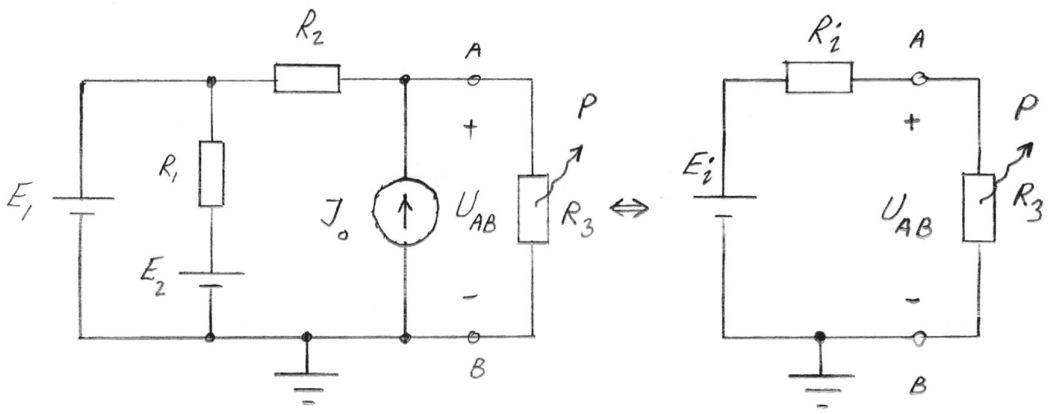
Lösningsförslag till tentamen TMEL08 Eltekniska system 2024-08-28

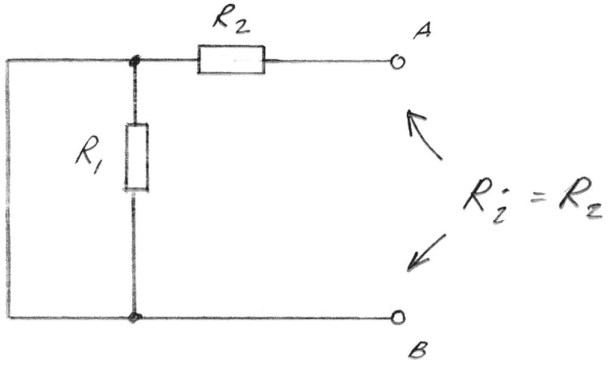
1.



$P = P_{MAX}$ OM $R_3 = R_i$

OCH $P_{MAX} = \dfrac{E_i^2}{4R_i}$

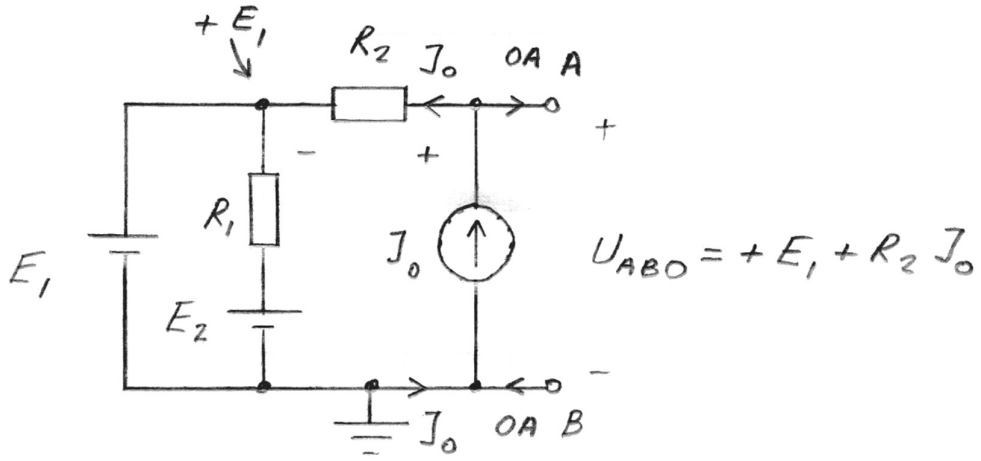
a) NOLLSTÄLL E_1, E_2 OCH J_0.
BESTÄM R_i MELLAN A OCH B.



