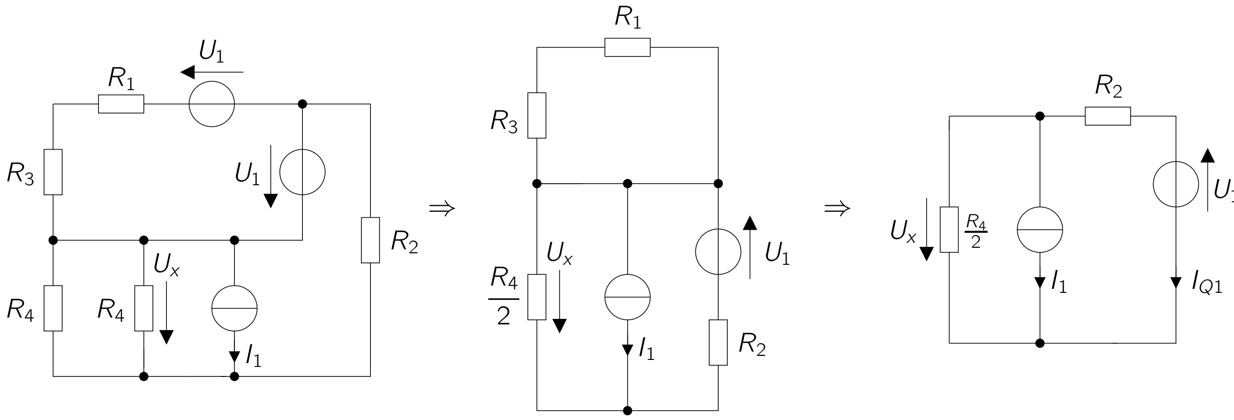
Aufgabe 1

(a) i)



<u>Superposition</u>

$$U_1 = 0 \Rightarrow U_x' = -I_1 \left(\frac{R_4}{2} \parallel R_2 \right) = -I_1 \left(\frac{\frac{R_4}{2} R_2}{\frac{R_4}{2} + R_2} \right)$$

$$I_1 = 0 \Rightarrow U_x'' = -U_1 \frac{\frac{R_4}{2}}{\frac{R_4}{2} + R_2}$$

Gesamt: $U_x = U_x' + U_x'' = -I_1 \left(\frac{\frac{R_4}{2} R_2}{\frac{R_4}{2} + R_2} \right) - U_1 \frac{\frac{R_4}{2}}{\frac{R_4}{2} + R_2}$

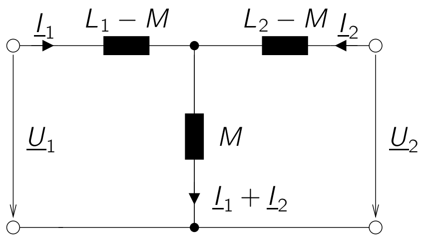
ii) Gesamtlösung: Summe der Leistungen an den Quellen:

$$P_{\sum} = P_{Stromquelle} + P_{Spannungspuelle}$$
$$= -I_1 U_x + U_1 I_{Q1} = I_1 U_x + U_1 \left(\frac{U_x}{\frac{R_4}{2}} + I_1 \right)$$

(b)

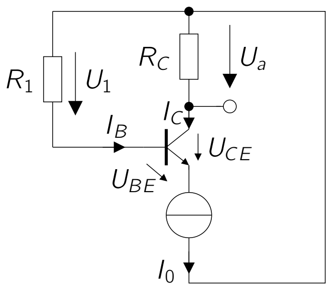
$$\begin{aligned}
\underline{U}_1 &= \mathrm{j}\,\omega L_1 \underline{I}_1 + \mathrm{j}\,\omega M \underline{I}_2 \qquad | + \mathrm{j}\,\omega M \underline{I}_1 - \mathrm{j}\,\omega M \underline{I}_1 \\
\underline{U}_2 &= \mathrm{j}\,\omega M \underline{I}_1 + \mathrm{j}\,\omega L_2 \underline{I}_2 \qquad | + \mathrm{j}\,\omega M \underline{I}_2 - \mathrm{j}\,\omega M \underline{I}_2
\end{aligned}$$

