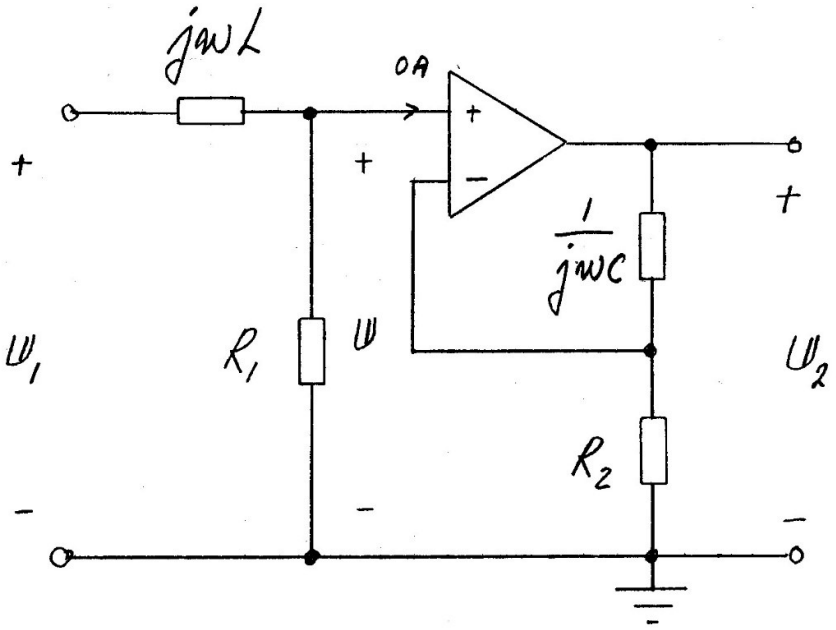
4b)



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

$|F| = 50 \Rightarrow$ $R_3 =$ 10 Ω $\rightarrow$ $R_4 =$ 380 Ω

5.



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

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

(1) ΚΑΙ (2) $\rightarrow$

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

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

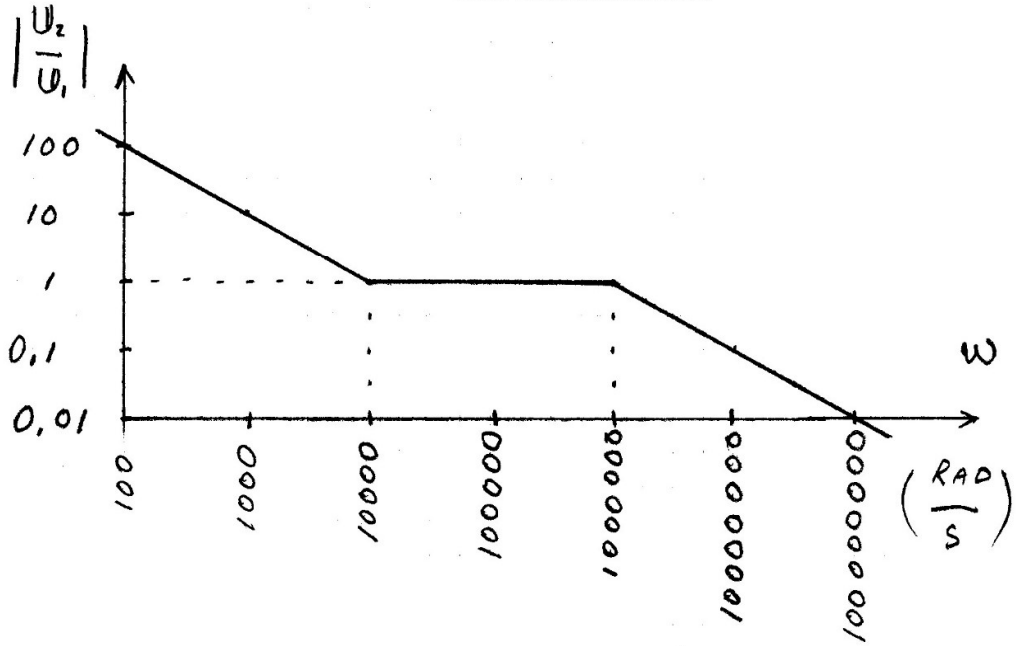
$$\left|\frac{U_2}{U_1}\right| = \frac{\sqrt{1^2 + \left(\frac{w}{10000}\right)^2}}{\sqrt{1^2 + \left(\frac{w}{1000000}\right)^2} \cdot \frac{w}{10000}}$$

