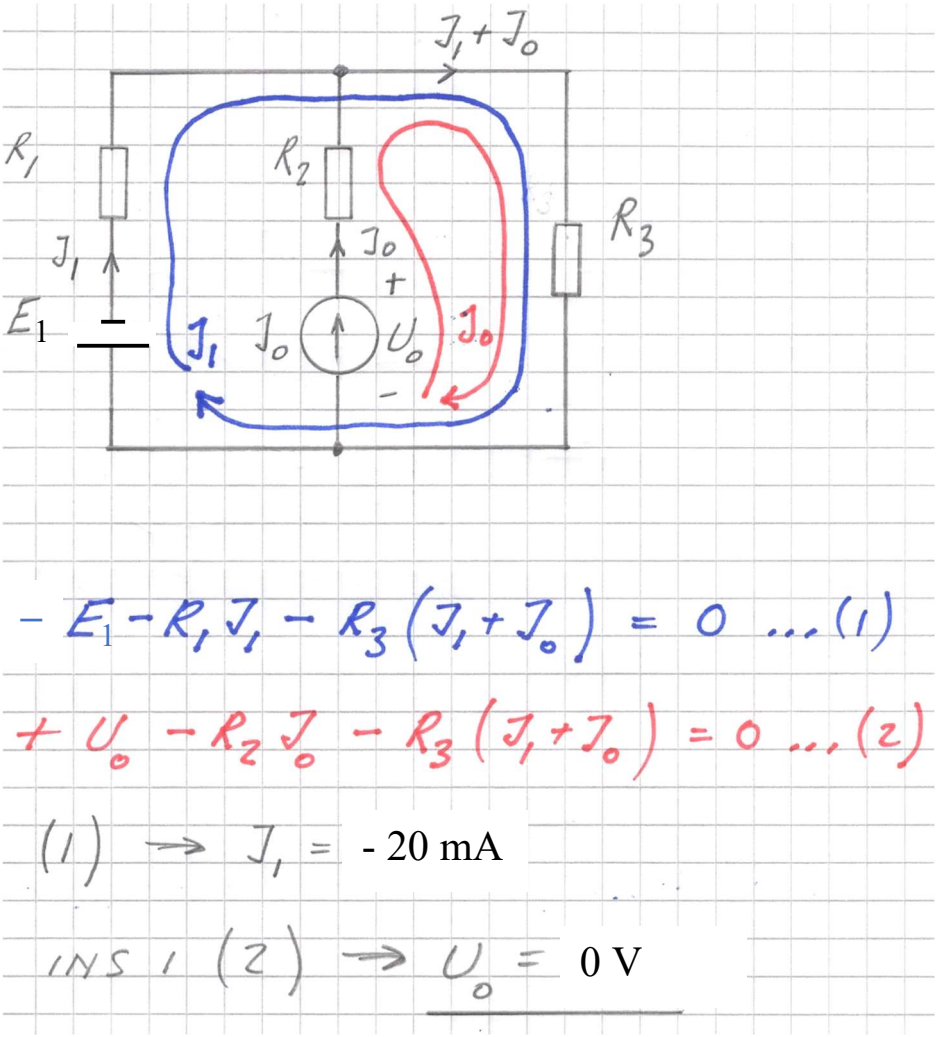
Lösningsförslag till tentamen TMEL08 Eltekniska system 2024-01-02

1.



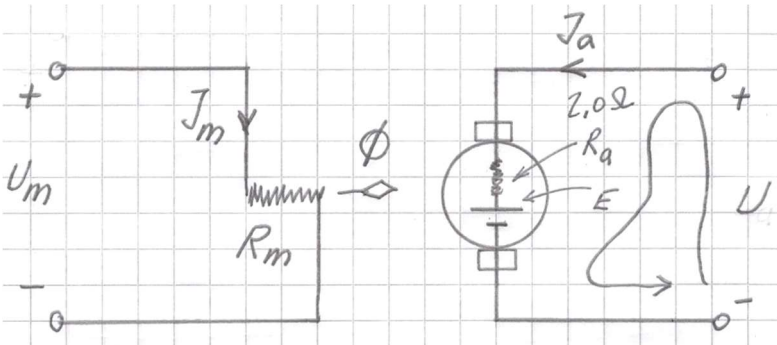
$$-E_1 - R_1 J_1 - R_3 (J_1 + J_0) = 0 \quad \ldots (1)$$

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

$(1) \rightarrow J_1 =$ - 20 mA

INS i $(2) \rightarrow U_0 =$ 0 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) $M = k_2 \Phi J_{aI}$ } $\Rightarrow J_{aII} = J_{aI} = \underline{10\ A}$
$M = k_2 \Phi J_{aII}$ }

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

3a)

