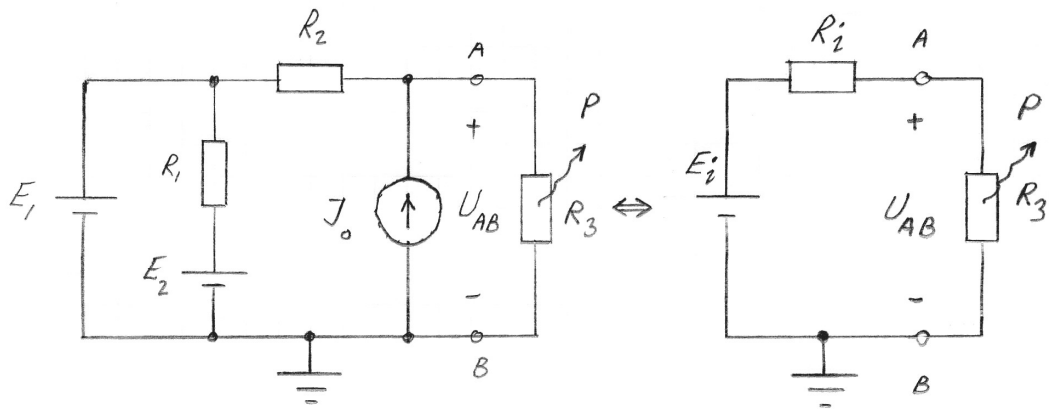
Lösningsförslag till tentamen TMEL08 Eltekniska system 2022-10-25

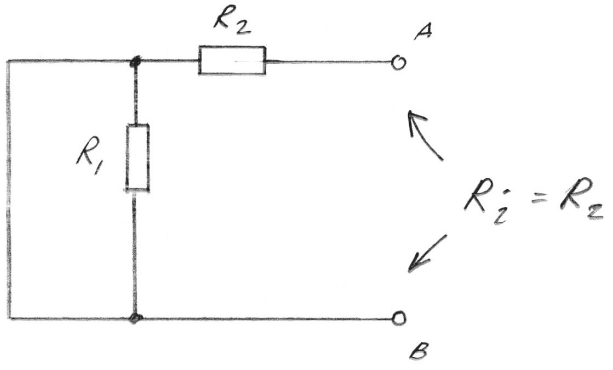
1.



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

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

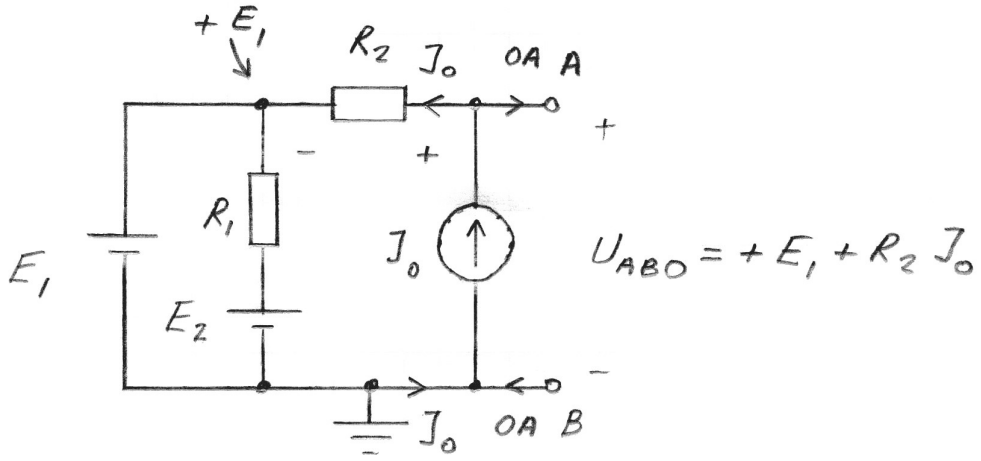
a) NOLLSTÄLL E_1, E_2 OCH J_0.
BESTÄM R_i MELLAN A OCH B.