ALLTSÅ $P = P_{MAX}$ OM $R_3 = R_2 \rightarrow \underline{\underline{R_3 = 20\,\Omega}}$

b) BESTÄM TOMGÅNGSSPÄNNINGEN U_{ABO}

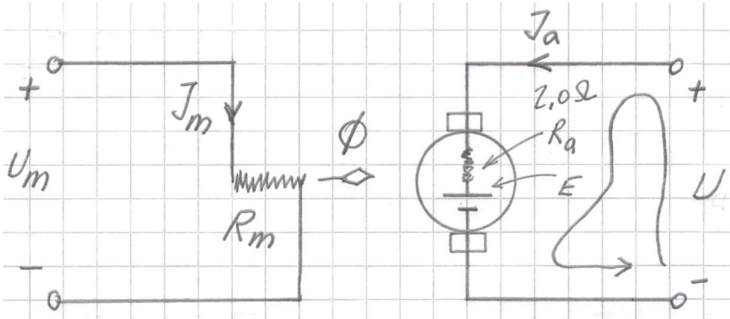
$E_i = U_{ABO}$



$\rightarrow U_{ABO} = 16\,V \rightarrow E_i = 16\,V$

$$\underline{\underline{P_{MAX}}} = \frac{16^2}{4 \cdot 20} = \underline{\underline{3{,}2\,W}}$$

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

$M = k_2 \Phi J_{aII}$ }

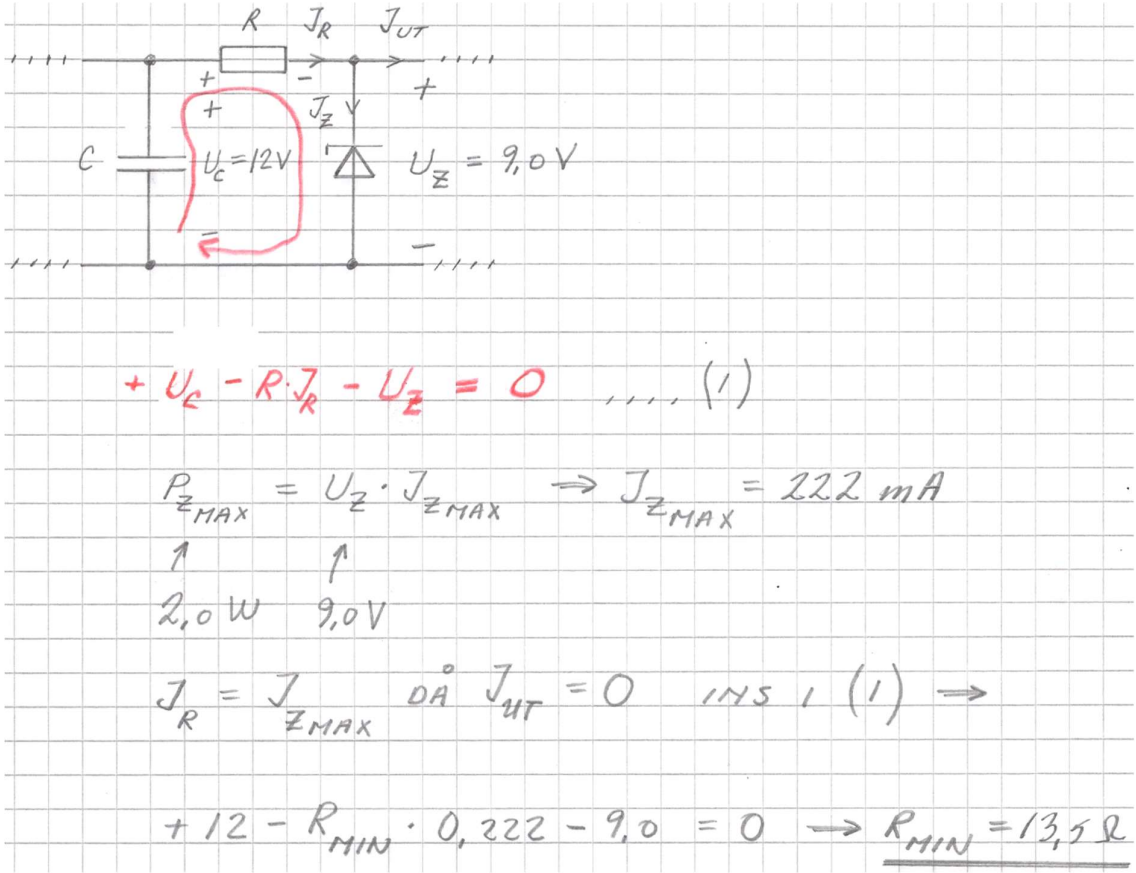
b) KIRCHHOFFS SPÄNNINGSLAG →

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

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

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

3a)



$+ U_C - R \cdot J_R - U_Z = 0$ .... (1)