$$\begin{aligned}
\Leftrightarrow \qquad \underline{U}_1 &= \mathrm{j}\,\omega (L_1 - M) \underline{I}_1 + \mathrm{j}\,\omega M (\underline{I}_2 + \underline{I}_1) \\
\Leftrightarrow \qquad \underline{U}_2 &= \mathrm{j}\,\omega M (\underline{I}_1 + \underline{I}_2) + \mathrm{j}\,\omega (L_2 - M) \underline{I}_2
\end{aligned}$$



Aufgabe 2

(a)



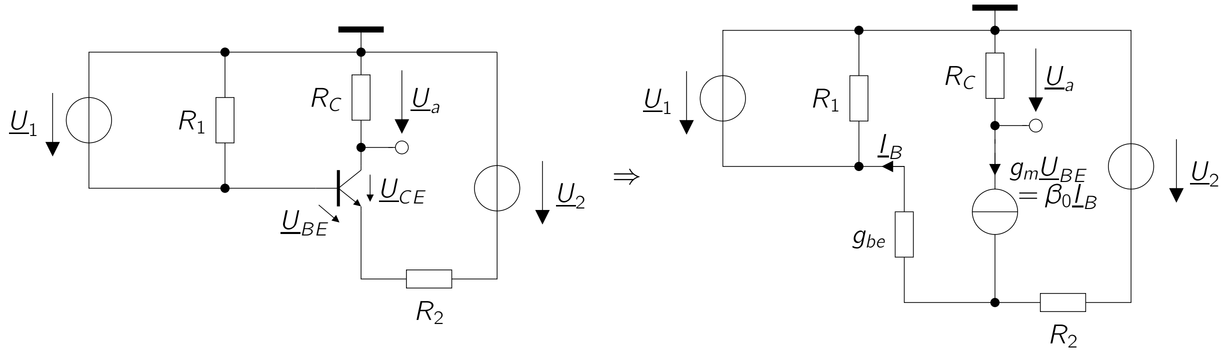
(b)

$$U_{CE} = 10\,U_{BE}$$
$$U_a = 5\,U_{BE}$$

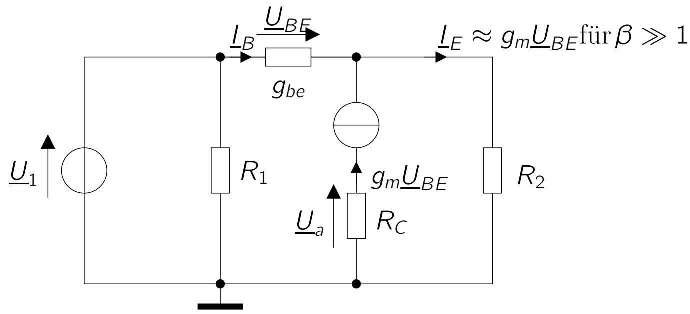
$$I_E = I_0 = I_C + I_B = I_B B + I_B = I_B\,(B+1) \qquad I_B > 0 \quad \text{für normal aktiv}$$
$$\Leftrightarrow I_0 = I_C\left(1 + \frac{1}{B}\right) \Rightarrow I_C = \frac{I_0 B}{B+1}$$

$$U_a = I_C R_C \Leftrightarrow R_C = \frac{U_a}{I_C} = \frac{5\,U_{BE}\,(B+1)}{I_0 B}$$
$$U_1 = R_1 I_B = R_1 \frac{I_0}{B+1}$$
$$U_{BE} + U_1 = U_a + U_{CE} \Leftrightarrow U_1 = U_a + U_{CE} - U_{BE} = 14\,U_{BE}$$
$$\Rightarrow R_1 = \frac{B+1}{I_0} U_1 = \frac{B+1}{I_0} 14\,U_{BE}$$

(c)



(d)



Für $U_2 = 0$ gilt:

$\underline{U}_a = g_m \, \underline{U}_{BE} \, R_C = \beta_0 \underline{I}_B R_C$

$\underline{I}_C \approx \underline{I}_E \quad \text{für} \, \beta \gg 1$

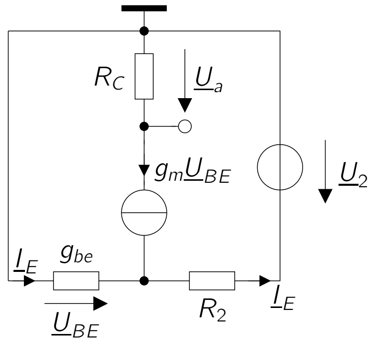
$$\underline{U}_1 = -\underline{I}_B \frac{1}{g_{be}} - \beta_0 \underline{I}_B R_2$$

$$\Leftrightarrow \underline{I}_B = -\frac{\underline{U}_1}{\frac{1}{g_{be}} + \beta_0 R_2}$$

$$\Rightarrow \underline{U}_a = -\beta_0 \frac{R_C \underline{U}_1}{\frac{1}{g_{be}} + \beta_0 R_2}$$

$$\left.\frac{\underline{U}_a}{\underline{U}_1}\right|_{\underline{U}_2 = 0} = -\frac{\beta_0 R_C}{\frac{1}{g_{be}} + \beta_0 R_2} = -\frac{R_C}{\frac{1}{g_m} + R_2}$$

(e)



Für $U_1 = 0$ gilt:

$$\underline{U}_a = \beta_0 \underline{I}_B R_C = g_m \underline{U}_{BE} R_C$$

$$\underline{U}_2 = \underline{I}_B \tfrac{1}{g_{be}} + \beta_0 \underline{I}_B R_2 \quad | \, \beta \gg 1 \ \Rightarrow \underline{I}_E \approx \underline{I}_C$$

$$\underline{I}_B = \frac{\underline{U}_2}{\frac{1}{g_{be}} + \beta_0 R_2}$$

$$\left.\frac{\underline{U}_a}{\underline{U}_2}\right|_{\underline{U}_1=0} = \beta_0 R_C \frac{\underline{U}_2}{\frac{1}{g_{be}} + \beta_0 R_2} = \frac{\beta_0 R_C}{\frac{1}{g_{be}} + \beta_0 R_2} = \frac{R_C}{\frac{1}{g_m} + R_2}$$

$$\underline{U}_{a,ges} = \left.\frac{\underline{U}_a}{\underline{U}_1}\right|_{\underline{U}_2=0} + \left.\frac{\underline{U}_a}{\underline{U}_2}\right|_{\underline{U}_1=0} = -\frac{R_C}{\frac{1}{g_m} + R_2}\underline{U}_1 + \frac{R_C}{\frac{1}{g_m} + R_2}\underline{U}_2 = \frac{R_C}{\frac{1}{g_m} + R_2}\left(\underline{U}_2 - \underline{U}_1\right)$$

Aufgabe 3

(a) i)

Fall 1:

$I_C = 0$

$\Rightarrow U_{CE} = U_0 = 1{,}2\,\mathrm{V}$

Fall 2:

$U_{CE} = 0$

$\dfrac{U_0}{R_C} = I_C = \dfrac{1{,}2\,\mathrm{V}}{40\,\Omega} = 30\,\mathrm{mA}$

ii)

$I_B \geq 100\,\mu\mathrm{A}$

bzw.