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

b) BESTÄM TOMGÅNGSSPÄNNINGEN U_{ABO}

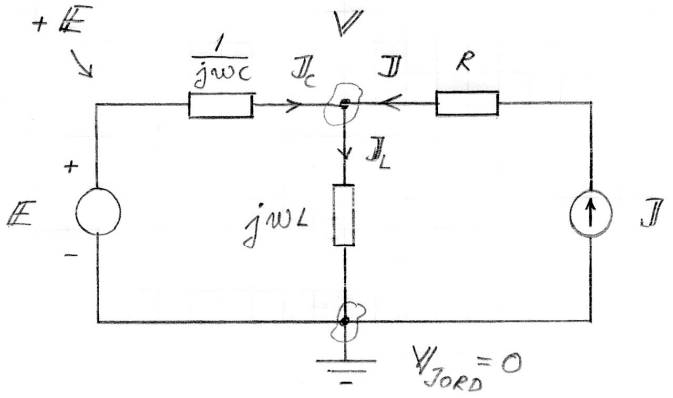
$E_i = U_{ABO}$



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

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

2.



$$I_C + J = I_L \Rightarrow I_C + J - I_L = 0$$

$$\Rightarrow \frac{+E - V}{1/j\omega C} + J - \frac{V - V_{JORD}}{j\omega L} = 0$$

$$\frac{10\sqrt{2}\cdot e^{j0^\circ} - V}{1/j0{,}020} + 0{,}20\sqrt{2}\cdot e^{j90^\circ} - \frac{V-0}{j\,100} = 0$$

$$j0{,}20\sqrt{2} - j0{,}02V + j0{,}20\sqrt{2} + j0{,}01V = 0$$

$$j\,0{,}01\,V = j0{,}40\sqrt{2} \Rightarrow V = +40\sqrt{2}\ V$$

$$I_L = \frac{V - V_{JORD}}{j\omega L} \rightarrow I_L = \frac{40\sqrt{2} - 0}{j\,100} = 0{,}40\sqrt{2}\,e^{-90^\circ}\ A$$

$$\rightsquigarrow \underline{\underline{i_L(t) = 0{,}40\sqrt{2}\sin(1000t - 90^\circ)\ A}}$$

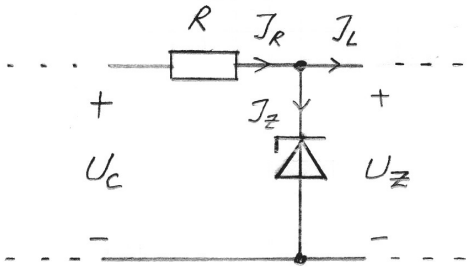
$P = R \cdot J^2$ DÄR J ÄR EFFEKTIV-VÄRDET AV $i(t)$.

$$\underline{\underline{P = 100 \cdot 0{,}20^2 = 4{,}0\ W}}$$

3a)

$$\frac{u_1}{u_2} = \frac{N_1}{N_2} \Rightarrow u_2 = 23\sqrt{2}\sin(100\pi t)\ V$$

b)



$$U_c \approx \hat{U}_2 - 2 \cdot 0{,}70 \Rightarrow U_c = 31{,}1\ V$$

$$P_z = U_z J_z \Rightarrow J_{z_{max}} = 0{,}833\ A$$

$$R_{min} = \frac{U_c - U_z}{J_{R_{max}}} \qquad J_{R_{max}} = J_{z_{max}} \text{ då } J_L = 0$$

