

Aufgabe 1

(a) $E_2 = E_1$

$$V = E_1 \frac{R_3}{R_1 + R_3} + I_2 \frac{R_1 R_3}{R_1 + R_3}$$

$$I = \frac{E_1}{R_1 + R_3} - I_2 \frac{R_3}{R_1 + R_3}$$

(b) $R_{th} = R_1 + R_2$

$$E_{th} = -E - I R_1$$

(c) i) $R = \frac{\rho}{a} \frac{l}{w} = n \frac{\rho}{a}$

$$R_0 = \frac{\rho}{a}$$

$$d = \frac{\rho}{R_{03}} = 850 \text{ nm}$$

$$\begin{aligned} \text{ii) } R_{tot} &= \frac{1}{w} R_{03} + \frac{l}{w} (R_{01} \parallel R_{02}) = \\ &= \frac{l}{w} (R_{03} + R_{01} \parallel R_{02}) \end{aligned}$$

iii) $V_{tot} = I R_{tot}$

$$\begin{aligned} \text{iv) } R_{tot} &= \frac{0,01 E}{I} \\ &= \frac{l}{w} R_0 \end{aligned}$$

$$\begin{aligned} w &= \frac{I l R_0}{0,01 E} = \frac{I l}{0,01 E} (R_{03} + R_{01} \parallel R_{02}) \\ &= 16 \mu\text{m} \end{aligned}$$

(d) i) $V_1 = I_4 \frac{R_1 R_3}{R_1 + R_3} + E_1 \frac{R_1}{R_3 + R_1} + E_2 \frac{R_3}{R_1 + R_3}$

$$V_2 = E_1 - I_4 R_4$$

$$V_3 = E_1$$

$$V_4 = 3 I_3 R_7$$

$$V_5 = V_4$$

$$ii) \quad I_x = I_4 + I_3$$

Aufgabe 2:

$$(a) \quad i) \quad V_{C1}(t) = \frac{It}{C_1}$$

$$V_{C2}(t) = IR(1 - e^{-\frac{t}{RC_2}})$$

$$I_{R2}(t) = I(1 - e^{-\frac{t}{RC_2}})$$

$$I_{C2}(t) = I e^{-\frac{t}{RC_2}}$$

ii) $V_{C2}(t_1)$ sei die Spannung V_{C2} am Ende von Phase 1, also

$$V_{C2}(t_1) = IR(1 - e^{-\frac{t_1}{RC_2}})$$

Daraus folgt:

$$V_{C1}(t) = \frac{It_1}{C_1}$$

$$V_{C2}(t) = V_{C2}(t_1) e^{-\frac{t-t_1}{RC_2}}$$

$$I_{R2}(t) = \frac{V_{C2}(t_1)}{R} e^{-\frac{t-t_1}{RC_2}}$$

$$iii) \quad V_{C3}(t) = \frac{Q_{tot}}{C_{tot}} = \frac{It_1}{C_1 + C_3}$$

$$iv) \quad U_{C3} = \frac{1}{2} CV^2 \\ = \frac{1}{2} C_3 \left(\frac{It_1}{C_1 + C_3} \right)^2$$

v) Dieselbe Spannung wie am Ende von Phase 3 (also $V_{C3}(t_3) = \frac{It_1}{C_1 + C_3}$) da sich C_3 während Phase 4 nicht entladen kann (kein geschlossener Stromkreis).