$P_{Z_{MAX}} = U_Z \cdot J_{Z_{MAX}} \Rightarrow J_{Z_{MAX}} = 222\ mA$

↑ ↑

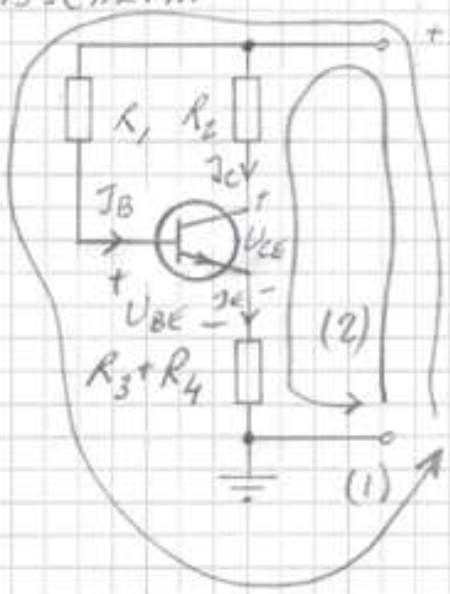
2,0 W 9,0 V

$J_R = J_{Z_{MAX}}$ DA $J_{UT} = 0$ INS I (1) $\rightarrow$

$+ 12 - R_{MIN} \cdot 0,222 - 9,0 = 0 \rightarrow \underline{R_{MIN} = 13,5\ \Omega}$

3b)

LIKSTRÖMSSCHEMA



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

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

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

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

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

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

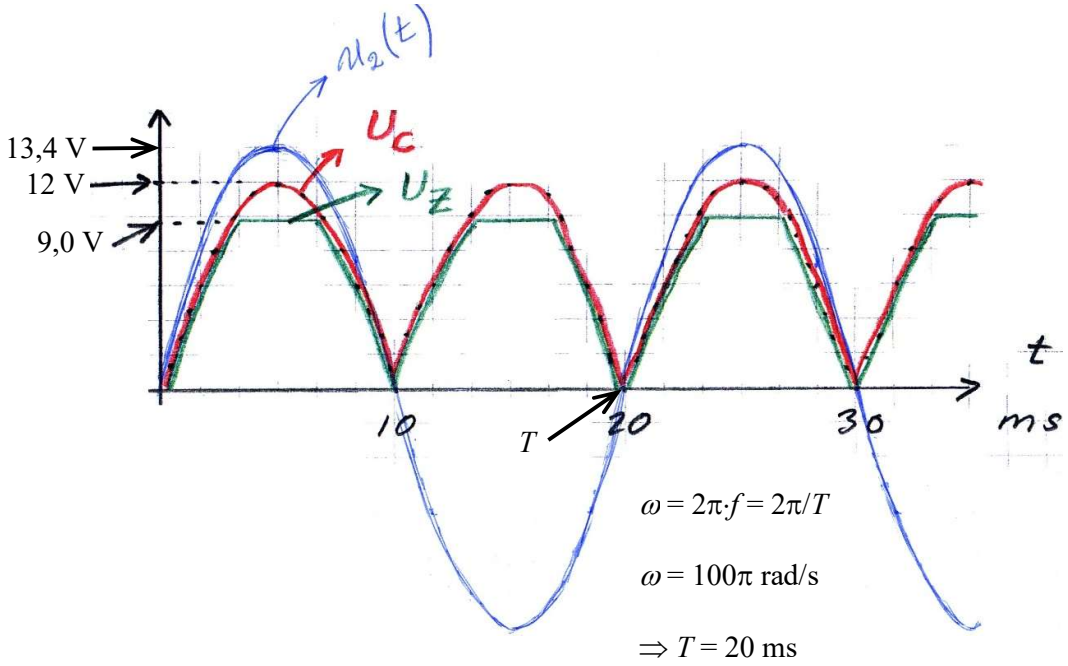
4a)

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

TVÅ DIODER LEDER

$$\Rightarrow \frac{N_1}{N_2} = \frac{230\sqrt{2}}{12 + 1{,}4} \approx 24$$

4b) Tidsdiagram för $u_2(t)$, U_C och U_Z då glättningskondensatorn gått sönder:

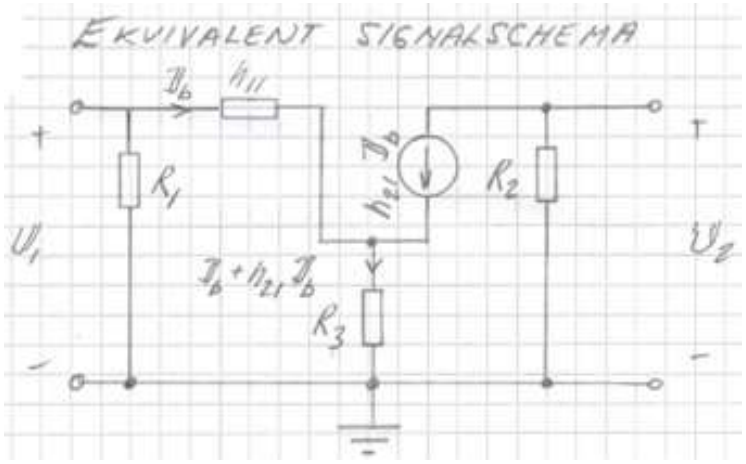


$\omega = 2\pi \cdot f = 2\pi / T$

$\omega = 100\pi$ rad/s

$\Rightarrow T = 20$ ms

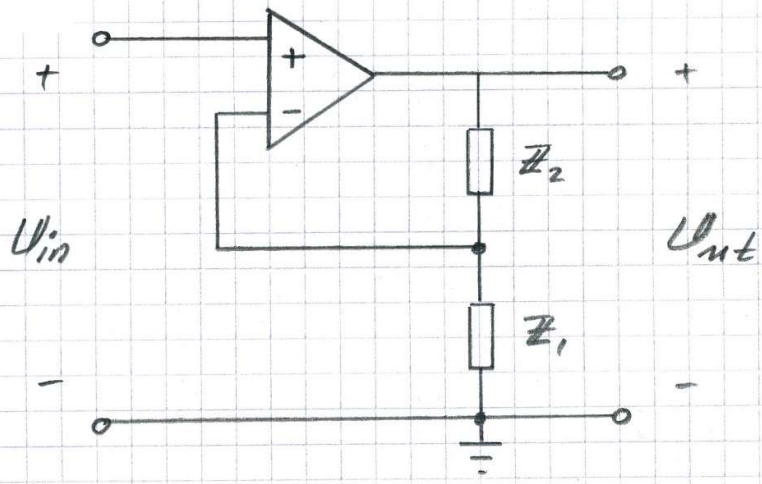
4c)



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

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

5.



$$\frac{U_{ut}}{U_{in}} = 1 + \frac{Z_2}{Z_1} \quad \text{ОДНАК} \quad Z_1 = R_1$$

$$\text{ОСКІЛЬКИ} \quad Z_2 = \frac{\frac{1}{j\omega C} \cdot R_2}{\frac{1}{j\omega C} + R_2} = \frac{R_2}{1 + j\omega C R_2}$$

$$\frac{U_{ut}}{U_{in}} = 1 + \frac{R_2}{R_1 (1 + j\omega C R_2)} =$$

$$= \dots = \frac{R_1 + R_2}{R_1} \cdot \frac{1 + j\omega C \cdot \frac{R_1 R_2}{R_1 + R_2}}{1 + j\omega C R_2}$$

$$\left|\frac{U_{ut}}{U_{in}}\right| = \frac{R_1+R_2}{R_1} \cdot \frac{\sqrt{1^2+\left(\omega C \cdot \frac{R_1 R_2}{R_1+R_2}\right)^2}}{\sqrt{1^2+\left(\omega C R_2\right)^2}}$$

$R_1 = 1{,}0\ k\Omega$, $R_2 = 100\ k\Omega$ och $C = 2{,}7\ nF$

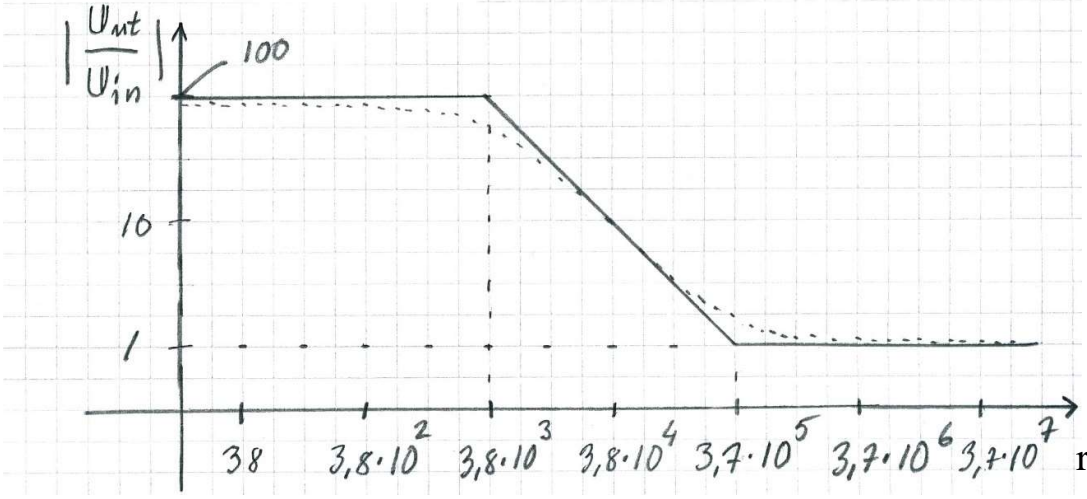
$$\rightarrow \left|\frac{U_{ut}}{U_{in}}\right| \approx 100 \cdot \frac{\sqrt{1^2+\left(\frac{\omega}{3{,}7\cdot 10^5}\right)^2}}{\sqrt{1^2+\left(\frac{\omega}{3{,}8\cdot 10^3}\right)^2}}$$