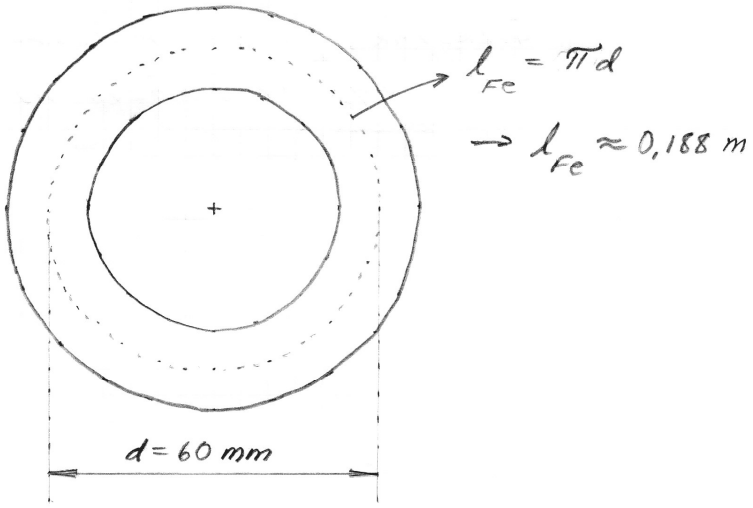
$$R_{min} = \frac{31{,}1 - 12}{0{,}833} \approx 23\ \Omega$$

$$R_{max} = \frac{U_c - U_z}{J_{R_{min}}} \qquad J_{R_{min}} = J_{z_{min}} + J_{L\,max}$$

$$R_{max} = \frac{31{,}1 - 12}{0{,}100 + 0{,}600} \approx 32\ \Omega$$

ALLTSÅ VÄLJ R: $23\ \Omega < R < 32\ \Omega$

c)



$N, J_1 = R_m \Phi$

FALL 1: INGEN SPRICKA

$$\Rightarrow R_{m1} = R_{mFe} = \frac{l_{Fe}}{\mu_r \mu_0 A_{Fe}} = 133333\ \frac{A}{Vs}$$

$$A_{Fe} = 0{,}015 \cdot 0{,}015\ m^2 = 2{,}25 \cdot 10^{-4}\ m^2$$

FALL 2: MED SPRICKA δ

$$R_{m2} = R_{mFe} + R_\delta \quad \text{DÄR} \quad R_\delta = \frac{\delta}{\mu_0 A_\delta}$$

INGEN LUFTGAPSSPRIDNING $A_\delta \approx A_{Fe}$

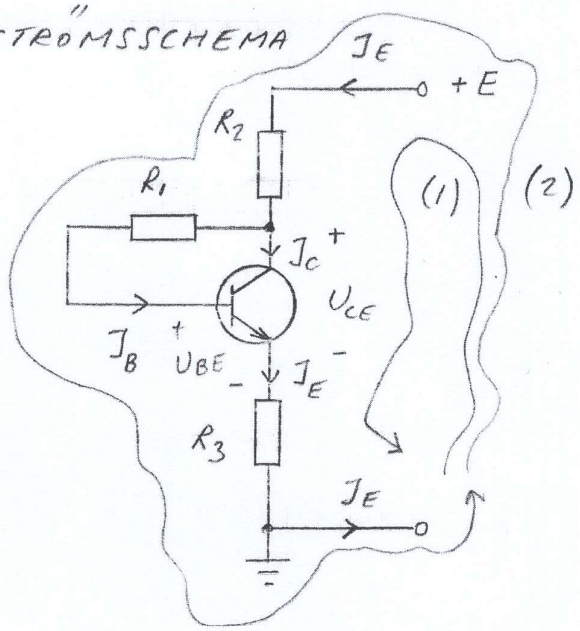
$$\Rightarrow R_{m2} = 310172\ \frac{A}{Vs}$$

J_1 OFÖRÄNDRAD $\rightarrow$

$$R_{m1} \Phi_1 = R_{m2} \Phi_2 \rightarrow \frac{\Phi_2}{\Phi_1} = 0{,}43$$

DVS. 43% AV MAGNETISKA FLÖDET ÅTERSTÅR. FLÖDET MINSKAR SÅLEDES MED 57% TILL FÖLJD AV SPRICKAN.