$I_B \leq 25\,\mu\mathrm{A}$

um Bedingung zu erfüllen

(b) Graphische Bestimmung des Arbeitspunktes: $U_D \approx 0{,}82\,\mathrm{V}$ und $I_D \approx 2{,}9\,\mathrm{mA}$

Fall 1: $I_D = 0$

$\Rightarrow U_D = I_0 R_1 = 14\,\mathrm{mA}\,100\,\Omega = 1{,}4\,\mathrm{V}$

Fall 2: $U_D = 0$

$$I_D = I_0 \frac{R_2}{R_1 + R_2} = 14\,\mathrm{mA} \cdot 0{,}5 = 7\,\mathrm{mA}$$

Aufgabe 4

(a) $0 \leq t \leq D\,T$

$$u_{out}\,(t) = -C\,R\,\frac{du_{out}\,(t)}{dt} \qquad i_C = C\,\frac{du_{out}\,(t)}{dt}$$

$$u_{out}\,(t) = -C\,R\,\dot{u} \qquad i_R = \frac{u_{out}\,(t)}{R}$$

$$-i_C = i_R$$

$D\,T \leq t < T$

$$I_0 = i_C$$

$$I_0 = C\,\frac{du_{out}\,(t)}{dt}$$

$$I_0 = C\,\dot{u}_{out}\,(t)$$

(b)

$$0 \leq t \leq D\,T$$

$$u_{out}\left(t\right) = -CR\,\frac{du_{out}\left(t\right)}{dt} \quad |\text{Ansatz} \rightarrow e^{\lambda t}$$

$$e^{\lambda t} = -CR\,\lambda\,e^{\lambda t}$$

$$1 = -CR\,\lambda$$

$$\lambda = -\frac{1}{RC}$$

Lösung: $0 \leq t \leq D\,T$

$$\begin{aligned} u_{out}\left(t\right) &= k_1 e^{-\frac{t}{RC}} && k_1 \text{ ist Anfgangsbedingung} \\ &= u_{out}\left(0\right) e^{-\frac{t}{RC}} && k_1 = u_{out}\left(t=0\right) = u_{out,max} \end{aligned}$$

$$D\,T \leq t < T$$

$$I_0 = C\,\frac{du_{out}\left(t\right)}{dt} \qquad \Big|\int\limits_{DT}^{T} dt$$

$$\int\limits_{DT}^{T} I_0 dt = C\int\limits_{DT}^{T} \frac{du_{out}\left(t\right)}{dt} dt = C\int\limits_{DT}^{T} du_{out}\left(t\right) \qquad |I_0 \text{ ist konstant}$$

$$I_0\left(T - D\,T\right) = C\left[u_{out}\left(T\right) - u_{out}\left(D\,T\right)\right]$$

(c)

$$0 \leq t \leq D\,T$$

$$u_{out}\,(t) = u_{out}\,(0)\;e^{-\frac{t}{RC}} \qquad |e^x \approx (1+x) \parallel RC \ll \frac{1}{T}$$

$$u_{out}\,(t) = u_{out}\,(0)\left(1 - \frac{t}{RC}\right) \qquad |t = DT$$

$$u_{out}\,(DT) = u_{out}\,(0)\left(1 - \frac{DT}{RC}\right)$$

$$u_{out}\,(DT) = u_{out}\,(0) - u_{out}\,(0)\,\frac{DT}{RC}$$

$$\underbrace{u_{out}\,(DT) - u_{out}\,(0)}_{\triangle u'_{out}(t)} = -u_{out}\,(0)\,\frac{DT}{RC}$$

$$D\,T \leq t < T$$

$$I_0\,(T - D\,T) = C\,\underbrace{\left[u_{out}\,(T) - u_{out}\,(D\,T)\right]}_{\triangle u''_{out}(t)} = C\,\triangle\,u''_{out}\,(t)$$

$$\Rightarrow \triangle u''_{out}\,(t) = -\,\triangle\,u'_{out}\,(t)$$

$$\frac{I_0}{C}T\,(1-D) = \frac{DT}{RC}u_{out}\,(0)$$

$$\Leftrightarrow u_{out}\,(0) = \frac{RI_0}{D}\,(1-D) = RI_0\,\frac{(1-D)}{D} = u_{out,max}$$

(d)

$$\overline{u_{out}} = u_{out,max} - \frac{\mid \triangle u'_{out}(t) \mid}{2}$$

$$= u_{out}(0) - u_{out}(0)\frac{DT}{2RC} = u_{out}(0)\left(1 - \frac{DT}{2RC}\right)$$