

Aufgabe 1

a) $U_{BC} = 0V$, $U_{BE} > 0V \rightarrow$ Normalbetrieb, (Sättigung)

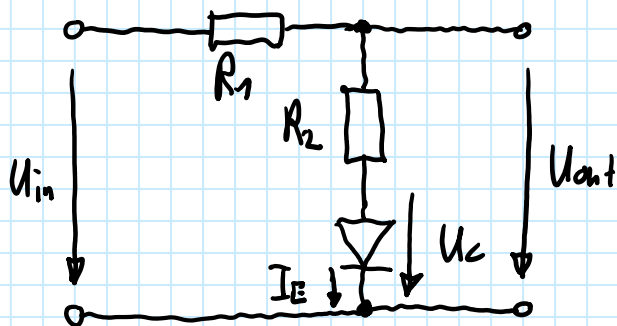
$$b) I_B = \frac{I_S}{\beta_N} \left(e^{U_{BE}/U_T} - 1 \right) + \underbrace{\frac{I_S}{\beta_I} \left(e^{U_{BC}/U_T} - 1 \right)}_{=0} \quad \text{mit } U_{BC} = 0V$$
$$= \frac{I_S}{\beta_N} \left(e^{U_{BE}/U_T} - 1 \right)$$

$$I_{CT} = I_S \left(e^{U_{BE}/U_T} - e^{U_{BC}/U_T} \right) \quad \text{mit } U_{BC} = 0V$$
$$= I_S \left(e^{U_{BE}/U_T} - 1 \right)$$

$$I_E = I_B + I_{CT} = I_S \left(e^{U_C/U_T} - 1 \right) \left(\frac{1}{\beta_N} + 1 \right) \quad \text{mit } U_{BE} = U_C$$

$\rightarrow$ entspricht Diodenkennlinie

ESB:



c) Masche:

$$U_{in} = (R_1 + R_2) \cdot I_E + U_C$$
$$= (R_1 + R_2) I_S \left(e^{U_C/U_T} - 1 \right) \left(\frac{1}{\beta_N} + 1 \right) + U_C$$

$$f(U_C) = (R_1 + R_2) \left(\frac{1}{\beta_N} + 1 \right) I_S \left(e^{U_C/U_T} - 1 \right) + U_C - U_{in} \stackrel{!}{=} 0$$

$$f'(U_C) = (R_1 + R_2) \left(\frac{1}{\beta_N} + 1 \right) \frac{I_S}{U_T} e^{U_C/U_T} + 1$$