$$\omega << 3{,}8\cdot 10^3 \ \frac{RAD}{s} \rightarrow \left|\frac{U_{ut}}{U_{in}}\right| \approx 100$$

$$3{,}8\cdot 10^3 << \omega << 3{,}7\cdot 10^5 \rightarrow \left|\frac{U_{ut}}{U_{in}}\right| \approx \frac{3{,}8\cdot 10^5}{\omega}$$

$$\omega >> 3{,}7\cdot 10^5 \ \frac{RAD}{s} \rightarrow \left|\frac{U_{ut}}{U_{in}}\right| \approx 1{,}0$$

Amplitudkurva:



$$\arg U_{ut} - \arg U_{in} = \arg\left(\frac{U_{ut}}{U_{in}}\right) =$$

$$= \arg\left(\frac{R_1+R_2}{R_1} \cdot \frac{1+jwC\cdot\frac{R_1R_2}{R_1+R_2}}{1+jwCR_2}\right) =$$

$$= \arg\left(\frac{R_1+R_2}{R_1}\right) + \arg\left(1+jwC\cdot\frac{R_1R_2}{R_1+R_2}\right) -$$

$$- \arg\left(1+jwCR_2\right) =$$

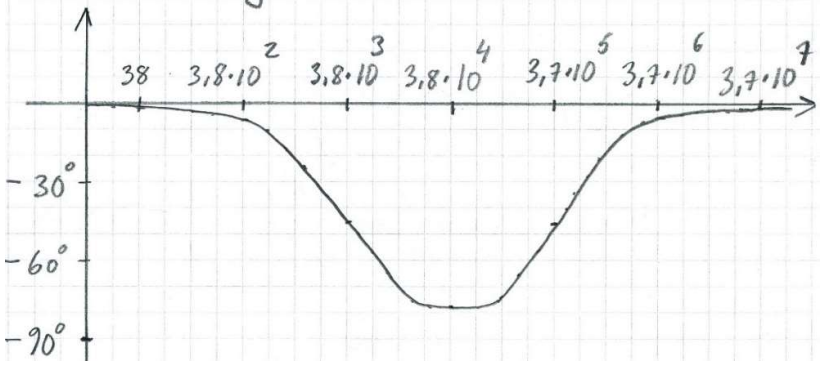
$$= 0 + \arctan\left(wC\cdot\frac{R_1R_2}{R_1+R_2}\right) - \arctan\left(wCR_2\right) \approx$$

$$\approx \arctan\left(\frac{w}{3{,}7\cdot10^5}\right) - \arctan\left(\frac{w}{3{,}8\cdot10^3}\right)$$

$w\,(\mathrm{RAD/S})$	$\arg U_{ut} - \arg U_2$
38	$-1°$
$3{,}8\cdot10^2$	$-6°$
$3{,}8\cdot10^3$	$-44°$
$3{,}8\cdot10^4$	$-78°$
$3{,}7\cdot10^5$	$-44°$
$3{,}7\cdot10^6$	$-6°$
$3{,}7\cdot10^7$	$-1°$

FASKURVA:

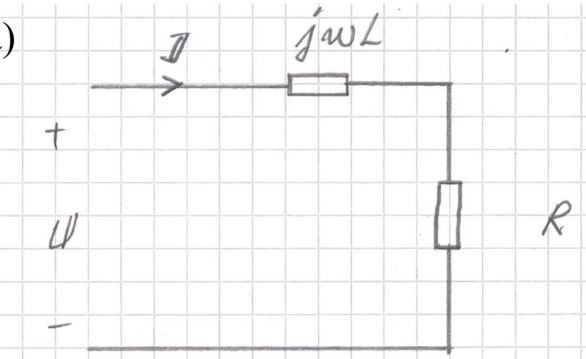
$\arg U_{ut} - \arg U_{in}$



rad/s

ω

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