Aufgabe 3:

i) $H(j\omega) = -\frac{1}{j\omega RC}$

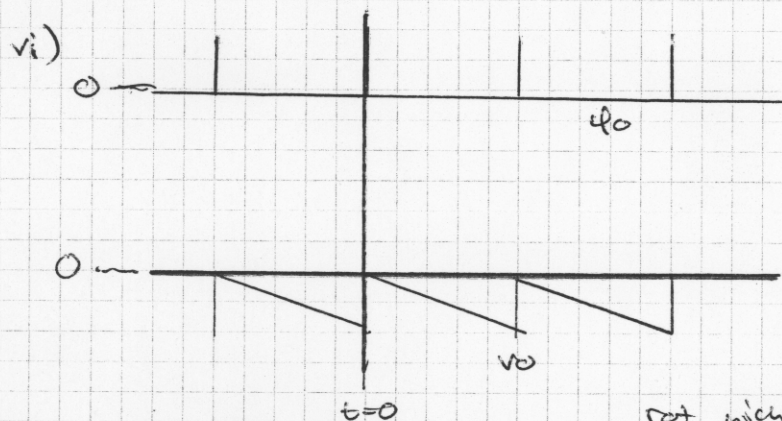
ii) Integrator

iii) $I_{in} = \frac{V_i}{R}$

iv) Virtual ground, negative Rückkoppelung über OpAmp

$$V_1 = 0$$

v) $V_C = 0$
 $V_O = 0$



vii)

$$V_C(t) = \frac{V_i}{RC} t$$

viii) $R = \frac{V_i}{C} t_p \frac{1}{V_{max}} = 250 \Omega$

ix)

$$\begin{aligned}
 P &= \frac{V_i}{R} V_i + \frac{\frac{1}{2} C V_{max}^2}{t_p} + \frac{1}{t_p} \int_{t=0}^{t=t_p} \left(\frac{V_{max}}{t_p} t \right)^2 dt \\
 &= \frac{V_i}{R} V_i + \frac{\frac{1}{2} C V_{max}^2}{t_p} + \frac{\left(\frac{V_{max}}{t_p} \right)^2}{R_L} \frac{1}{3} t_p^2 \\
 &= 0,004 W + 0,008 W + 0,00533 W \\
 &= \underline{\underline{17,33 mW}}
 \end{aligned}$$

$$(b) \quad i) \quad \underline{U} = \underline{I} \underline{Z} = \underline{I} \frac{j\omega RL}{R + j\omega L}$$

$$ii) \quad U = I \frac{\omega RL}{\sqrt{R^2 + (\omega L)^2}}$$

$$\varphi_u = \arctan\left(\frac{R}{\omega L}\right)$$

iii) Parallel, d.h. 0°

iv) Technisch gesehen ist es nur sinnvoll den Strom aufzuteilen. Über R und L fällt wegen der Parallelschaltung der beiden Elemente die gleiche Spannung ab, jedoch fließen verschiedene Ströme durch sie hindurch.

Aufgabe 1.

$$\begin{aligned} \text{a) i)} \quad I_x &= I \cdot \frac{R_1 \parallel (R_2 + R_3)}{R_1 + R_2 + R_3} \\ &= I \cdot \frac{R_1}{R_1 + R_2 + R_3} \end{aligned}$$

$$\begin{aligned} \text{ii)} \quad P_1 &= \frac{V_1^2}{R_1} \\ &= \frac{(I \cdot [R_1 \parallel (R_2 + R_3)])^2}{R_1} \\ &= I^2 R_1 \left(\frac{R_2 + R_3}{R_1 + R_2 + R_3} \right)^2 \end{aligned}$$

$$\begin{aligned} \text{b) i)} \quad V_2 &= E \cdot \frac{R_2}{R_1 + R_2} \\ V_4 &= E \cdot \frac{R_4}{R_3 + R_4} \end{aligned}$$

$$V_b = V_2 - V_4 = E \left(\frac{R_2}{R_1 + R_2} + \frac{R_4}{R_3 + R_4} \right)$$

$$\text{ii)} \quad I = E \cdot \frac{1}{(R_1 + R_2) \parallel (R_3 + R_4)} = E \cdot \frac{R_1 + R_2 + R_3 + R_4}{(R_1 + R_2)(R_3 + R_4)}$$

$$\text{c) i)} \quad V_1 = I_1 \frac{R_3 R_4}{R_3 + R_4} + E_1 \frac{R_4}{R_3 + R_4}$$

