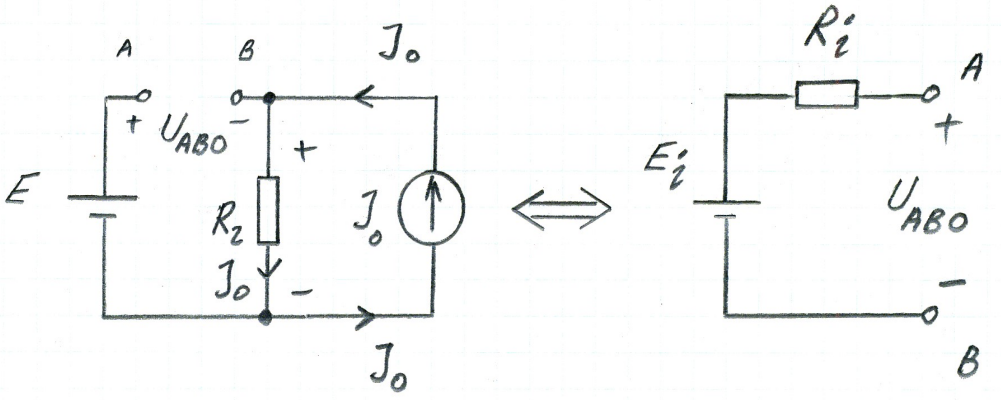
Lösningsförslag till tentamen TMMI04 Elektroteknik 2020-03-17

1a) TVÅPOLSSATSEN

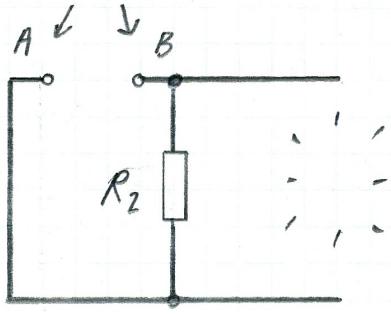
TAG BORT R_1 OCH ERSÄTT RESTEN AV KRETSEN MED EN EKVIVALENT TVÅPOL



$$E_i = U_{ABO} = E - R_2 J_0 \Rightarrow E_i = 6{,}0\ \text{V}$$

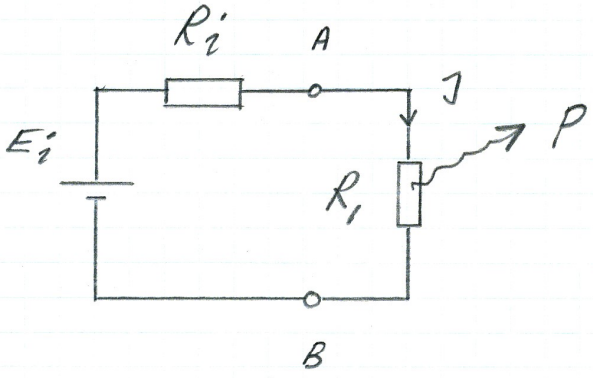
NOLLSTÄLL E OCH J_0. BERÄKNA R_i MELLAN A OCH B.

$R_i = R_2$



$$\Rightarrow R_i = 3{,}0\ \Omega$$

SÄTT TILLBAKA R_1 PÅ DEN EKVIVALENTA TVÅPOLEN



$$J = \frac{E_i}{R_i + R_1} \Rightarrow J = 1{,}0\ A$$

$$P = R_1 \cdot J^2 \Rightarrow \underline{P = 3{,}0\ W}$$

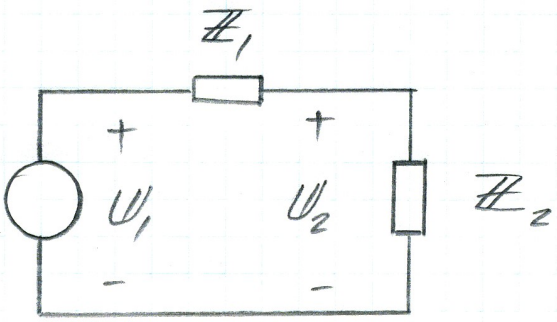
1b)

$P = P_{MAX}$ OM $R_1 = R_i$

I VÅRT FALL ÄR $R_1 = R_i = 3{,}0\ \Omega$

"ÄNDRA INTE R_1"