4a) LIKSTRÖMSSCHEMA



$$+E - R_2 I_E - U_{CE} - R_3 I_E = 0 \quad \ldots\ldots (1)$$

$$+E - R_2 I_E - R_1 I_B - U_{BE} - R_3 I_E = 0 \ldots\ldots (2)$$

$$I_E = I_B + I_C = I_B + h_{FE} I_B = I_B (1 + h_{FE})$$

$$(2) \Rightarrow +E - R_2 I_B (1+h_{FE}) - R_1 I_B - U_{BE} - R_3 I_B (1+h_{FE}) = 0$$

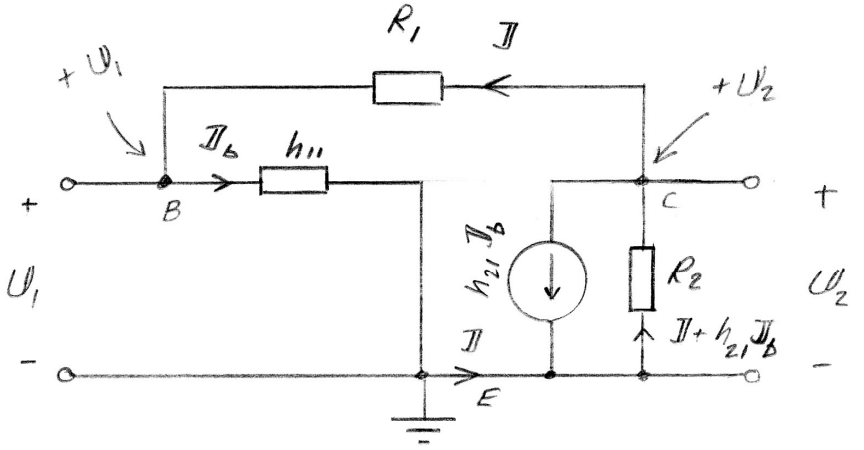
$$\Rightarrow \underline{\underline{I_C = h_{FE} I_B}} \quad \text{DÄR}$$

$$I_B = \frac{E - U_{BE}}{R_2 (1+h_{FE}) + R_1 + R_3 (1+h_{FE})}$$

$$(1) \Rightarrow \underline{\underline{U_{CE} = E - (R_2 + R_3) I_E}} \quad \text{DÄR}$$

$$I_E = I_B (1 + h_{FE})$$

b)



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

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

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

$$U_1 = h_{11} I_b \rightarrow I_b = \frac{U_1}{h_{11}}$$

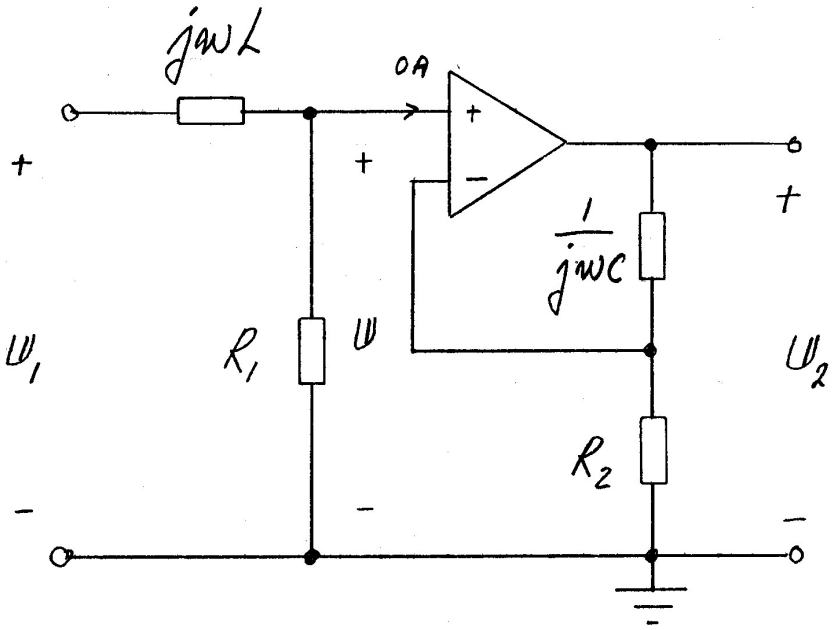
INS. (4) $\rightarrow$

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

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

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

5.



