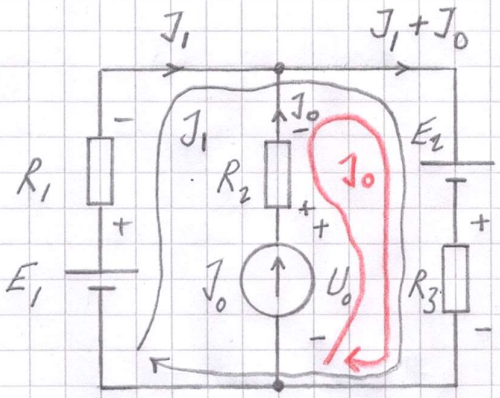
Lösningsförslag till tentamen TMEL08 Eltekniska system 2025-08-21

1.

ANVÄND EXEMPELVIS SLINGANALYS:



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

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

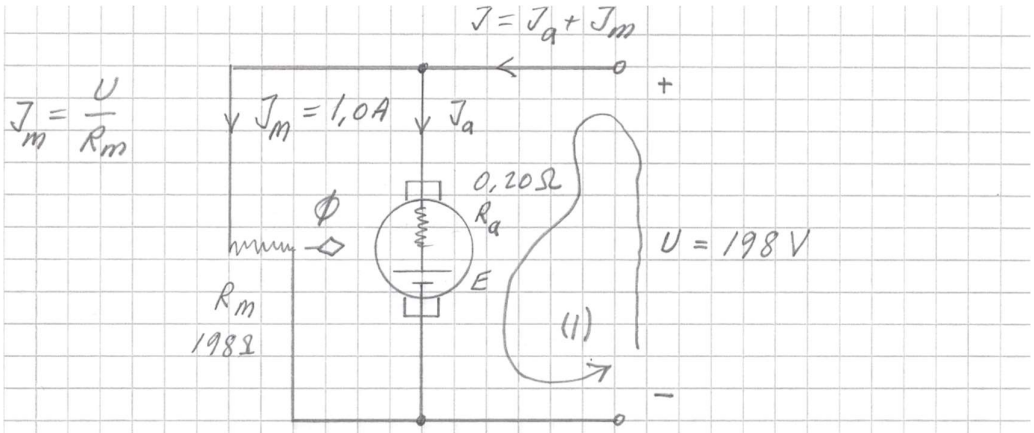
$$+25 - 1000 J_1 - 10 - 1000 (J_1 + 0{,}005) = 0 \quad \ldots (1)$$

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

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

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

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)

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

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

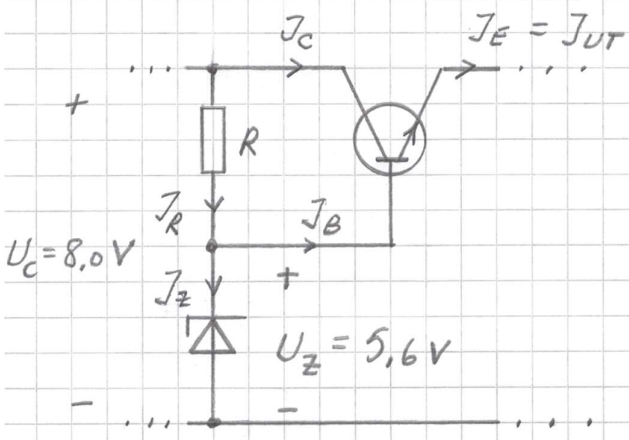
$\Rightarrow \underline{M_a = 83\,Nm}$

3a) $U_{UT} = U_Z - U_{BE}$

OM "ÖVERBELASTNING EJ SKER, HÅLLER SIG U_Z KONSTANT $\Rightarrow$

$U_{UT} = 5,6 - 0,70 = \underline{\underline{4,9\ V}}$

3b)