2a)



$$U_2 = U_1 \cdot \frac{\mathbb{Z}_2}{\mathbb{Z}_1 + \mathbb{Z}_2} \quad \ldots (1)$$

$$U_1 = 115\sqrt{2} \cdot e^{j0^\circ} \; V$$

$$\mathbb{Z}_1 = \frac{1}{jwC}$$

$$w = 120\pi \; \frac{RAD}{s} \; ; \; C = 84.5 \mu F$$

$$\rightarrow \quad \mathbb{Z}_1 = -j\,31.4 \; \Omega$$

$$\mathbb{Z}_2 = R + jwL$$

$$R = 20.0 \; \Omega \; ; \; L = 127 \; mH$$

$$\Rightarrow \quad \mathbb{Z}_2 = 20.0 + j\,47.1 \quad \Omega$$

INS ↑ (1) →

$$\underline{U}_2 = 115\sqrt{2}\cdot e^{j0^\circ}\cdot\frac{20{,}0+j47{,}1}{-j31{,}4+20{,}0+j47{,}1}\approx$$

$$\approx 115\sqrt{2}\cdot e^{j0^\circ}\,\frac{51{,}2\cdot e^{j67^\circ}}{25{,}4\cdot e^{j38^\circ}}\approx$$

$$\approx 232\sqrt{2}\,e^{j29^\circ}\ V \Rightarrow$$

$$u_2(t) = 232\sqrt{2}\sin\left(120\pi t + 29^\circ\right) V$$

2b) NYTT ω!

$\omega = 2\pi f \qquad f = 50\,Hz \rightarrow \omega = 100\pi\ \frac{RAD}{S}$

$\rightarrow \underline{Z}_1 = -j37{,}7\ \Omega$

$\underline{Z}_2 = 20{,}0 + j39{,}9\ \Omega$

$\underline{I} = \frac{\underline{U}}{\underline{Z}}$ OM $\underline{Z} = \frac{\underline{Z}_1\,\underline{Z}_2}{\underline{Z}_1+\underline{Z}_2}$

$U = 230V \rightarrow \hat{U} = 230\sqrt{2}\,V \rightarrow$

$\underline{U} = 230\sqrt{2}\,e^{j\arg\underline{U}}\ V$

$$\underline{Z} = \frac{-j37{,}7\,(20{,}0+j39{,}9)}{-j37{,}7+20{,}0+j39{,}9} =$$

$$= \frac{37{,}7\cdot e^{-j90^\circ}\cdot 44{,}6\cdot e^{j63^\circ}}{20{,}1\cdot e^{j6^\circ}} \approx$$

$$\approx 83{,}7\,e^{-j33^\circ}\ \Omega$$

$$\underline{I} = \frac{230\sqrt{2}\cdot e^{j\arg \underline{U}}}{83{,}7\,e^{-j33^\circ}} \approx$$

$$\approx 2{,}75\sqrt{2}\cdot e^{j(\arg \underline{U}+33^\circ)}\ A$$

$$\hat{I} = 2{,}75\sqrt{2}\ A \rightarrow \underline{\underline{I = 2{,}75\ A}}$$

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

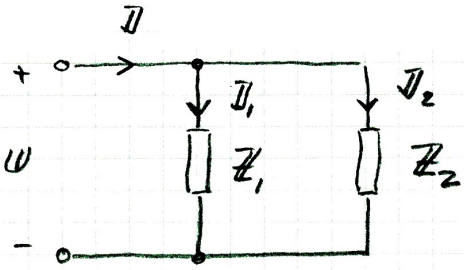
$$Q = U\cdot I\cdot \sin\varphi$$

OBS $\varphi = \arg \underline{U} - \arg \underline{I} = -33^\circ$

$$\Rightarrow P = 230\cdot 2{,}75\cdot \cos(-33^\circ) = \underline{\underline{530\ W}}$$

$$Q = 230\cdot 2{,}75\cdot \sin(-33^\circ) \approx \underline{\underline{-344\ VAr}}$$

Alternativ lösning till uppgift 2b)