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

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

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

AMPLITUDKURVAN :



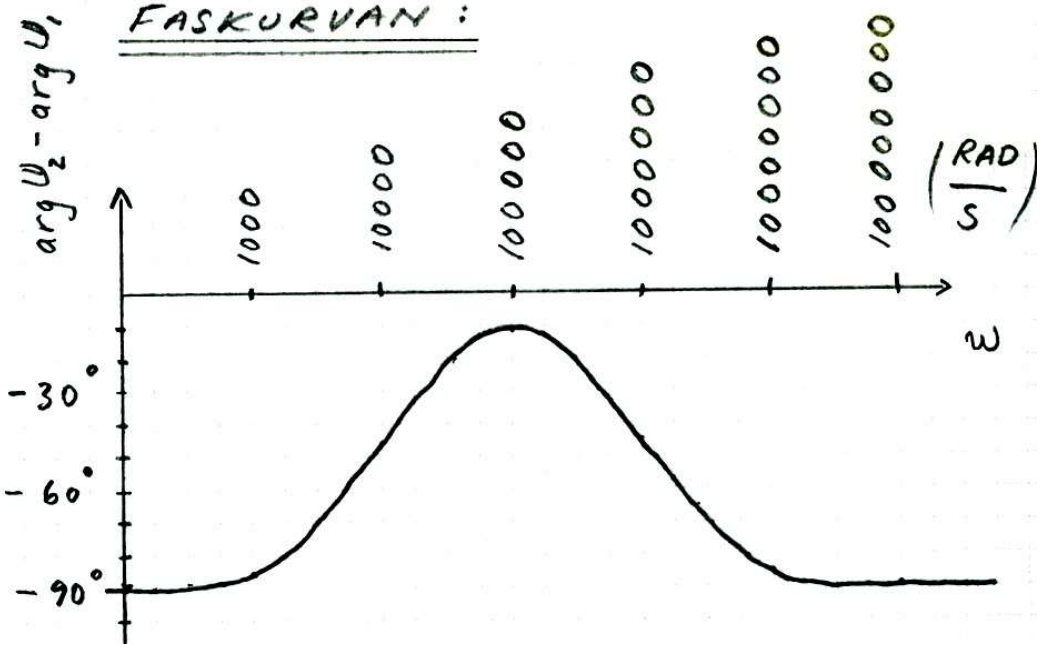
$$\arg U_2 - \arg U_1 = \arg\left(\frac{U_2}{U_1}\right) =$$

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

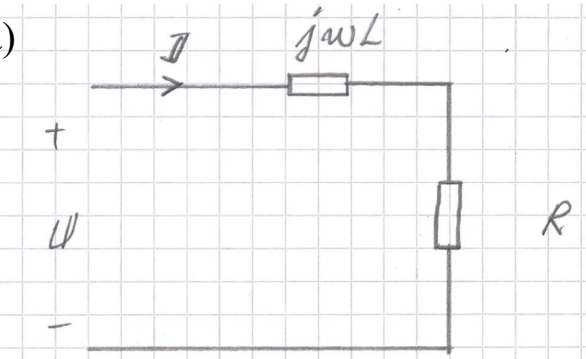
$$= \underbrace{\arg\left(1+jwCR_2\right)}_{\arctan(wCR_2)} - \underbrace{\arg\left(1+jw\cdot\frac{L}{R_1}\right)}_{\arctan\left(\frac{wL}{R_1}\right)} - \underbrace{\arg\left(jwCR_2\right)}_{90^\circ}$$

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

FASKURVAN :



6a)



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

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

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

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

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

6b)

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

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

(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:

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

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

$S = U \cdot J$

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

$\uparrow \quad \uparrow$

$0° \quad -37°$

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

6c)

$Q = Q_L - Q_C$

$Q = 0 \rightarrow Q_C = Q_L$

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

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

6d)

$Q = 0 \rightarrow S = P$ 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 $\arg\underline{J} = \arg\underline{U}$)