"ÖVRE LÄGET" →

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

$$5{,}1 = 6{,}6 \cdot \frac{R_3 + R_4}{30000 + R_3 + R_4} \rightarrow$$

$$R_3 + R_4 = 51000\ \Omega$$

"NEDRE LÄGET" →

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

$$5{,}1 = 13{,}2 \cdot \frac{R_4}{30000 + 51000} \rightarrow$$

$$R_4 = 25{,}5\ \text{k}\Omega \rightarrow R_3 = 25{,}5\ \text{k}\Omega$$

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

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

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

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

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

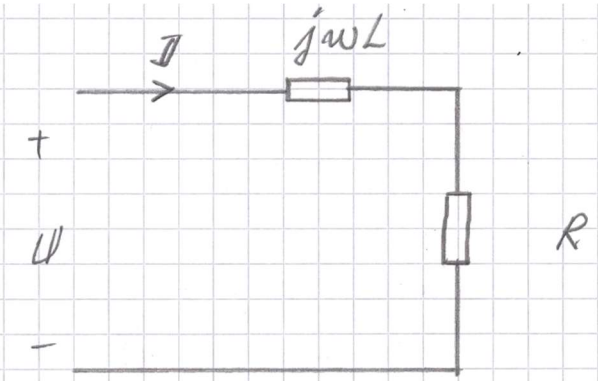
3c) $J_{R1} = J_Z$ TY STRÖMMEN IN TILL OP'NS PLUSINGÅNG ÄR NOLL.

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

$$R_1 = \frac{15 - 5{,}1}{0{,}050} = 198\ \Omega$$

VÄLJ R_1 STRAX UNDER 198 Ω

4a)



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

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

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

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

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

4b)

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

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

(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:

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

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

$S = U \cdot J$

$\varphi = \arg U - \arg J = 37°$

$\uparrow \quad \uparrow$

$0° \quad -37°$

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

4c)

$Q = Q_L - Q_C$

$Q = 0 \Rightarrow Q_C = Q_L$

$Q_C = \frac{U^2}{X_C} = \left| X_C = \frac{1}{\omega C} \right| = U^2 \omega C$

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

4d)

$Q = 0 \Rightarrow S = P$ OCH $\cos\varphi = 1 \rightarrow \varphi = 0°$

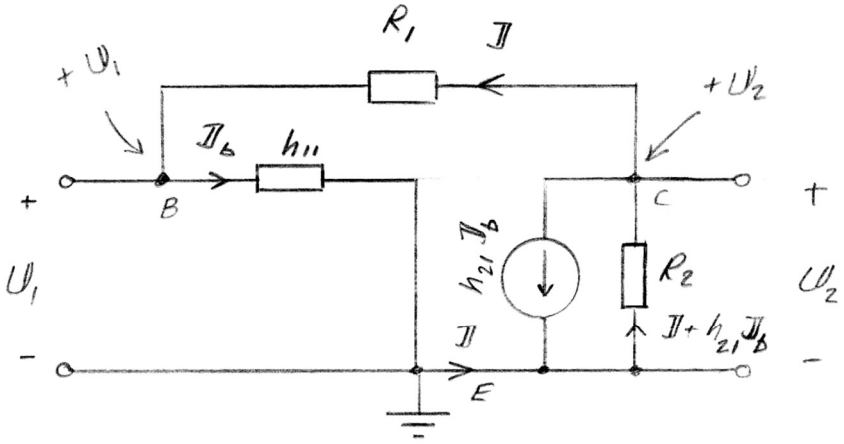
$S = U \cdot J \rightarrow 1{,}41 \cdot 10^3 = 230 \cdot J$

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

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

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

5.



$$F = \frac{U_2}{U_1} \quad \ldots (3)$$

$$U_2 = -R_2\left(\mathbb{I} + h_{21}\mathbb{I}_b\right) \ldots (4)$$

$$\mathbb{I} = \frac{U_2 - U_1}{R_1}$$

$$U_1 = h_{11}\mathbb{I}_b \rightarrow \mathbb{I}_b = \frac{U_1}{h_{11}}$$

INS ı (4) $\rightarrow$

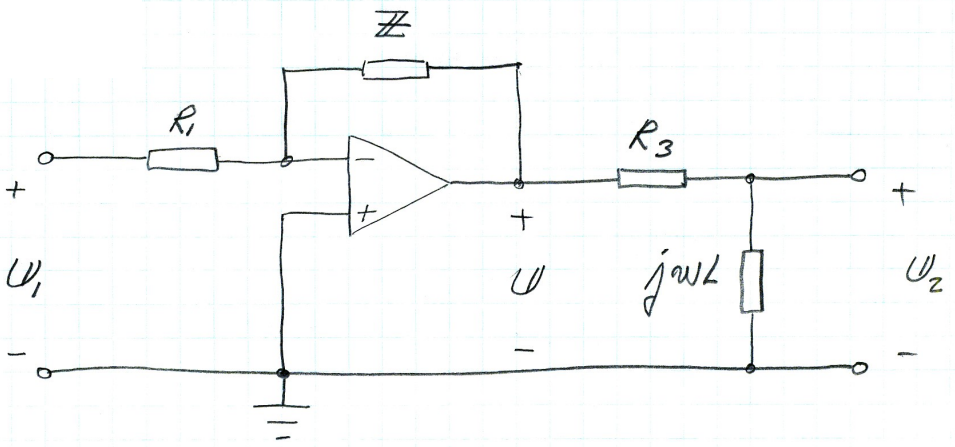
$$U_2 = -R_2\left(\frac{U_2 - U_1}{R_1} + \frac{h_{21}}{h_{11}} \cdot U_1\right)$$