VID $f = 50$ Hz FÅR $\underline{Z}_1$ OCH $\underline{Z}_2$ ANDRA VÄRDEN

$$\underline{Z}_1 = -j\frac{1}{100\pi \cdot 84{,}5 \cdot 10^{-6}} = -j37{,}7\ \Omega$$

$$\underline{Z}_2 = 20{,}0 + j100\pi \cdot 0{,}127 = (20{,}0 + j39{,}9)\ \Omega$$

$$I_1 = \frac{U}{|\underline{Z}_1|} \rightarrow I_1 = \frac{230}{37{,}7} \approx 6{,}10\ A$$

$$I_2 = \frac{U}{|\underline{Z}_2|} \rightarrow I_2 = \frac{230}{\sqrt{20{,}0^2 + 39{,}9^2}} \approx 5{,}15\ A$$

$$P = R \cdot I_2^2 \rightarrow P = 20{,}0 \cdot 5{,}15^2 = \underline{\underline{530\ W}}$$

$$Q_L = \omega L \cdot I_2^2 \rightarrow Q_L = 39{,}9 \cdot 5{,}15^2 = 1058\ VAr$$

$$Q_C = \frac{1}{\omega C} \cdot I_1^2 \rightarrow Q_C = 37{,}7 \cdot 6{,}10^2 = 1403\ VAr$$

$$Q = Q_L - Q_C \Rightarrow \underline{\underline{Q = -345\ VAr}}$$

$$S = \sqrt{P^2 + Q^2} \rightarrow S = 632\ VA$$

$$S = U \cdot I \rightarrow 632 = 230 \cdot I \rightarrow \underline{\underline{I = 2{,}75\ A}}$$

3a) $\frac{U_1}{U_2} = \frac{N_1}{N_2} \Rightarrow N_2 = N_1 \cdot \frac{U_2}{U_1}$

$\Rightarrow \underline{N_2 \approx 92 \text{ VARV}}$

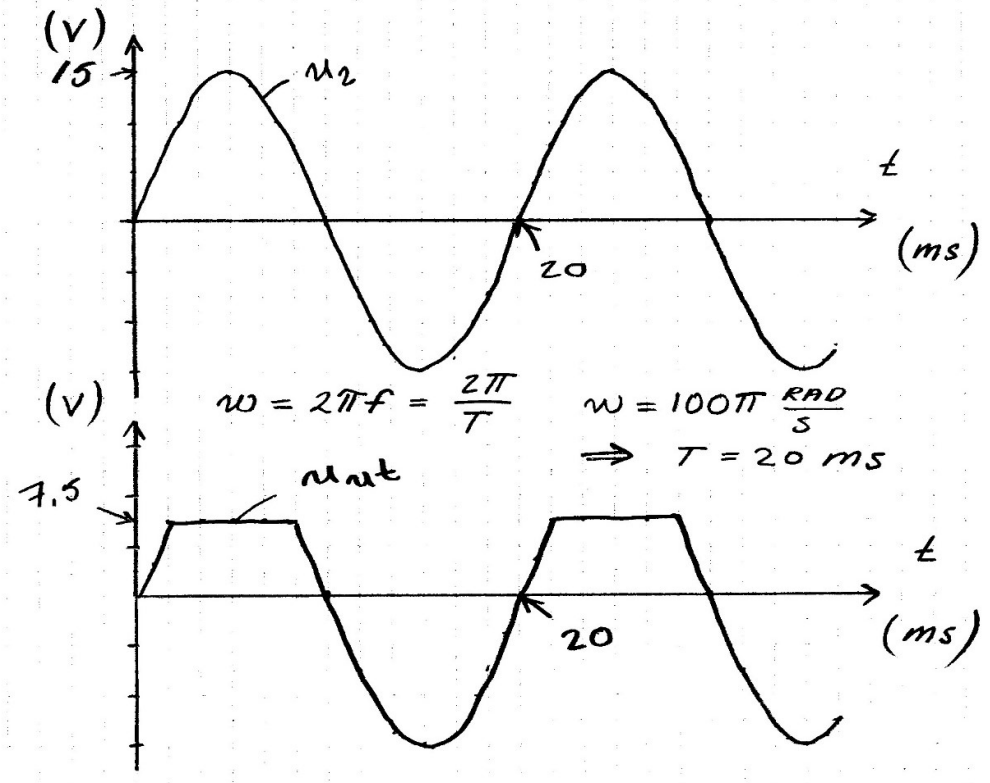
3b) $U_{ut} = E + 0{,}70 = 7{,}5 \text{ V}$

