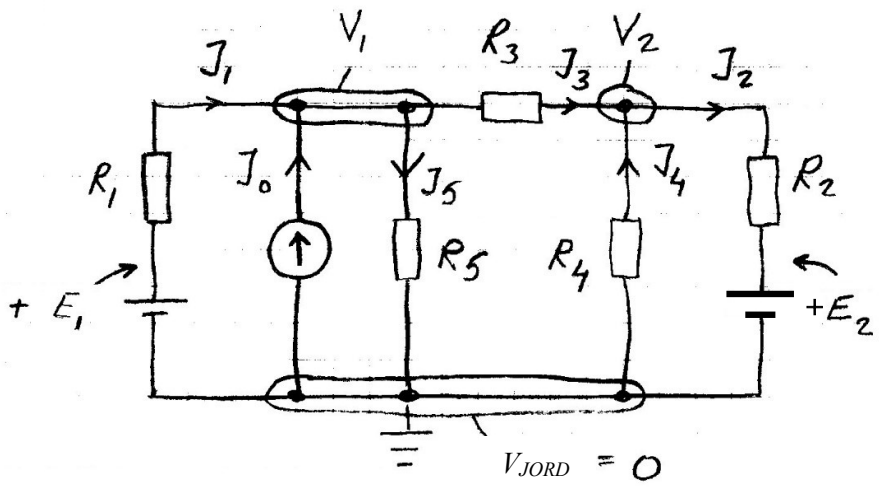
Lösningsförslag till tentamen TMMI04 Elektroteknik 2020-01-10

1.



$$J_1 + J_0 - J_5 - J_3 = 0 \quad \ldots (1)$$

$$J_3 + J_4 - J_2 = 0 \quad \ldots (2)$$

$$\frac{E_1 - V_1}{R_1} + J_0 - \frac{V_1 - 0}{R_5} - \frac{V_1 - V_2}{R_3} = 0 \quad \ldots (1)$$

$$\frac{V_1 - V_2}{R_3} + \frac{0 - V_2}{R_4} - \frac{V_2 - E_2}{R_2} = 0 \ldots (2)$$

$$\Rightarrow V_1 = +6{,}75\ V \qquad V_2 = +6.75\ V$$

$$J_3 = \frac{V_1 - V_2}{R_3} \Longrightarrow \underline{J_3 = 0}$$

2.

$$\underline{Z}_1 = R_1 + j\omega L = 65 + j2000\pi =$$

$$= \sqrt{65^2 + (2000\pi)^2}\, e^{j \arctan \frac{2000\pi}{65}} =$$

$$\approx 6284 \cdot e^{j89{,}4^\circ}\ \Omega$$

$$\underline{Z}_2 = R_2 + \frac{1}{j\omega C} = 100 - j \cdot \frac{10^6}{2000\pi} =$$

$$\approx \sqrt{100^2 + (-159)^2} \cdot e^{j \arctan \frac{-159}{100}} =$$

$$\approx 188 \cdot e^{-j57{,}9^\circ}\ \Omega$$

$$\underline{Z} = \frac{\underline{Z}_1 \underline{Z}_2}{\underline{Z}_1 + \underline{Z}_2} = \frac{6284 \cdot e^{j89{,}4^\circ} \cdot 188 \cdot e^{-j57{,}9^\circ}}{65 + j2000\pi + 100 - j159} =$$

$$\approx \frac{1{,}18 \cdot 10^6 \cdot e^{j31{,}5^\circ}}{165 + j6124} \approx \frac{1{,}18 \cdot 10^6 \cdot e^{j31{,}5^\circ}}{6126 \cdot e^{j88{,}5^\circ}} =$$

$$\approx 193 \cdot e^{-j57^\circ}\ \Omega$$

$$I = \frac{U}{|\underline{Z}|} \quad \text{där} \quad U = \frac{\hat{U}}{\sqrt{2}} = 500\,V$$

$$I = \frac{500}{193} \approx \underline{2{,}6\,A}$$

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

$$P = 500 \cdot 2{,}6 \cdot \cos(-57^\circ) \approx \underline{0{,}71\,kW}$$

$$\left(arg(Z) = arg\left(\frac{U}{I}\right) = arg(U) - arg(I) = \varphi \quad \Rightarrow \quad \varphi = -57^\circ\right)$$