$$U_C^{(n+1)} = U_C^{(n)} - \frac{f(U_C^{(n)})}{f'(U_C^{(n)})}$$

n	$U_C^{(n)} / V$
0	0,7 V
1	0,7797
2	0,7591
3	0,7457
4	0,7411
5	0,7407

> < 1mV

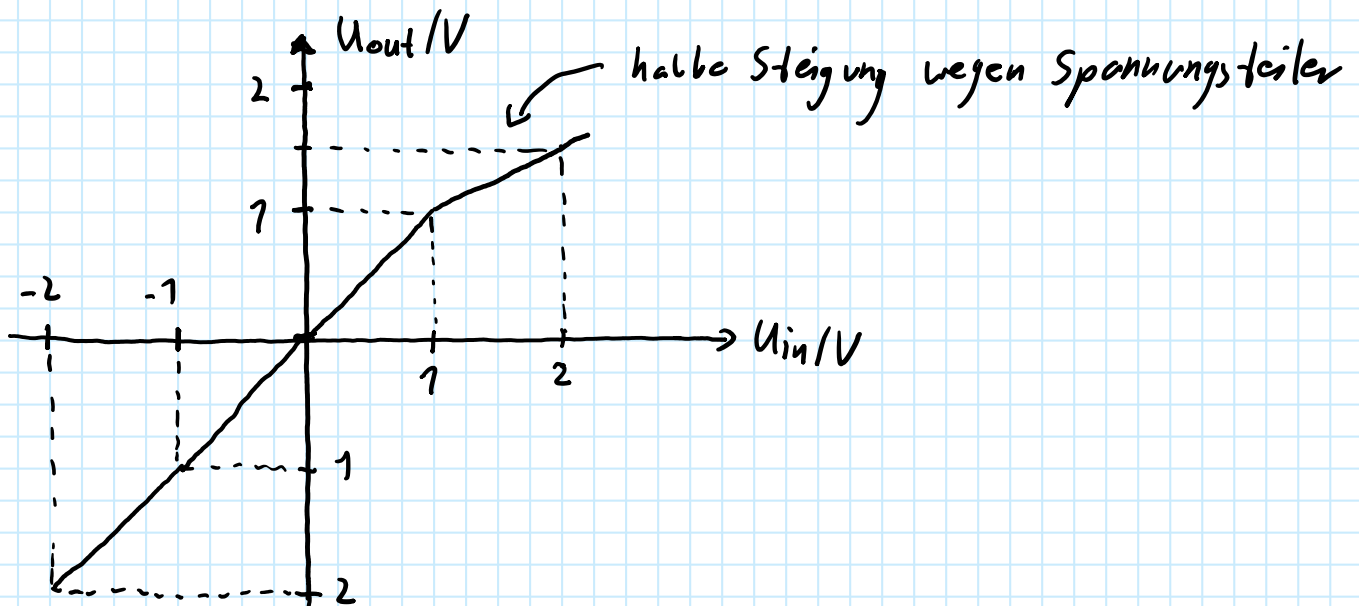
$$\rightarrow U_C = 0,7407 V$$

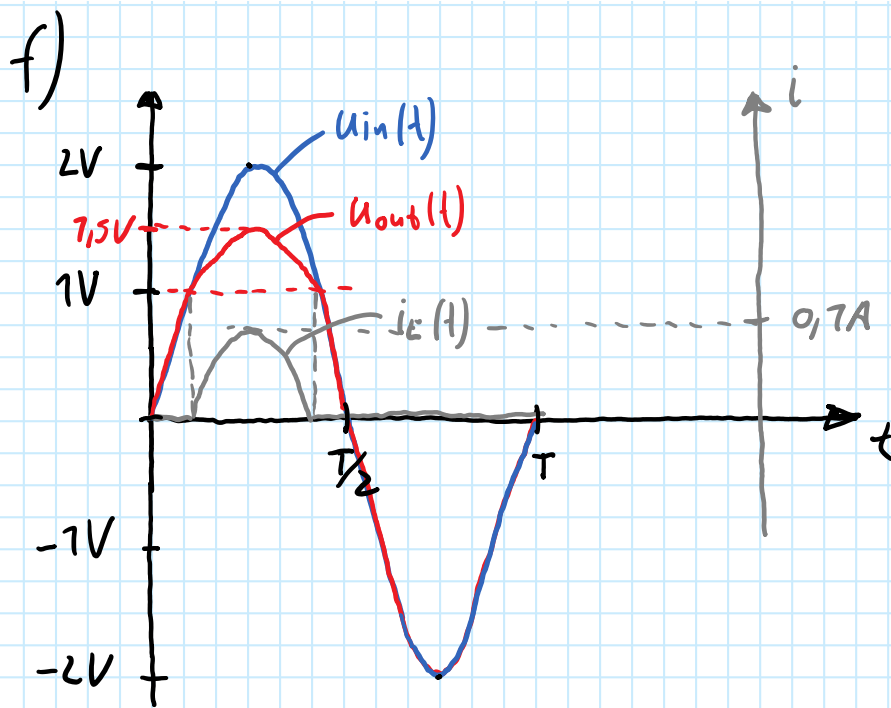
$$\begin{aligned} \rightarrow U_{out} &= U_C + I_E \cdot R_2 & I_E &= 0,0259 A \\ &= 0,7407 V + 0,0259 A \cdot 5 \Omega \\ &= 0,8702 V \end{aligned}$$

d) $U_{BC} = 0 V, U_{BE} < 0 V \rightarrow$ Sperrbetrieb, (Inversbetrieb)