$$U = U_1 \cdot \frac{R_1}{R_1 + j\omega L} = U_1 \cdot \frac{1}{1 + j\omega \frac{L}{R_1}} \quad \ldots(1)$$

$$U_2 = U \cdot \frac{\frac{1}{j\omega C} + R_2}{R_2} = U \cdot \frac{1 + j\omega C R_2}{j\omega C R_2} \quad \ldots(2)$$

(1) ΚΑΙ (2) $\rightarrow$

$$\frac{U_2}{U_1} = \frac{1 + j\omega C R_2}{\left(1 + j\omega \frac{L}{R_1}\right) j\omega C R_2} \Rightarrow$$

$$\left|\frac{U_2}{U_1}\right| = \frac{\sqrt{1^2 + (\omega C R_2)^2}}{\sqrt{1^2 + \left(\omega \cdot \frac{L}{R_1}\right)^2} \cdot \omega C R_2} \Rightarrow$$

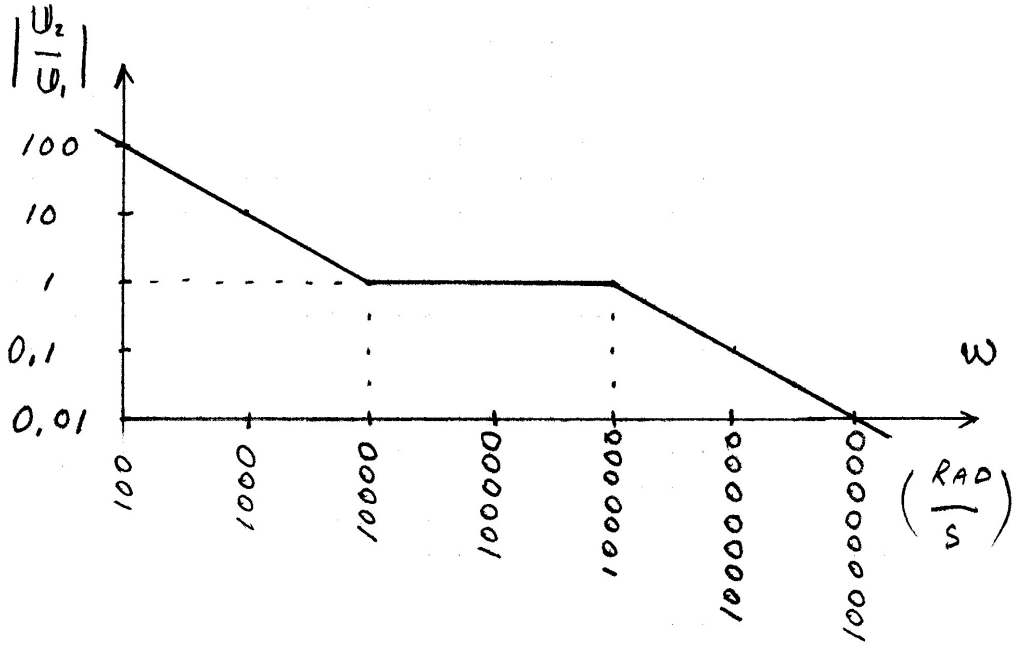
$$\left|\frac{U_2}{U_1}\right| = \frac{\sqrt{1^2 + \left(\frac{w}{10000}\right)^2}}{\sqrt{1^2 + \left(\frac{w}{1000000}\right)^2} \cdot \frac{w}{10000}}$$

$$w << 10000 \rightarrow \left|\frac{U_2}{U_1}\right| \approx \frac{10000}{w}$$

$$10000 << w << 1000000 \rightarrow \left|\frac{U_2}{U_1}\right| \approx 1$$

$$w >> 1000000 \rightarrow \left|\frac{U_2}{U_1}\right| \approx \frac{1000000}{w}$$