$\uparrow$

$6{,}8 \text{ V}$ OM $U_2 \geq 7{,}5 \text{ V}$ (Dioden leder)

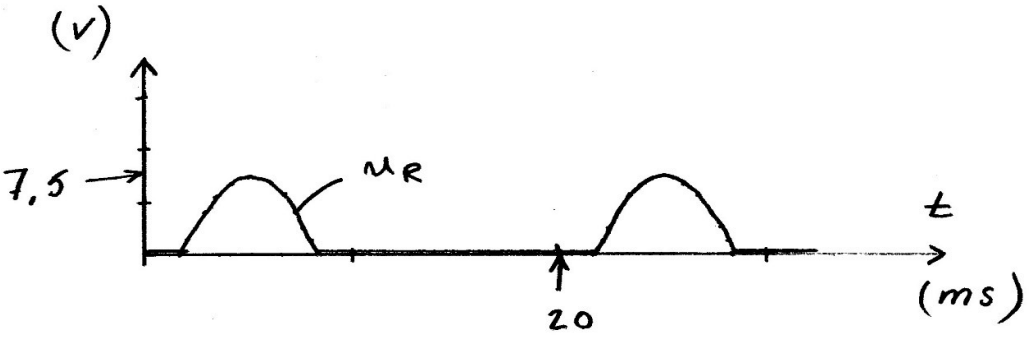
$U_{ut} = U_2$ OM $U_2 < 7{,}5 \text{ V}$ (Dioden spärrar)

$U_R = U_2 - U_{ut}$

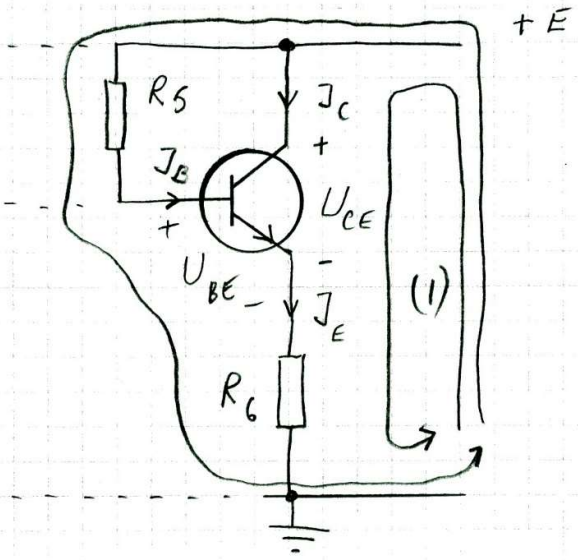


(V) $\omega = 2\pi f = \frac{2\pi}{T}$ $\omega = 100\pi \frac{\text{RAD}}{\text{S}}$

$\Rightarrow T = 20 \text{ ms}$



4. ARBETSPUNKTEN FÖR T2 :



$$+E - U_{CE} - R_6 J_E = 0 \quad \dots (1)$$

$$+E - R_5 J_B - U_{BE} - R_6 J_E = 0 \dots (2)$$

$$J_E = J_B + J_C = J_B + h_{FE} J_B = (1 + h_{FE}) J_B$$

INS I (2) $\rightarrow$

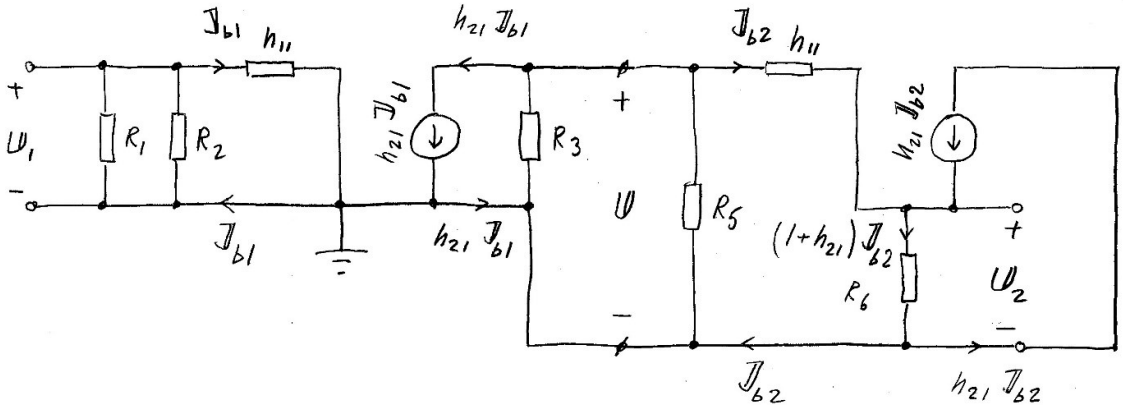
$$+10 - 270000\, J_B - 0{,}70 - 1000\,(1 + 400)\, J_B = 0$$