$\hookrightarrow I_E \approx 0 V$ für $U_{BE} < 0 V \rightarrow U_{out} = U_{in} = -1 V$

e) Knickkennlinie mit $U_K = 1 V$





g) siehe f)

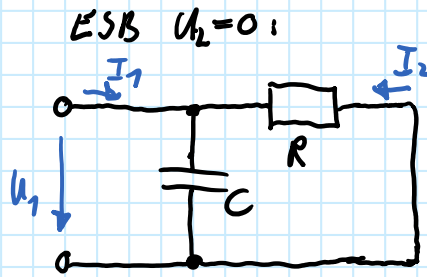
$$i_{E,max} = \frac{2V - 1V}{R_1 + R_2} = \frac{1V}{70\Omega} = 0.7A$$

$$= \frac{2V - 1.5V}{R_1} = \frac{0.5V}{5\Omega} = 0.1A$$

Aufgabe 2

a) Parallel-Parallel-Schaltung

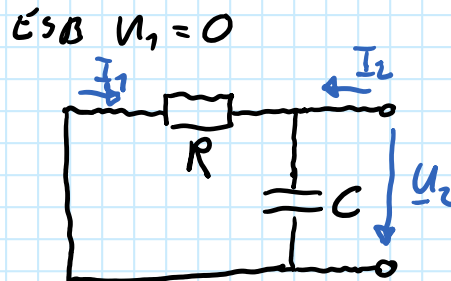
$$b) \underline{Y}_{11} = \frac{\underline{I}_1}{\underline{U}_1} \Big|_{\underline{U}_2=0} \\ = j\omega C + \frac{1}{R}$$



$$\underline{Y}_{21} = \frac{\underline{I}_2}{\underline{U}_1} \Big|_{\underline{U}_2=0} = -\frac{1}{R}$$

$$\underline{U}_1 = -\underline{I}_2 \cdot R$$

$$\underline{Y}_{12} = \frac{\underline{I}_1}{\underline{U}_2} \Big|_{\underline{U}_1=0} \\ = -\frac{1}{R} = \underline{Y}_{21}$$



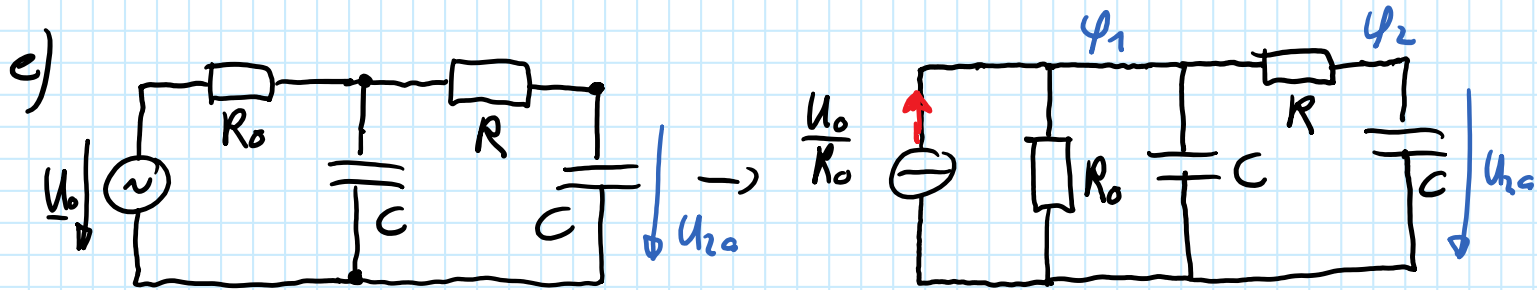
$$\underline{Y}_{22} = \frac{\underline{I}_2}{\underline{U}_2} \Big|_{\underline{U}_1=0} = j\omega C + \frac{1}{R} = \underline{Y}_{11}$$

c) Tabelle Skript T-Schaltung

$$[\underline{Y}_b] = \frac{1}{\frac{2}{R} + \frac{1}{j\omega L}} \begin{bmatrix} \frac{1}{R} \left(\frac{1}{j\omega L} + \frac{1}{R} \right) & -\frac{1}{R} \cdot \frac{1}{j\omega L} \\ -\frac{1}{R} \cdot \frac{1}{j\omega L} & \frac{1}{j\omega L} \left(\frac{2}{R} \right) \end{bmatrix}$$

