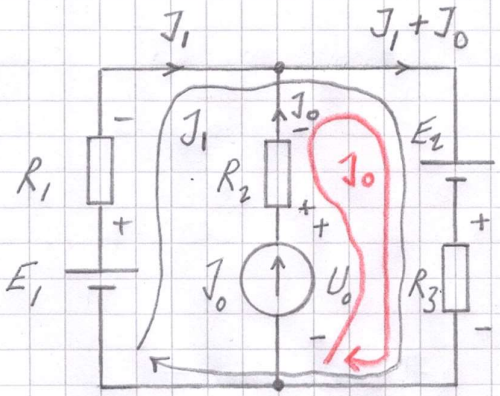
Lösningsförslag till tentamen TMEL08 Eltekniska system 2023-10-24

1.

ANVÄND EXEMPELVIS SLINGANALYS:



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

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

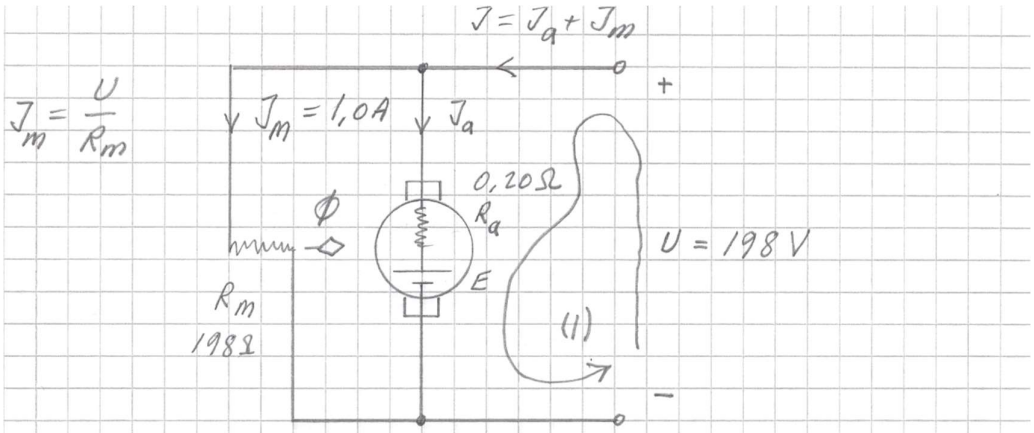
$$+ 25 - 1000 J_1 - 10 - 1000 (J_1 + 0{,}005) = 0 \quad \ldots (1)$$

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

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

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

2.



FALL I (TOMGÅNG) FALL II (BELASTNING)

$J_{aI} = 4{,}0\,A$ $J_{aII} = 49\,A$

$n_I = 985\,RPM$ $n_{II} = ?$

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

$\eta = ?$

$M_a = ?$

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

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

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

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

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

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

P_1 = TILLFÖRD EFFEKT

P_{2a} = AVGIVEN EFFEKT PÅ UTGÅENDE MOTORAXEL

P_F = FÖRLUSTER

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

P_{FM} = FÖRLUST I MAGNETISERINGSLINDNINGEN

P_{FB} = BELASTNINGSFÖRLUST I ANKARET

P_{FO} = FRIKTION OCH VENTILATION

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

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

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

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

$(3) \Rightarrow P_F = 1467\,W$

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

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

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

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

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

3a)

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

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

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" $\rightarrow$

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

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

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

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

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

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

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

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

3d) $I_{R1} = I_Z$ TY STRÖMMEN IN TILL OP'NS PLUSINGÅNG ÄR NOLL.

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

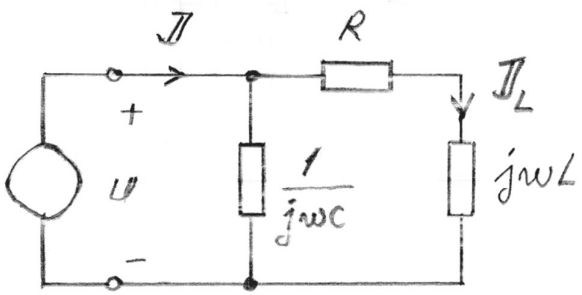
$$R_1 = \frac{15 - 5{,}6}{0{,}030} = 313\ \Omega$$