$J_R = J_Z + J_B \quad \ldots (1)$

$J_R = \dfrac{U_C - U_Z}{R} \Rightarrow J_R = 20\ mA$

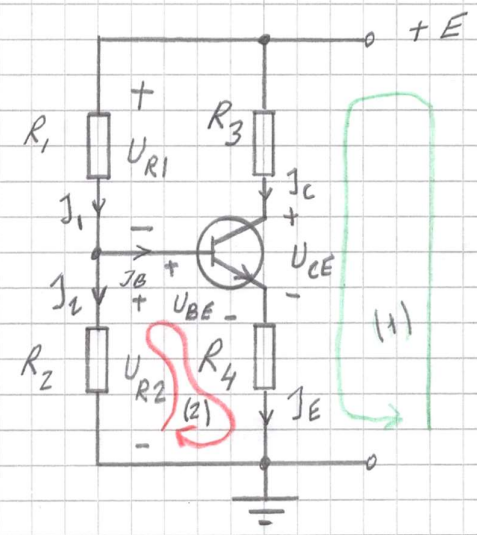
$U_Z = 5,6\ V$ om $J_{Z\,min} = 10\ mA$

$(1) \Rightarrow J_{B\,max} = 10\ mA$

$J_{UT} = J_E = J_B + J_C = J_B + h_{FE} J_B$

$\Rightarrow J_{UT\,max} = \underline{\underline{1,0\ A}}$

3c) LIKSTRÖMSSCHEMA



$+E - R_3 J_C - U_{CE} - R_4 J_E = 0 \quad \ldots (1)$

$+U_{R2} - U_{BE} - R_4 J_E = 0 \quad \ldots (2)$

$J_E = J_B + J_C = \frac{J_C}{h_{FE}} + J_C \Rightarrow J_E = 4{,}04\,mA$

$(1) \rightarrow \underline{\underline{R_4 \approx 2{,}0\,k\Omega}} \quad (1980\,\Omega)$

$(2) \rightarrow U_{R2} = 8{,}1\,V$

$U_{R2} + U_{R1} = E \Rightarrow U_{R1} = 11{,}3\,V$

$J_1 = J_2 + J_B = \frac{U_{R2}}{R_2} + \frac{J_C}{h_{FE}} \rightarrow J_1 = 910\,\mu A$

$R_1 = \frac{U_{R1}}{J_1} \rightarrow \underline{\underline{R_1 \approx 12\,k\Omega}} \quad (12419\,\Omega)$

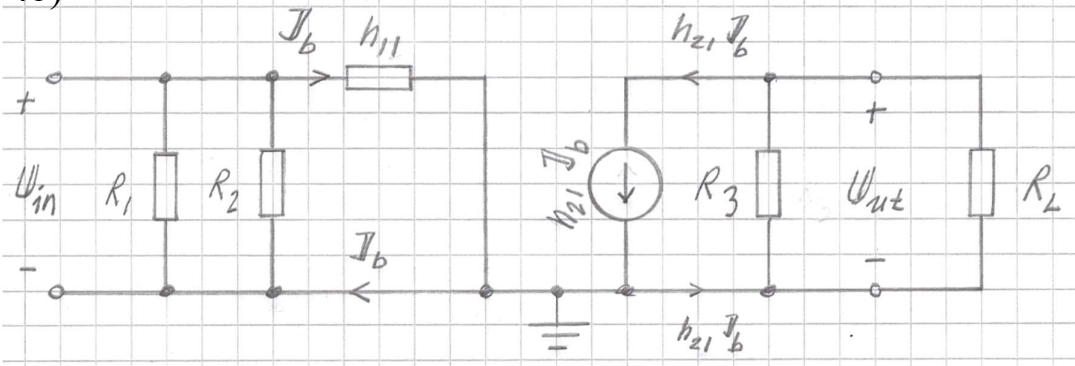
4a)

$$\frac{N_1}{N_2} = \frac{\hat{U}}{\hat{U}_2} = \frac{\hat{U}}{U_c + 2 \cdot 0{,}70} \approx \underline{\underline{35}} \; (34{,}6)$$