3a)

$$R = \frac{U_C - U_Z}{I_R} \quad \text{dar} \quad I_R = I_Z + I_L$$

$$\Rightarrow \quad R_{MAX} = \frac{10 - 5{,}1}{0{,}100 + 0{,}500} \approx \underline{8{,}2\ \Omega}$$

$$P_{Z\,max} = U_Z \cdot I_{Z\,max}$$

$$\Rightarrow \quad I_{Z\,max} = \frac{5{,}1}{5{,}1} = 1{,}0\ A$$

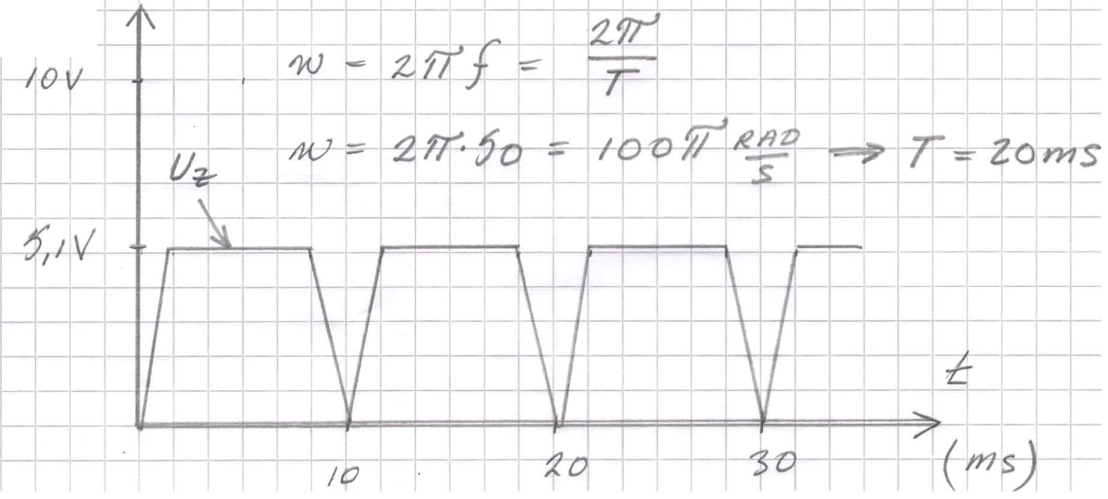
$$R_{MIN} = \frac{10 - 5{,}1}{1{,}0 + 0} = \underline{4{,}9\ \Omega}$$

b)

$$\frac{N_1}{N_2} = \frac{\hat{U}_1}{\hat{U}_2} = \frac{\hat{U}_1}{U_C + 2 \cdot U_{DIOD}}$$

$$\frac{N_1}{N_2} = \frac{230\sqrt{2}}{10 + 2 \cdot 0{,}70} \approx 29$$

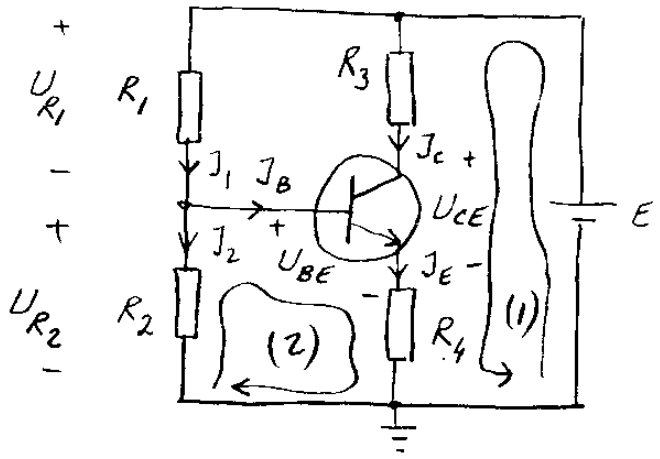
c)