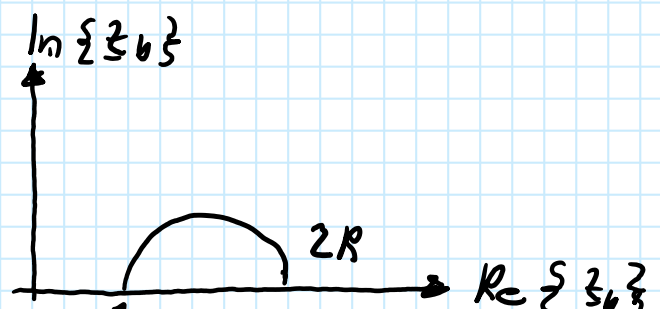
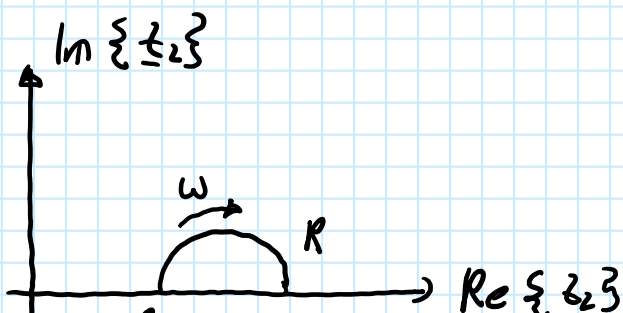
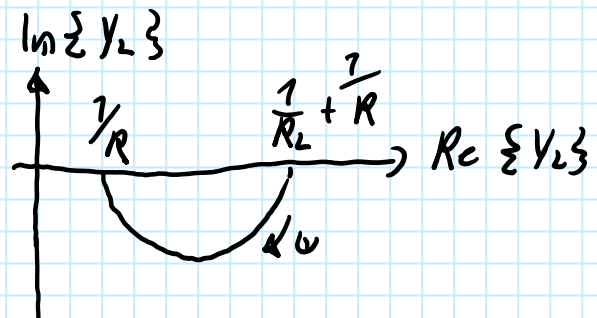
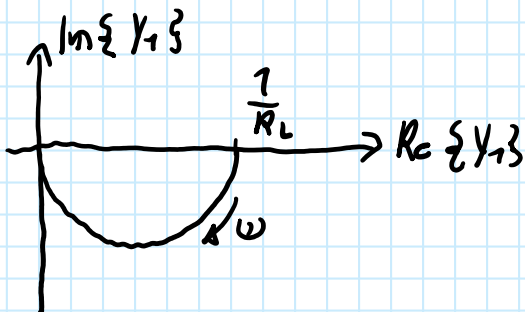
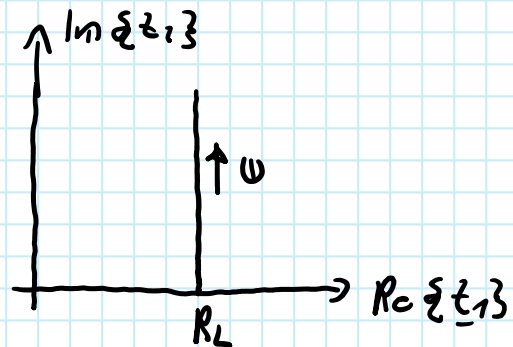
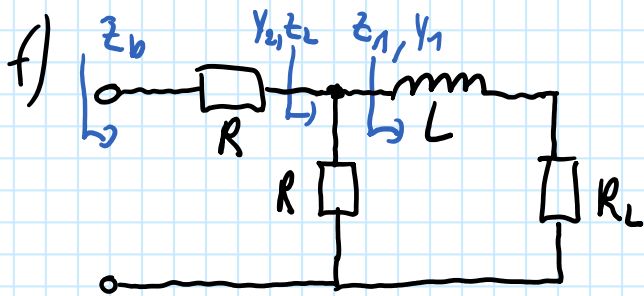
$$d) [\underline{Y}_{ges}] = [\underline{Y}_a] + [\underline{Y}_b] = \begin{bmatrix} \underline{Y}_{11a} + \underline{Y}_{11b} & \underline{Y}_{12a} + \underline{Y}_{12b} \\ \underline{Y}_{21a} + \underline{Y}_{21b} & \underline{Y}_{22a} + \underline{Y}_{22b} \end{bmatrix}$$