$$U_2 + \frac{R_2}{R_1}U_2 = \frac{R_2}{R_1}U_1 - R_2 \cdot \frac{h_{21}}{h_{11}} \cdot U_1$$

$$\frac{U_2}{U_1} = \frac{\frac{R_2}{R_1} - R_2 \cdot \frac{h_{21}}{h_{11}}}{1 + \frac{R_2}{R_1}} \rightarrow F \approx -135$$

$$\underline{\underline{|F| \approx 135}}$$

6a)



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

$$U_2 = U \cdot \frac{jwL}{R_3 + jwL} \rightarrow \frac{U_2}{U} = \frac{jw \cdot \frac{L}{R_3}}{1 + jw \cdot \frac{L}{R_3}}$$

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

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

$$= \frac{R_2}{1 + jwCR_2} \rightarrow \frac{U}{U_1} = -\frac{R_2}{R_1} \cdot \frac{1}{1 + jwCR_2}$$

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

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

6b)

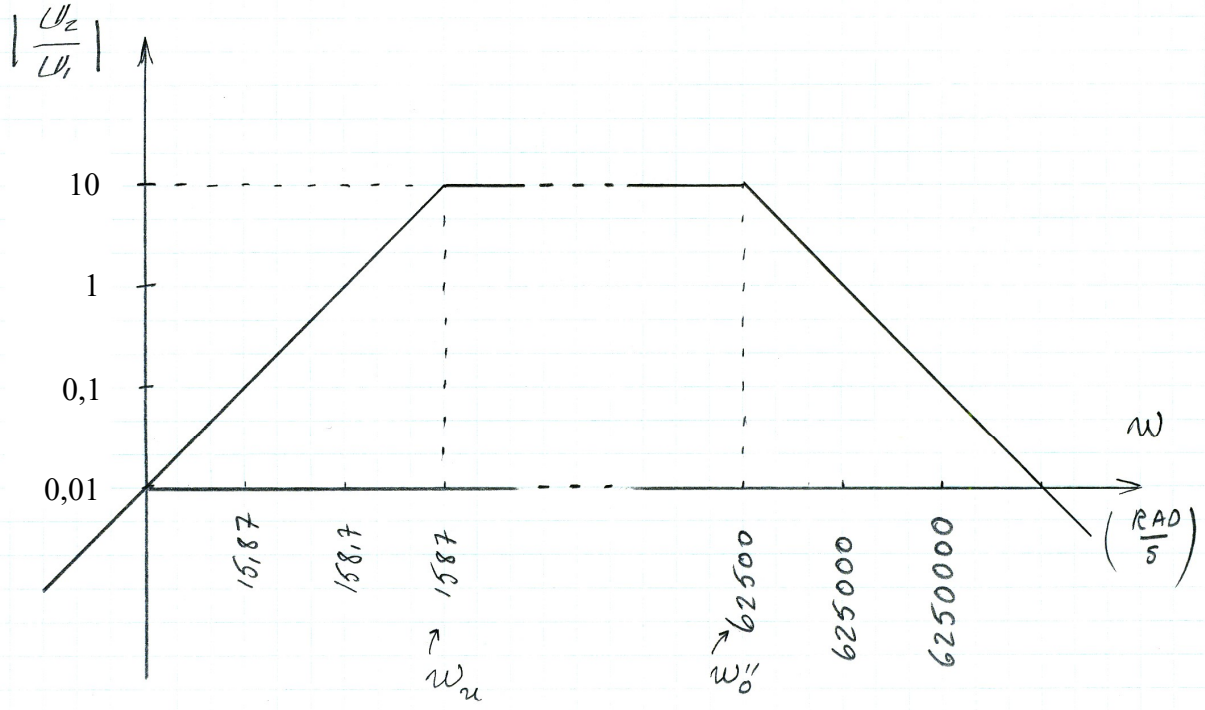
$$\left|\frac{U_2}{U_1}\right| = 10 \cdot \frac{1}{\sqrt{1^2 + \left(\frac{\omega}{62500}\right)^2}} \cdot \frac{\frac{\omega}{1587}}{\sqrt{1^2 + \left(\frac{\omega}{1587}\right)^2}}$$

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)



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

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