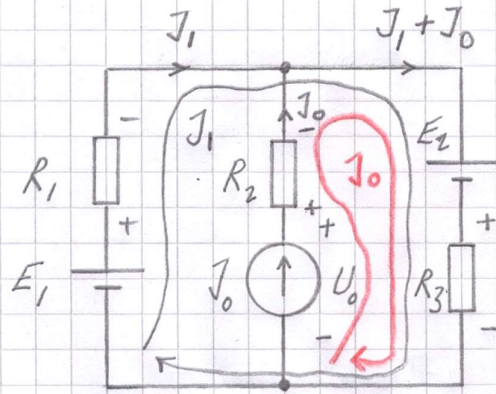


Lösningförslag till tentamen TMEL08 Eltekniska system 2023-10-24

1.

ANVÄND EXEMPELVIS SLINGANALYS :



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

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

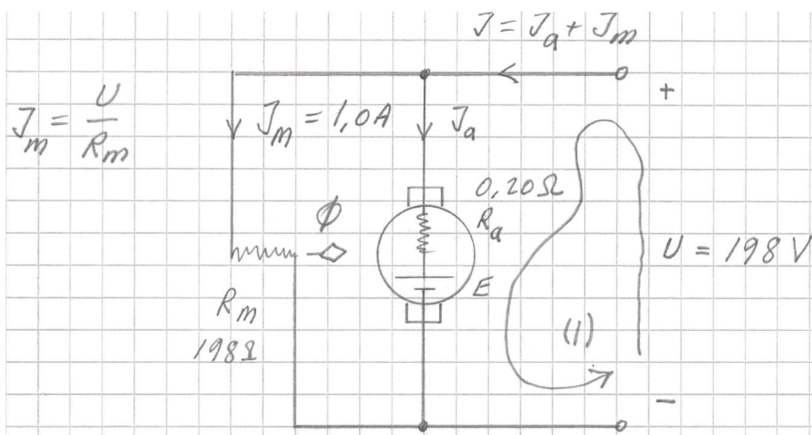
$$+ 25 - 1000 J_1 - 10 - 1000 (J_1 + 0,005) = 0 \dots (1)$$

$$+ U_0 - 1000 \cdot 0,005 - 10 - 1000 (J_1 + 0,005) = 0 \dots (2)$$

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

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

2.



FALL I (TOMGÅNG) FALL II (BELASTNING)

$$J_{aI} = 4,0 A$$

$$J_{aII} = 49 A$$

$$n_I = 985 \text{ RPM}$$

$$n_{II} = ?$$

$$\Phi_I = \Phi$$

$$\Phi_{II} = 0,97 \Phi$$

$$\eta = ?$$

$$M_a = ?$$

$$+U - R_a J_a - E = 0 \dots (1)$$

$$\text{FALL I} \Rightarrow +198 - 0,20 \cdot 4,0 - E_I = 0 \Rightarrow E_I = 197,2 V$$

$$\text{FALL II} \Rightarrow +198 - 0,20 \cdot 49 - E_{II} = 0 \Rightarrow E_{II} = 188,2 V$$

$$\frac{E_I}{E_{II}} = \frac{\cancel{X} \cdot \cancel{\Phi} n_I}{\cancel{X} \cdot 0,97 \cancel{\Phi} n_{II}} \Rightarrow \frac{197,2}{188,2} = \frac{985}{0,97 n_{II}}$$

$$\Rightarrow \underline{\underline{n_{II} = 969 \text{ RPM}}}$$

$$\eta = \frac{P_{2a}}{P_1} = \frac{P_1 - P_F}{P_1} \dots (2)$$

P_1 = TILLFÖRD EFFEKT

P_{2a} = AVGIVEN EFFEKT PÅ UTGÅENDE MOTORAXEL

P_F = FÖRLUSTER

$$P_F = P_{FM} + P_{FB} + P_{FO} \dots (3)$$

P_{FM} = FÖRLUST I MAGNETISERINGSLEDNINGEN.