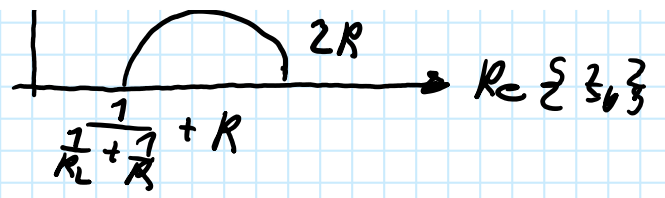
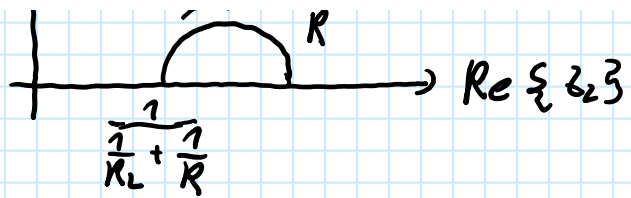
$$[\underline{Z}_{ges}] = \frac{1}{\det \underline{Y}_{ges}} \begin{bmatrix} \underline{Y}_{22ges} & -\underline{Y}_{12ges} \\ -\underline{Y}_{21ges} & \underline{Y}_{11ges} \end{bmatrix}$$



φ_1	φ_2	
$\frac{1}{R_0} + \frac{1}{R} + j\omega C$	$-\frac{1}{R}$	$\frac{U_0}{R_0}$
$-\frac{1}{R}$	$\frac{1}{R} + j\omega C$	0

$$U_{20} = \varphi_2 = \frac{\det \varphi_2}{\det \Delta} = \frac{+\frac{U_0}{R_0 \cdot R}}{\left(\frac{1}{R_0} + \frac{1}{R} + j\omega C\right)\left(\frac{1}{R} + j\omega C\right) - \frac{1}{R^2}}$$





$$g) \quad \bar{T} = \frac{1 + (j\omega RC)^2}{1 + j\omega RC \cdot 10^7 + (j\omega RC)^2} \hat{=} \frac{1 + (j\frac{\omega}{\omega_1})^2}{(1 + j\frac{\omega}{\omega_2})(1 + j\frac{\omega}{\omega_3})}$$

$\hookrightarrow$ Zähler: System 2. Ord. mit Dämpfung $d=0 \rightarrow$ starker

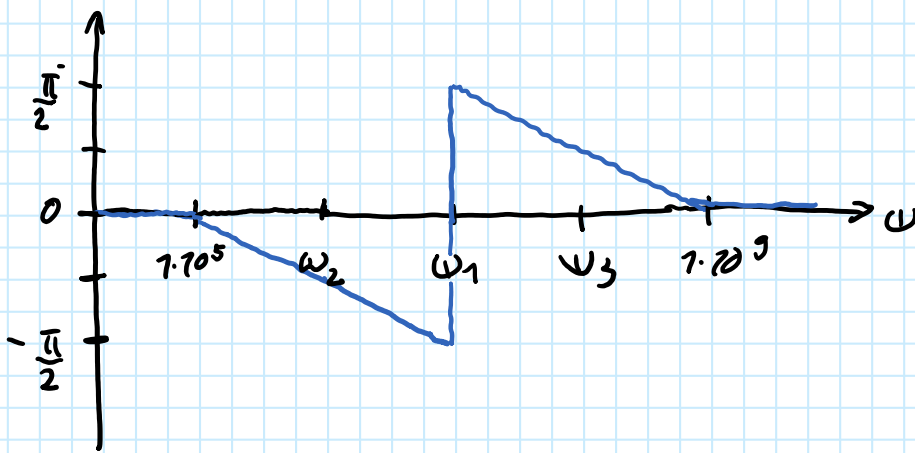
$\hookrightarrow$ Nenner: " " "