$$V_2 = E_1 + E_2 - (I_1 + I_2) R_1 - I_1 R_2$$

$$V_3 = I_2 R_5$$

$$V_4 = V_2 + I_1 R_2 - (I_1 + I_2) R_6$$

$$V_5 = V_4 - I_3 R_8$$

$$\text{ii)} \quad I_1 = I_4 + I_3$$

$$\text{d)} \quad 0 = -E_1 + I_1 R_1 + I_1 R_2 + (I_1 + I_2 + I) R_3$$

$$0 = E_2 + (I_1 + I_2 + I) R_3$$

$$I_2 = - \frac{E_2 + I R_3 + I_1 R_3}{R_3}$$

$$0 = -E_1 + I_1 R_1 + I_1 R_2 + I_1 R_3 + I R_3 - E_2 - I_1 R_3 - I R_3$$

$$I_1 = \frac{E_1 + E_2}{R_1 + R_2}$$

Aufgabe 1.

$$\begin{aligned}
 d) \quad I_2 &= - \frac{E_2 + I_1 R_3 + I R_3}{R_3} \\
 &= - \frac{E_2 + R_3 \frac{E_1 + E_2}{R_1 + R_2} + I \cdot R_3}{R_3} \\
 &= - \left(I + \frac{E_2}{R_3} + \frac{E_1 + E_2}{R_1 + R_2} \right) \\
 &= - \left(I + \frac{E_1}{R_1 + R_2} + \frac{E_2 (R_1 + R_2 + R_3)}{R_3 (R_1 + R_2)} \right)
 \end{aligned}$$

Superposition

$$I_1 = \frac{E_1 - 0}{R_1 + R_2} + \frac{0 - (-E_2)}{R_1 + R_2} + 0$$

$$I_2 = - \frac{E_2 (R_1 + R_2 + R_3)}{R_3 (R_1 + R_2)} - I - \frac{E_1}{R_1 + R_2}$$

Aufgabe 2

a) Parallelschwingkreis

b)

$$U = \frac{1}{2} C V_c^2$$

$$C = \frac{2U}{V_c^2} = 2 \text{ nF}$$

c)

$$r_D = \frac{dD}{2}$$

$$A_D = \pi r_D^2$$

$$R_D = \rho_{\text{Cu}} \cdot \frac{L_D}{A_D} = 3,993 \Omega$$

d)

$$\omega_c = 2\pi f_0 = \frac{1}{\sqrt{LC}}$$

$$L = \frac{1}{\omega_c^2 C}$$

$$L_2 = L - L_1 = \frac{1}{(2\pi f_0)^2 C} - L_1 = 100,629 \mu\text{H}$$

e)

$$L_2 = \frac{\mu_0 N^2 h}{2\pi} \ln\left(\frac{r_2}{r_1}\right)$$

$$N = \sqrt{\frac{L_2}{\frac{\mu_0 h}{2\pi} \ln\left(\frac{r_2}{r_1}\right)}} = 201$$

f)

Das Feld verläuft vollständig im Spulen Kern und ist deshalb gegenüber äusseren Kräften (Einflüssen) abgeschirmt.

Aufgabe 2

$$g) \quad Q_{L2} = \frac{\omega_0 L_2}{R_{L2}} = 31,672$$

$$h) \quad Q_{L_{\text{tot}}} = \frac{\omega_0 L_{\text{tot}}}{R_{L2}} = \frac{\omega_0 \cdot (L_1 + L_2)}{R_{L2}}$$