$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$\omega = 2\pi \cdot 50 = 100\pi \ \frac{RAD}{s} \rightarrow T = 20ms$$

4a) LIKSTRÖMSSCHEMA



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

$$+ U_{R_2} - U_{BE} - R_4 J_E = 0 \quad \ldots (2)$$

$$J_B = \frac{J_C}{h_{FE}} \Rightarrow J_B = 17{,}5\,\mu A$$

$$J_E = J_B + J_C \Rightarrow J_E \approx 1{,}42\,mA$$

$$(1) \rightarrow +12 - R_3 \cdot 0{,}0014 - 6{,}0 - 1000 \cdot 0{,}00142 = 0$$

$$\Rightarrow R_3 \approx 3{,}3\,k\Omega$$

$$(2) \rightarrow U_{R_2} - 0{,}70 - 1000 \cdot 0{,}00142 = 0$$

$$\rightarrow U_{R_2} \approx 2{,}12\,V$$

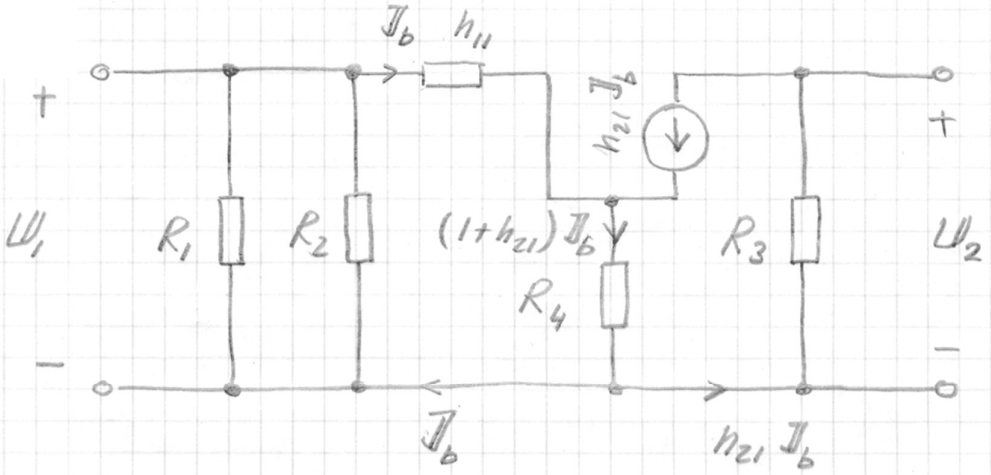
$$\rightarrow U_{R_1} \approx 12 - 2{,}12 = 9{,}88\,V$$

$$I_2 = \frac{U_{R2}}{R_2} \approx 141{,}2\ \mu A$$

$$I_1 = I_2 + I_B \approx 158{,}7\ \mu A$$

$$R_1 = \frac{U_{R1}}{I_1} \approx 62\ k\Omega$$

b)



$$\underline{U}_2 = -h_{21}\,\underline{I}_b\,R_3$$

$$\underline{U}_1 = h_{11}\,\underline{I}_b + (1+h_{21})\,\underline{I}_b\,R_4$$

$$\frac{\underline{U}_2}{\underline{U}_1} = \frac{-h_{21}R_3}{h_{11} + (1+h_{21})R_4} \approx -3{,}2$$

$$\Rightarrow \underline{U}_2 = -3{,}2 \cdot \underline{U}_1 = 3{,}2 \cdot e^{j180°} \cdot 20 \cdot e^{j0°}\ mV =$$