Phasenübergang

$$\omega_1 = \frac{1}{RC} = 1 \cdot 10^7 \frac{1}{s}$$

$$\text{Nenner: Polstellen } p_2 = -1 \cdot 10^{+6} \rightarrow \omega_2 = 1 \cdot 10^{+6} \frac{1}{s}$$

$$p_3 = -1 \cdot 10^{+8} \rightarrow \omega_3 = 1 \cdot 10^8 \frac{1}{s}$$



a-d) Aufgabe 3

a) Skript: 163 $\underline{F}_a(j\omega) = -\frac{\underline{Z}_2 \underline{V}(\omega)}{\underline{Z}_2 + \underline{Z}_1(1 + \underline{V}(\omega))}$

$$\underline{Z}_1 = R_1 + \frac{1}{j\omega C} \quad \underline{Z}_2 = R_2 \quad \underline{V}(\omega) = \frac{V_0}{1 + j\omega \frac{V_0}{\omega_g}}$$

$$\underline{F}_a(j\omega) = -\frac{R_2}{R_2 + (R_1 + \frac{1}{j\omega C})(1 + \underline{V}(\omega))} = -\frac{R_2 \frac{V_0}{1 + j\omega \frac{V_0}{\omega_g}}}{R_2 + (R_1 + \frac{1}{j\omega C})(1 + \frac{V_0}{1 + j\omega \frac{V_0}{\omega_g}})} =$$

$$= -\frac{R_2 V_0}{R_2 + j\omega R_2 \frac{V_0}{\omega_g} + (R_1 + \frac{1}{j\omega C})(1 + j\omega \frac{V_0}{\omega_g} + V_0)} = \frac{-j\omega C R_2 V_0}{j\omega C R_2 + (j\omega)^2 R_2 \frac{V_0}{\omega_g} C + (j\omega C R_1 + 1)(1 + j\omega \frac{V_0}{\omega_g} + V_0)}$$

$$= \frac{-j\omega C R_2 V_0 \omega_g}{(j\omega)^2 R_2 C V_0 + j\omega C R_2 \omega_g + (j\omega C R_1 + 1)(\omega_g + j\omega V_0 + \omega_g V_0)}$$

b)

Hochpass

c)

$$\underline{F}_c(j\omega) = \frac{-j\omega C R_2 \omega_g}{(j\omega)^2 R_2 C + (j\omega C R_1 + 1)(j\omega + \omega_g)}$$

d)