$\hat{U} \leftarrow 230\sqrt{2}\ \text{V}$

$U_c \uparrow 8{,}0\ \text{V}$

4b)



$$F = \frac{U_{ut}}{U_{in}} \quad \ldots (1)$$

$$U_{ut} = - h_{21} I_b \cdot \frac{R_3 \cdot R_L}{R_3 + R_L} \quad \ldots (2)$$

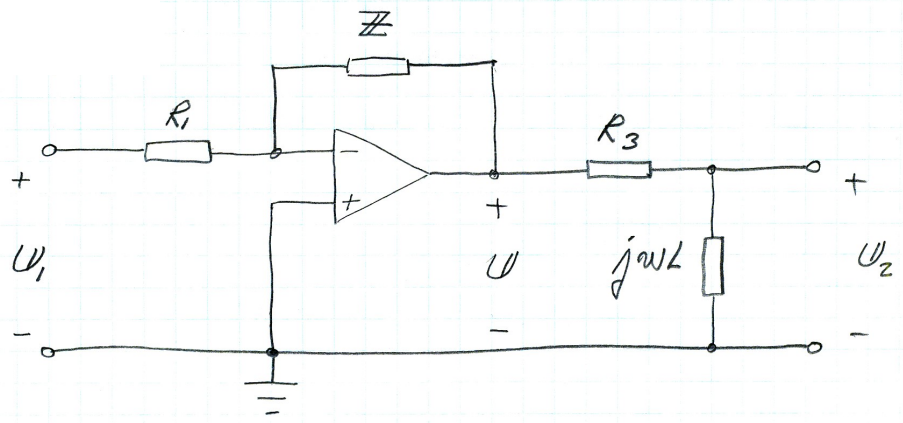
$$U_{in} = h_{11} I_b \quad \ldots (3)$$

(2) & (3) INS (1) $\rightarrow$

$$F = - \frac{h_{21} \cdot \frac{R_3 \cdot R_L}{R_3 + R_L}}{h_{11}}$$

$\rightarrow |F| = 267$ GGR

5a)



$$\frac{U_2}{U_1} = \frac{U_2}{U} \cdot \frac{U}{U_1} \quad \ldots (1)$$

$$U_2 = U \cdot \frac{j\omega L}{R_3 + j\omega L} \Rightarrow \frac{U_2}{U} = \frac{j\omega \cdot \frac{L}{R_3}}{1 + j\omega \cdot \frac{L}{R_3}}$$

$$\Rightarrow \frac{U_2}{U} = \frac{j\frac{\omega}{1587}}{1 + j\frac{\omega}{1587}}$$

$$\frac{U}{U_1} = -\frac{Z}{R_1} \quad \text{där} \quad Z = \frac{\frac{1}{j\omega C} \cdot R_2}{\frac{1}{j\omega C} + R_2} =$$

$$= \frac{R_2}{1 + j\omega C R_2} \Rightarrow \frac{U}{U_1} = -\frac{R_2}{R_1} \cdot \frac{1}{1 + j\omega C R_2}$$

$$\Rightarrow \frac{U}{U_1} = -10 \cdot \frac{1}{1 + j\frac{\omega}{62500}}$$

$$(1) \Rightarrow \frac{U_2}{U_1} = -10 \cdot \frac{1}{1 + j\frac{\omega}{62500}} \cdot \frac{j\frac{\omega}{1587}}{1 + j\frac{\omega}{1587}}$$

5b)