VÄLJ R_1 STRAX UNDER $313\ \Omega$

4. 4a) I_{MIN} DÅ $Q = 0$ TY $S = U \cdot I$

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

$Q = Q_L - Q_C$, $Q = 0 \rightarrow Q_C = Q_L$



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

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

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

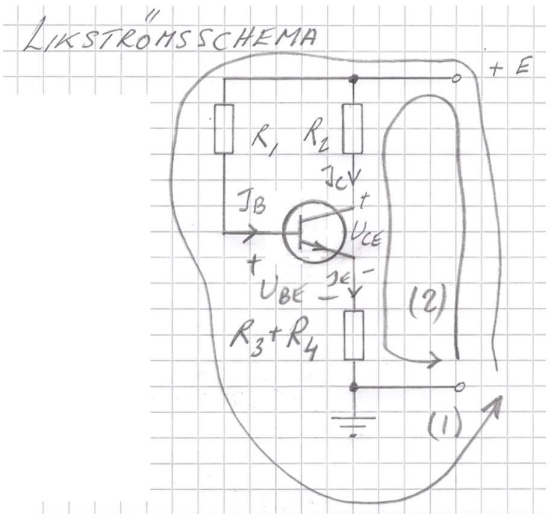
$$Q_L = 100\pi \cdot 0{,}069 \cdot 6{,}8^2 = 1002 \text{ VAr}$$

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

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

$$\rightarrow \underline{C = 60\,\mu F}$$

5a)



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

$$I_E = I_B + I_C \rightarrow I_E = 8040\ \mu A$$

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

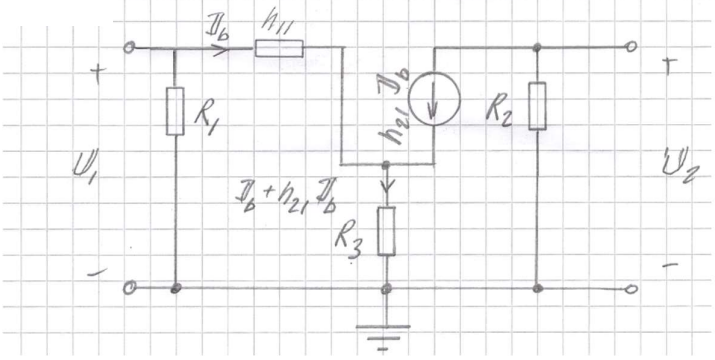
$$(1) \rightarrow R_1 \approx 0{,}51\ M\Omega$$

5b)

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

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

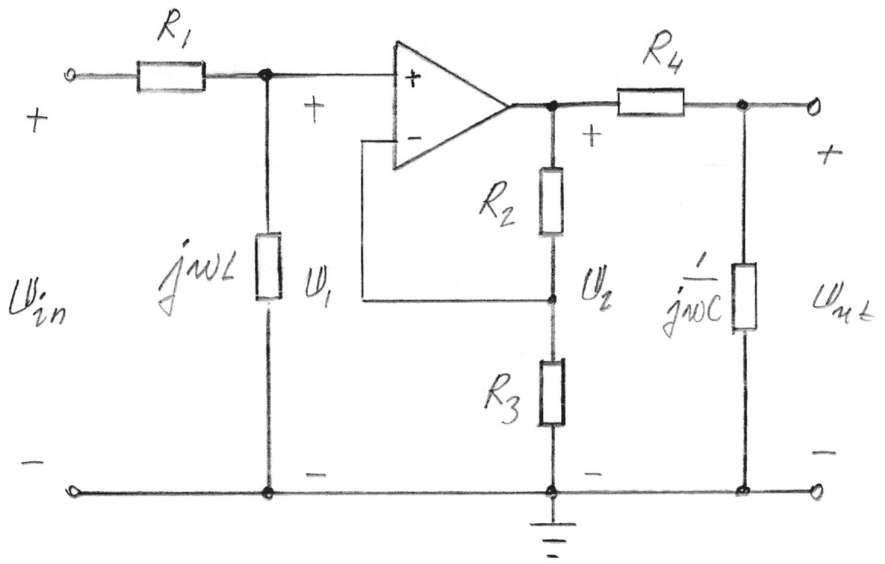
5c)



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

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

6.



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

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

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

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

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

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

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

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

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

BODEDIAGRAM (AMPLITUDKURVA)