Signal gerade: $b_v = 0$

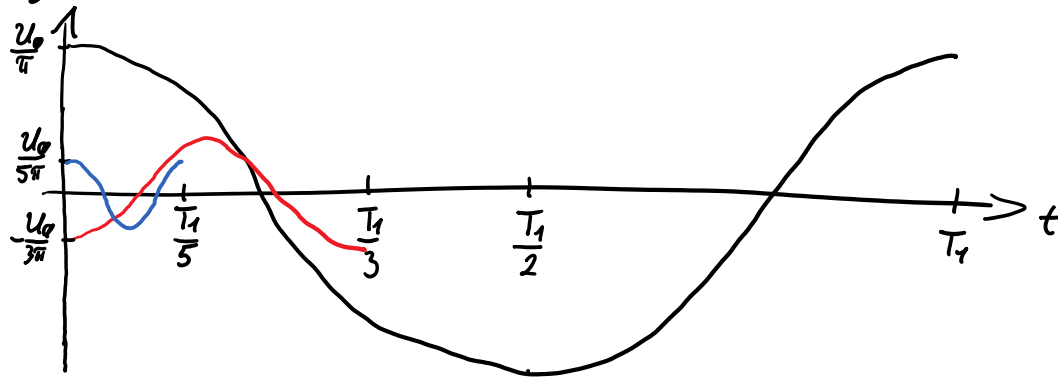
$$\begin{aligned} \underline{a}_0 &= \frac{U_0}{4} \quad \underline{a}_v = \frac{2}{T_1} \int_0^{T_1} u_e(t) \cos(v\omega_1 t) dt = \frac{4}{T_1} \int_0^{\frac{T_1}{2}} \frac{U_0}{2} \cos(v\omega_1 t) dt = \\ &= \frac{2U_0}{T_1} \left[\frac{1}{v\omega_1} \sin(v\omega_1 t) \right]_0^{\frac{T_1}{2}} = \frac{2U_0}{vT_1\omega_1} (\sin(v\omega_1 \frac{T_1}{4}) - 0) = \\ &= \frac{U_0}{\pi v} \sin(\frac{1}{2}\pi v) \end{aligned}$$

$$a_1 = \frac{U_0}{\pi} \quad a_2 = 0 \quad a_3 = -\frac{U_0}{3\pi} \quad a_4 = 0 \quad a_5 = \frac{U_0}{5\pi}$$

$$u_e(t) = \frac{U_0}{4} + \frac{U_0}{\pi} \left(\cos(\omega_1 t) - \frac{1}{3} \cos(3\omega_1 t) + \frac{1}{5} \cos(5\omega_1 t) \right)$$

e-f)

e)



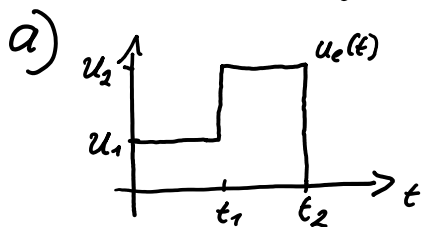
f)

$$u_a(t) = \frac{u_0}{\pi} \left(A(\omega_1) \cos(\omega_1 t + \psi(\omega_1)) - \frac{1}{3} A(3\omega_1) \cos(3\omega_1 t + \psi(3\omega_1)) + \right. \\ \left. + \frac{1}{5} A(5\omega_1) \cos(5\omega_1 t + \psi(5\omega_1)) \right)$$

g)

f
f
w
w
w
f
w
w

a-d) Aufgabe 4



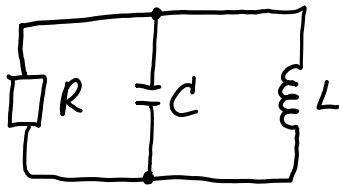
b)

$$\underline{u_c(t) = (U_2 - U_1) (1 - e^{-\frac{t-t_1}{RC}}) + U_1 \quad \text{für } t_1 < t < t_2}$$

c)

$$\underline{i_c(t) = C \frac{du_c}{dt} = C (U_2 - U_1) \frac{-1}{RC} e^{-\frac{t-t_1}{RC}} = -\frac{U_2 - U_1}{R} e^{-\frac{t-t_1}{RC}} \quad t_1 < t < t_2}$$

d)



$$\emptyset = i_R + i_C + i_L \quad i_C = C \frac{du_C}{dt} \quad u_C = u_L = u_R \quad u_C = L \frac{di_L}{dt}$$

$$\emptyset = \frac{u_C}{R} + C \frac{du_C}{dt} + i_L = \frac{L}{R} \frac{di_L}{dt} + LC \frac{d^2 i_L}{dt^2} + i_L$$

$$\Rightarrow \emptyset = LC (p^2 \underline{i_L(p)} - p i_L(t_2) - i_L'(t_2)) + \frac{L}{R} (p \underline{i_L(p)} - i_L(t_2)) + \underline{i_L(p)}$$