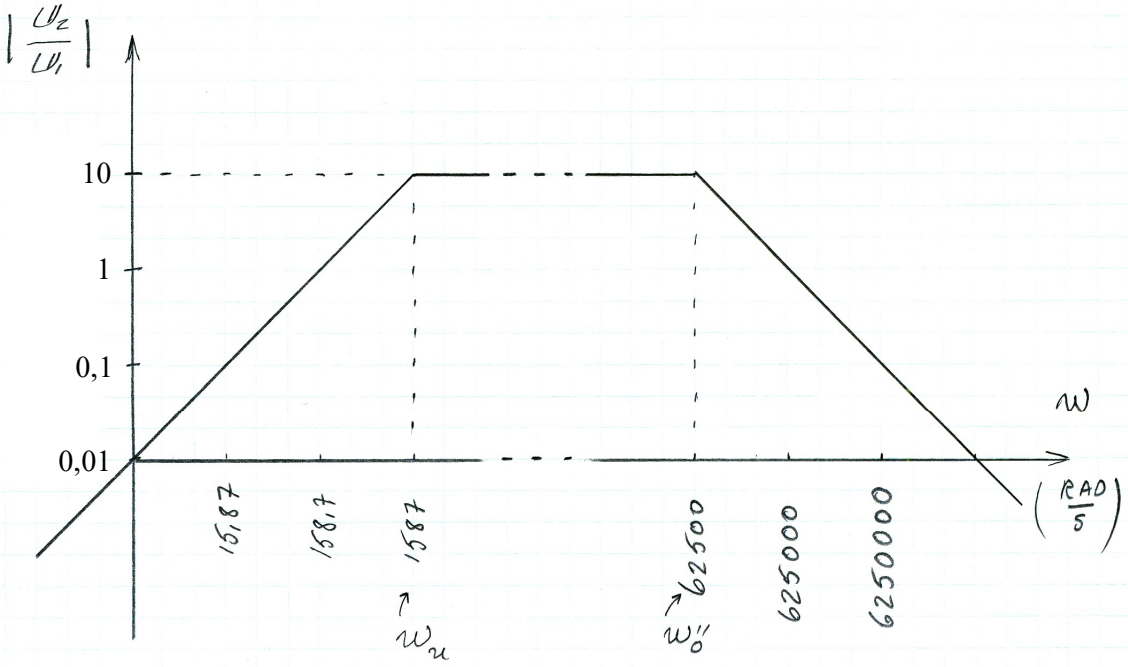
$$\left|\frac{U_2}{U_1}\right| = 10 \cdot \frac{1}{\sqrt{1^2 + \left(\frac{\omega}{62500}\right)^2}} \cdot \frac{\frac{\omega}{1587}}{\sqrt{1^2 + \left(\frac{\omega}{1587}\right)^2}}$$

OM $\omega << 1587 \frac{RAD}{S} \Rightarrow \left|\frac{U_2}{U_1}\right| \approx \frac{10}{1587} \cdot \omega$

OM $1587 \frac{RAD}{S} << \omega << 62500 \frac{RAD}{S} \Rightarrow \left|\frac{U_2}{U_1}\right| = 10$

OM $\omega >> 62500 \frac{RAD}{S} \Rightarrow \left|\frac{U_2}{U_1}\right| = \frac{625000}{\omega}$

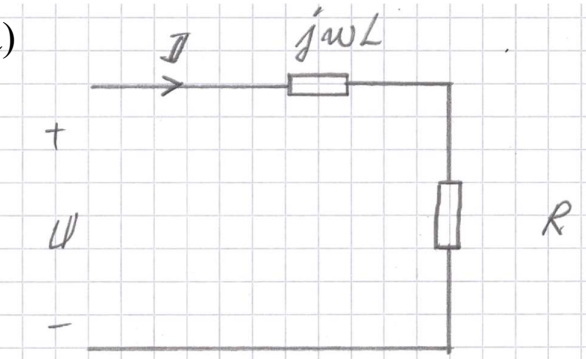
BODEDIAGRAM (AMPLITUDKURVA)



$\omega_u = 2\pi f_u \Rightarrow \underline{f_u \approx 0{,}25\ kHz}$

$\omega_o'' = 2\pi f_o'' \Rightarrow \underline{f_o'' \approx 9{,}9\ kHz}$

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 $\arg\underline{J} = \arg\underline{U}$)