P_{FB} = BELASTNINGSFÖRLUST I ANKARET

P_{FO} = FRIKTION OCH VENTILATION

$$P_1 = U J_{II} \rightarrow P_1 = 198 \cdot 50 = 9900 \text{ W}$$

$$P_{FM} = R_m \cdot J_m^2 \rightarrow P_{FM} = 198 \text{ W}$$

$$P_{FB} = R_a \cdot J_{aII}^2 \rightarrow P_{FB} = 0,20 \cdot 49^2 = 480,2 \text{ W}$$

$$P_{FO} = E_I \cdot J_{aI} \Rightarrow P_{FO} = 197,2 \cdot 4,0 = 788,8 \text{ W}$$

$$(3) \Rightarrow P_F = 1467 \text{ W}$$

$$(2) \Rightarrow \underline{\underline{\eta = 0,85}} \quad (85\%)$$

$$P_{2a} = M_a \cdot \frac{2\pi n_{II}}{60} \dots (4)$$

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

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

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

3a)

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

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

3b) "ÖVRE LÄGET" \rightarrow

$$U_2 = U_{ut} \cdot \frac{R_3 + R_4}{R_2 + R_3 + R_4}$$

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

$$R_3 + R_4 = 168000 \Omega$$

"NEDRE LÄGET" \rightarrow

$$U_2 = U_{ut} \cdot \frac{R_4}{R_2 + R_3 + R_4}$$

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

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

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

3c)

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

↑
0,70 V

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

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

3d)

$I_{R1} = I_Z$ TY STRÖMMEN IN TILL
OP'NS PLUSINGÅNG ÄR NOLL.

$$R_1 = \frac{U_{R1}}{I_{R1}} = \frac{U_{in} - U_Z}{I_Z}$$

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

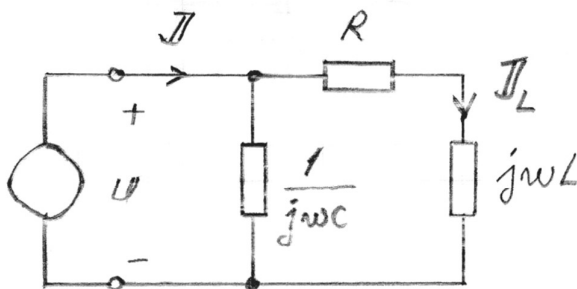
VÄLJ R_1 STRAX UNDER 313Ω

4.

$$I = I_{\text{MIN}} \quad \text{DÄ} \quad Q = 0 \quad \text{TY} \quad S = U \cdot I$$

$$\Rightarrow I = \frac{S}{U} \quad \text{DÄR} \quad S = \sqrt{P^2 + Q^2}$$

$$Q = Q_L - Q_C, \quad Q = 0 \Rightarrow Q_C = Q_L$$



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

$$I_L = \frac{230\sqrt{2} \cdot e^{j0^\circ}}{20 + j100\pi \cdot 0,069} = 6,8\sqrt{2} \cdot e^{-j39,8^\circ} \text{ A}$$

$$Q_L = X_L \cdot I_L^2 = \omega L I_L^2 \Rightarrow \left(I_L = \frac{\hat{I}_L}{\sqrt{2}} \right)$$

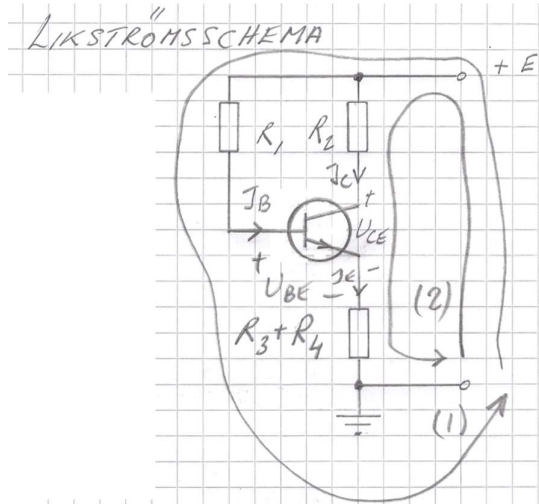
$$Q_L = 100\pi \cdot 0,069 \cdot 6,8^2 = 1002 \text{ VAr}$$