$$i_L(t_2) = \emptyset \quad i_L'(t_2) = \frac{u_C(t_2)}{L} = \frac{U_2}{L}$$

$$\Rightarrow \emptyset = LC (p^2 \underline{i_L(p)} - \frac{U_2}{L}) + \frac{L}{R} p \underline{i_L(p)} + \underline{i_L(p)} \Leftrightarrow C U_2 = \underline{i_L(p)} (LC p^2 + \frac{L}{R} p + 1)$$

$$\Rightarrow \underline{i_L(p)} = \frac{1}{p^2 + \frac{1}{RC} p + \frac{1}{LC}} \frac{U_2}{L} \quad p_{1,2} = \frac{-\frac{1}{RC} \pm \sqrt{\frac{1}{(RC)^2} - 4 \frac{1}{LC}}}{2} = -\frac{1}{2RC} \pm j \sqrt{\frac{1}{LC} - \frac{1}{(2RC)^2}} = -\sigma \pm j\omega$$

$$\frac{1}{(p-p_1)(p-p_2)} = \frac{A}{p-p_1} + \frac{B}{p-p_2} \quad A = \frac{1}{p_1-p_2} \quad B = -A \quad \underline{i_L(p)} = \frac{U_2}{L} \left(\frac{A}{p-p_1} + \frac{B}{p-p_2} \right)$$

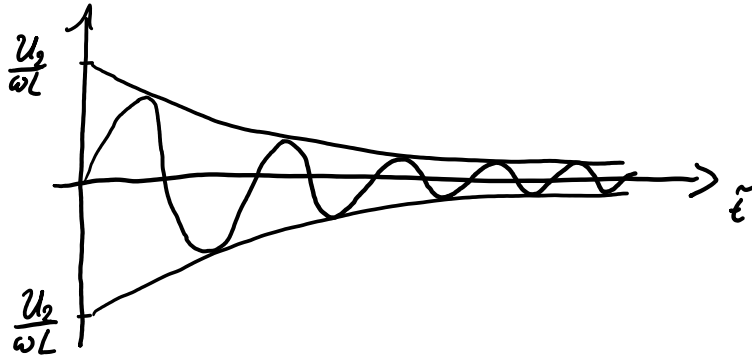
$$\Rightarrow \underline{i_L(\tilde{t})} = \frac{U_2}{L} (A s(\tilde{t}) e^{p_1 \tilde{t}} + B s(\tilde{t}) e^{p_2 \tilde{t}}) \quad \tilde{t} = t - t_2$$

e-g)

e)

$$i_L(\tilde{t}) = \frac{U_2}{L} \left(A s(\tilde{t}) e^{p_1 \tilde{t}} + B s(\tilde{t}) e^{p_2 \tilde{t}} \right) \quad A = -B = \frac{1}{p_1 - p_2} = \frac{1}{2j\omega} \quad p_{1/2} = -\alpha \pm j\omega$$

$$\Rightarrow \underline{i_L(\tilde{t})} = \frac{U_2}{\omega L} \frac{1}{2j} s(\tilde{t}) e^{-\alpha \tilde{t}} (e^{j\omega \tilde{t}} - e^{-j\omega \tilde{t}}) = \underline{\frac{U_2}{\omega L} s(\tilde{t}) e^{-\alpha \tilde{t}} \sin(\omega \tilde{t})}$$



f)

$$\underline{F(p)} = \frac{U_a}{U_e} = \frac{\frac{pL}{p^2 CL + 1}}{R + \frac{pL}{p^2 CL + 1}} = \underline{\frac{pL}{p^2 CLR + pL + R}}$$

g)

$$pL = 0 \Rightarrow \underline{n_1 = 0}$$

$$p^2 CLR + pL + R \Rightarrow p_{1/2} = \frac{-L \pm \sqrt{L^2 - 4CLR^2}}{2CLR}$$

$$\Rightarrow \underline{p_1 = -1 \cdot 10^8 \text{ Hz}} \quad \underline{p_2 = -2 \cdot 10^{10} \text{ Hz}}$$