$$= 64 \cdot e^{j180°}\ mV$$

$$\Rightarrow u_2(t) = 64 \sin(1000t + 180°)\ mV$$

c) AVKOPPLINGSKONDENSATOR ÖVER R_4 ("R_4 KORTSLUTEN") $\Rightarrow$

$$U_2 = -h_{21} I_b R_3$$

$$U_1 = h_{11} I_b$$

$$\frac{U_2}{U_1} = -\frac{h_{21} R_3}{h_{11}} \approx -165$$

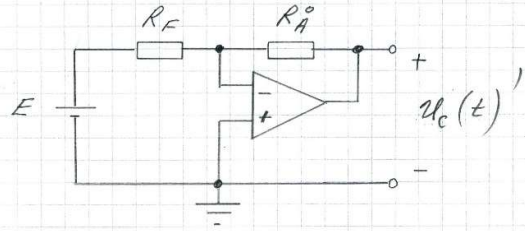
$$\Rightarrow U_2 = -165 \cdot U_1 =$$

$$= 165 \cdot e^{j180^\circ} \cdot 20 \cdot e^{j0^\circ} \text{ mV} = 3{,}3 \cdot e^{j180^\circ} \text{ V}$$

$$\Rightarrow u_2(t) = 3{,}3 \sin(1000t + 180^\circ) \text{ V}$$

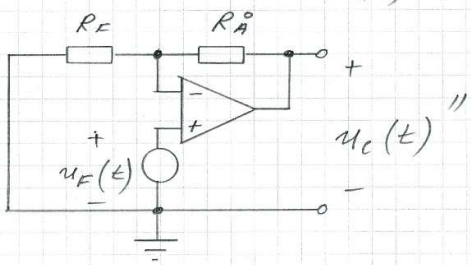
5.

5. NOLLSTÄLL $u_F(t)$. BERÄKNA BIDRAGET FRÅN E:



$$\frac{u_c(t)'}{E} = -\frac{R_A^\circ}{R_F} \rightarrow u_c(t)' = -4{,}0\ V$$

NOLLSTÄLL E. BERÄKNA BIDRAGET FRÅN $u_F(t)$:



$$\frac{u_c(t)''}{u_F(t)} = \frac{R_A^\circ + R_F}{R_F}$$

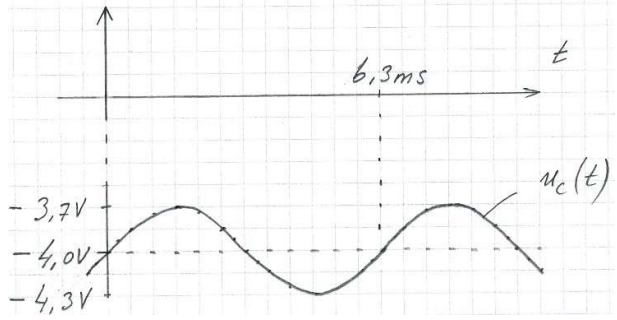
$$\Rightarrow u_c(t)'' = 0{,}30\sin(1000t)\ V$$

$$u_c(t) = u_c(t)' + u_c(t)'' \rightarrow$$

$$u_c(t) = -4{,}0 + 0{,}30\sin(1000t)\ V$$

$$w = 1000\ \frac{RAD}{s}$$

$$w = \frac{2\pi}{T} \Rightarrow T \approx 6{,}3\ ms$$



6.

Q	J K	Q^+
0	0 –	0
0	1 –	1
1	– 1	0
1	– 0	1

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 –	– 0	0 1 1
0	1	0	0 –	– 1	1 –	0 0 1
0	1	1	1 –	– 0	– 0	1 1 1
1	0	0	– 1	0 –	0 –	0 0 0
1	0	1	– 0	1 –	– 1	1 1 0
1	1	0	– 0	– 1	0 –	1 0 0
1	1	1	– 0	– 0	– 1	1 1 0

VI FÅR : $J_A = Q_B \cdot \bar{Q}_C$ $J_B = \bar{Q}_C$ $J_C = \bar{Q}_A$

$K_A = \bar{Q}_B \cdot \bar{Q}_C$ $K_B = \bar{Q}_C$ $K_C = Q_A$