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

$$1002 = 100\pi \text{ C} \cdot 230^2 \quad \left(U = \frac{\hat{U}}{\sqrt{2}} \right)$$

$$\Rightarrow \underline{\underline{C = 60 \mu\text{F}}}$$

5a)



$$h_{FE} = \frac{I_C}{I_B} \Rightarrow I_B = 40 \mu\text{A}$$

$$I_E = I_B + I_C \rightarrow I_E = 8040 \mu\text{A}$$

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

$$(1) \rightarrow R_1 \approx 0,51 \text{ M}\Omega$$

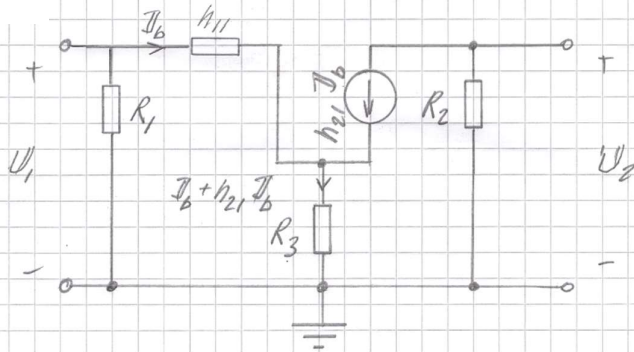
5b)

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

$$(2) \rightarrow U_{CE} \approx 9,0 \text{ V}$$

5c)

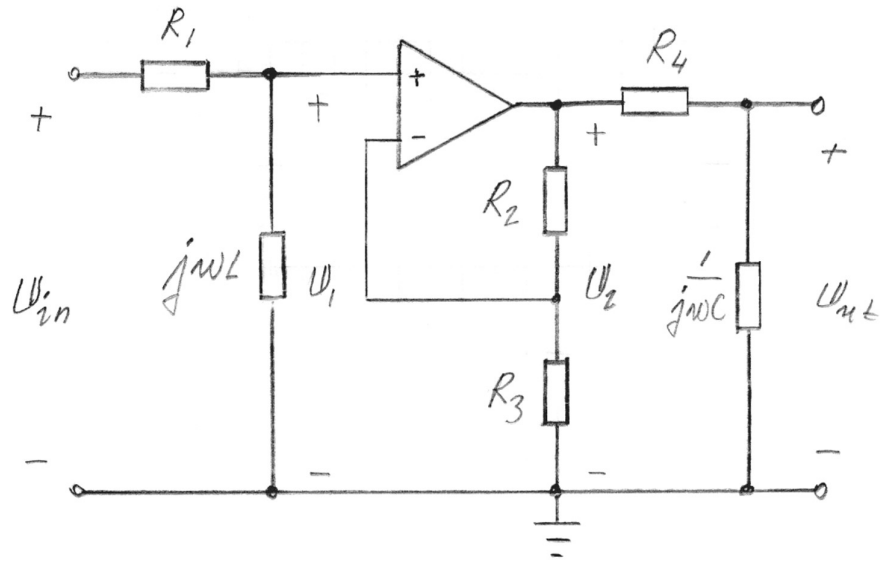
EKVIVALENT SIGNALSCHEMA



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

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

6.



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

$$\frac{U_{out}}{U_2} = \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + R_4} = \frac{1}{1 + j\omega C R_4}$$

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

$$\frac{U_1}{U_{in}} = \frac{j\omega L}{R_1 + j\omega L} = \frac{j\omega \cdot \frac{L}{R_1}}{1 + j\omega \cdot \frac{L}{R_1}}$$

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

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

$$\omega \ll 100 \frac{\text{RAD}}{\text{s}} \Rightarrow \left| \frac{U_{out}}{U_{in}} \right| \approx 2,5 \cdot \frac{\omega}{100}$$

$$100 \frac{\text{RAD}}{\text{s}} \ll \omega \ll 10000 \frac{\text{RAD}}{\text{s}} \Rightarrow \left| \frac{U_{out}}{U_{in}} \right| \approx 2,5$$

$$\omega \gg 10000 \frac{\text{RAD}}{\text{s}} \Rightarrow \left| \frac{U_{out}}{U_{in}} \right| \approx 2,5 \cdot \frac{10000}{\omega}$$

BODEDIAGRAM (AMPLITUDKURVA)