$$\rightarrow \quad J_B = 13{,}86\ \mu A$$

$$J_C = h_{FE} \cdot J_B \Rightarrow \underline{J_C = 5{,}5\ mA}$$

$$(1) \rightarrow +10 - U_{CE} - 1000\,(1 + 400) \cdot 13{,}86 \cdot 10^{-6} = 0$$

$$\Rightarrow \underline{U_{CE} = 4{,}4\ V}$$



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

$$U_2 = R_6 (1+h_{21}) I_{b2} = 401000\, I_{b2} \ldots (4)$$

$$U = h_{11} I_{b2} + R_6 (1+h_{21}) I_{b2} = 402100\, I_{b2} \ldots (5)$$

$$U = -h_{21} I_{b1} \cdot \left(R_3 // R_5 // \left(h_{11} + R_6 (1+h_{21}) \right) \right) =$$

$$= -187455\, I_{b1} \quad \ldots (6)$$

$$U_1 = h_{11} I_{b1} = 1100\, I_{b1} \ldots (7)$$

(4), (5), (6) & (7) INS I (3) $\rightarrow$

$$\frac{U_2}{U_1} = \frac{401000\, I_{b2}}{402100\, I_{b2}} \cdot \frac{-187455\, I_{b1}}{1100\, I_{b1}} \approx -170$$

$$\left| \frac{U_2}{U_1} \right| \approx 170 \text{ GÅNGER}$$

$$Z_{in} = R_1 // R_2 // h_{11} \rightarrow Z_{in} \approx 0{,}95\, k\Omega$$

$$Z_{ut} = R_6 // \left(\frac{h_{11} + (R_5 // R_3)}{1+h_{21}} \right) \rightarrow$$

$$Z_{ut} \approx 3{,}9\ \Omega$$

5.

$$u_2 = u_1 \cdot \frac{R_1 + R_2}{R_2} \Rightarrow u_2(t) = 3{,}0 \sin(1000t)\ V$$

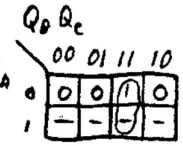
$$u_3 = -\frac{1}{R_3 C} \int u_2\, dt \Rightarrow u_3 = 3{,}0 \cos(1000t)\ V$$

$$u_4 = -\frac{R_5}{R_4} \cdot u_3 \Rightarrow u_4 = -1{,}0 \cos(1000t)\ V$$

6.

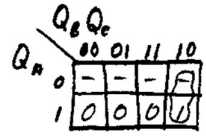
Q_A	Q_B	Q_C	J_A	K_A	J_B	K_B	J_C	K_C	Q_A^+	Q_B^+	Q_C^+
0	0	0	0	-	0	-	1	-	0	0	1
0	0	1	0	-	1	-	-	1	0	1	0
0	1	0	0	-	-	0	1	-	0	1	1
0	1	1	1	-	-	1	-	1	1	0	0
1	0	0	-	0	0	-	1	-	1	0	1
1	0	1	-	0	1	-	-	1	1	1	0
1	1	0	-	1	-	1	1	-	0	0	1
1	1	1	-	0	-	0	-	1	1	1	0

J_A:



$J_A = Q_B Q_C$

K_A:

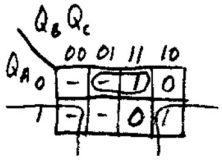


$K_A = Q_B \bar{Q}_C$

J_B:

$J_B = Q_C$

K_B:



$K_B = \bar{Q}_A Q_C + Q_A \bar{Q}_C \left(= Q_A \oplus Q_C\right)$

J_C:

$J_C = 1$

K_C:

$K_C = 1$