AMPLITUDKURVAN :



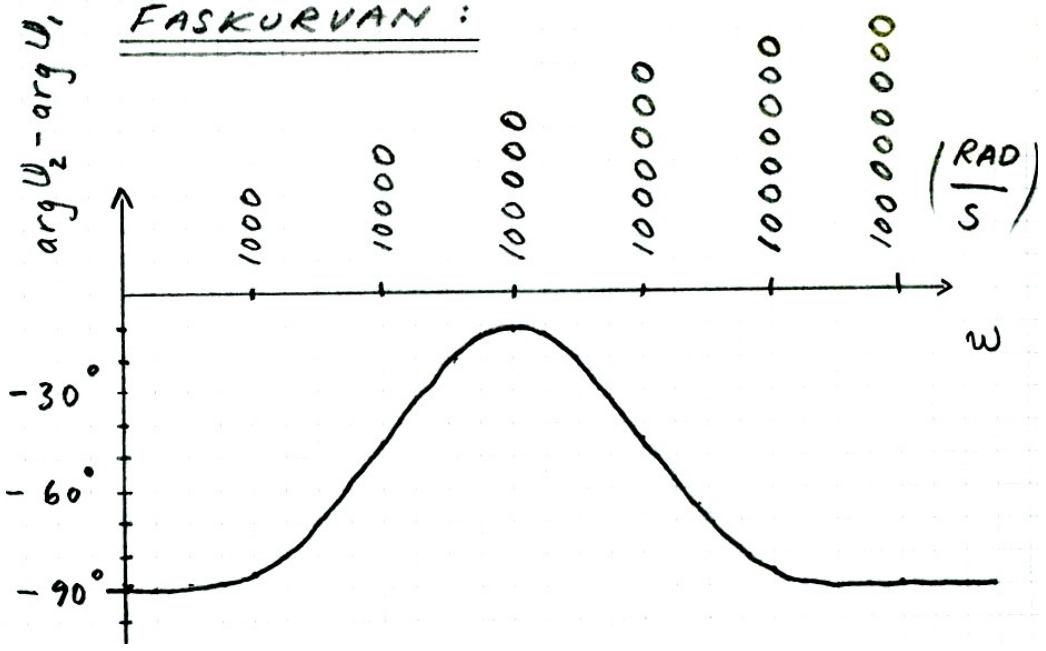
$$\arg U_2 - \arg U_1 = \arg\left(\frac{U_2}{U_1}\right) =$$

$$= \arg\left(\frac{1+jwCR_2}{\left(1+jw\frac{L}{R_1}\right)jwCR_2}\right) =$$

$$= \underbrace{\arg\left(1+jwCR_2\right)}_{\arctan(wCR_2)} - \underbrace{\arg\left(1+jw\cdot\frac{L}{R_1}\right)}_{\arctan\left(\frac{wL}{R_1}\right)} - \underbrace{\arg\left(jwCR_2\right)}_{90^\circ}$$

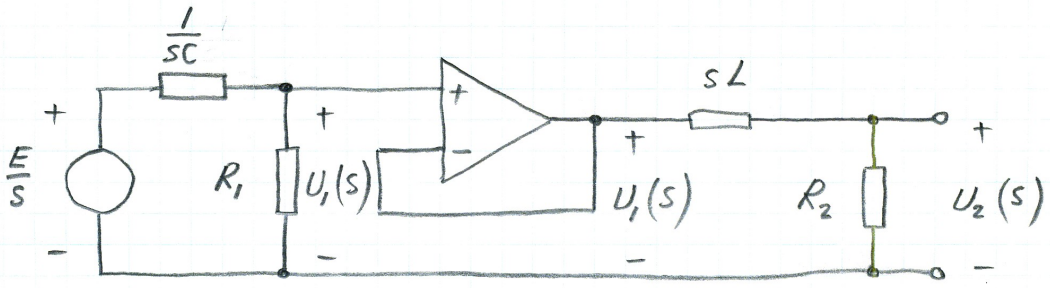
$w\ (^{RAD}/_{S})$	$\arg U_2 - \arg U_1$
100	-89°
1000	-84°
10000	-46°
100000	-11°
1000000	-46°
10000000	-84°
100000000	-89°

FASKURVAN :



6. BEGYNNELSEVILLKOR: C "ÄR OLADDAD OCH INGEN STRÖM FLYTER GENOM L ($t<0$)

OPERATORSCHEMA ($t \geq 0$):



$$U_1(s) = \frac{E}{s} \cdot \frac{R_1}{\frac{1}{sC} + R_1} = \frac{E}{s + \frac{1}{CR_1}}$$

$$\Rightarrow U_1(s) = \frac{2,5}{s+50} \rightsquigarrow u_1(t) = 2,5e^{-50t} \text{ V}$$

$$U_2(s) = U_1(s) \cdot \frac{R_2}{sL + R_2} = \frac{E}{s + \frac{1}{CR_1}} \cdot \frac{\frac{R_2}{L}}{s + \frac{R_2}{L}}$$

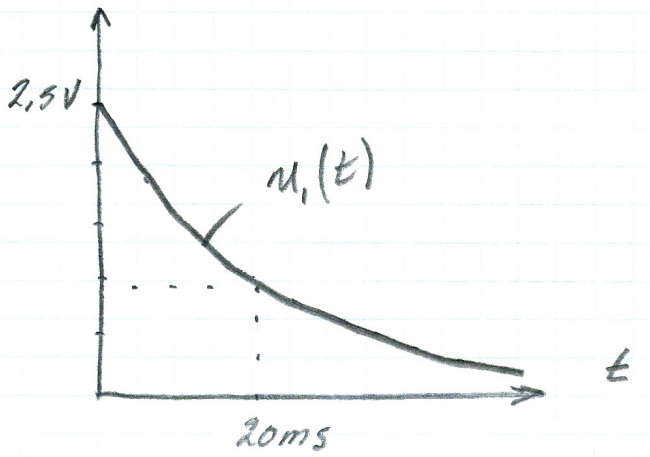
$$\Rightarrow U_2(s) = 250 \cdot \frac{1}{s+50} \cdot \frac{1}{s+100} = \frac{5}{s+50} - \frac{5}{s+100}$$

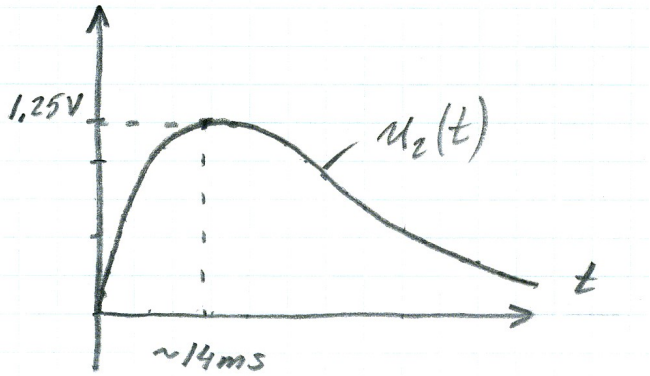
$$\rightsquigarrow u_2(t) = 5 \cdot e^{-50t} - 5 \cdot e^{-100t} \text{ V}$$

ALTERNATIVT:

$$u_2(t) = 5 \cdot e^{(-75+25)t} - 5 \cdot e^{(-75-25)t} =$$

$$= 5 \cdot e^{-75t} \cdot (e^{25t} - e^{-25t}) = 10 \cdot e^{-75t} \cdot \sinh(25t) \text{ V}$$


2,5V
$u_1(t)$
t
20ms


1,25V
$u_2(t)$
t
~14ms