$$R_{Lp} = R_{L2} \cdot (1 + Q_{L_{\text{tot}}}^2) = 33,656 \text{ k}\Omega$$

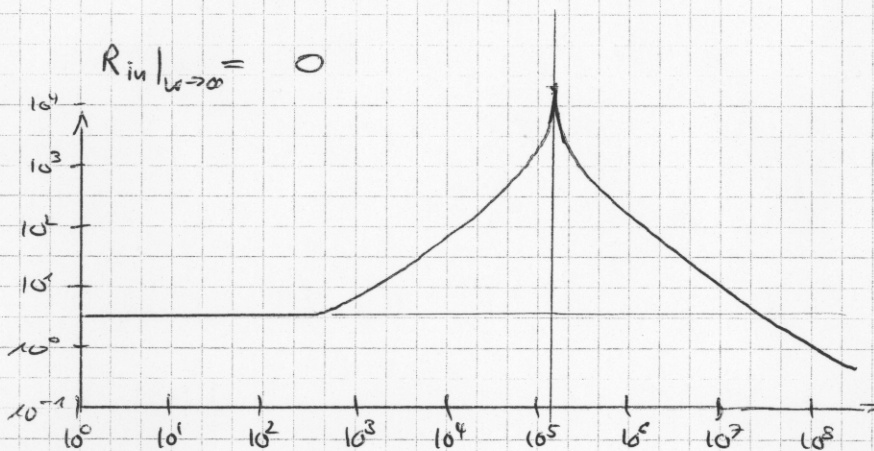
$$i) \quad R_{p_{\text{tot}}} = R_{Lp} \parallel R = 17,710 \text{ k}\Omega$$

$$Q = \frac{R_{p_{\text{tot}}}}{\omega_0 L_{\text{tot}}} = 44,509$$

j)

$$R_{\text{in}}|_{\omega \rightarrow \infty} = 0$$

k)



$$\text{bei } f=0 \quad R \parallel R_{L2} = 3,5325 \Omega$$

$$f \rightarrow \infty \quad 0$$

$$f = f_0 \quad 200 \text{ kHz}, 17,71 \text{ k}\Omega \quad (\text{Resonanz})$$

Aufgabe 3

$$a) \quad i) \quad V_{x,1} = 0 \text{ V}$$

$$ii) \quad V_{C1,1}(t) = V_i \left(1 - e^{-\frac{t}{RC}}\right)$$

$$iii) \quad Q = C \cdot U = C \cdot V_i \left(1 - e^{-\frac{t_x}{RC}}\right)$$

$$iv) \quad I_{\text{in},1} = 0$$

$$v) \quad Q_{\text{tot}} = -2Q = -2C \cdot V_i \left(1 - e^{-\frac{t_x}{RC}}\right)$$

$$vi) \quad V_{C1,2} = 0 \text{ V}$$

$$vii) \quad V_{0,2} = 2 \cdot V_{C1,1}(t) \Big|_{t=t_x} \\ = 2 \cdot V_i \left(1 - e^{-\frac{t_x}{RC}}\right)$$

Aufgabe 3

a) viii) Multipliziert die Eingangsspannung mit Faktor 2

b) i) $I = \frac{1}{\sqrt{2}}$

ii) $U_c(j\omega) = U_R(j\omega) = \underline{I} \frac{R}{1+j\omega RC}$

iii) $\underline{I}_R(j\omega) = \frac{U_R}{R} = \underline{I} \frac{1}{1+j\omega RC}$

$$\begin{aligned}\underline{I}_c(j\omega) &= \underline{U}_c \cdot j\omega C \\ &= \underline{I} \frac{j\omega RC}{1+j\omega RC}\end{aligned}$$

iv) $S = |\underline{U} \underline{I}^*|$

$$\begin{aligned}&= \left| \frac{\underline{I}^2 R}{1+j\omega RC} \right| \\ &= \underline{I}^2 \sqrt{\frac{R^2}{1+(\omega RC)^2}} \\ &= \underline{I}^2 \frac{R}{\sqrt{1+(\omega RC)^2}}\end{aligned}$$

v) $P = |\underline{U} \underline{I} R|$

$$\begin{aligned}&= \underline{I}^2 \left| \frac{R}{1-(\omega RC)^2 + 2j\omega RC} \right| \\ &= \underline{I}^2 \sqrt{\frac{R^2}{1+(\omega RC)^4 - 2(\omega RC)^2 + 4(\omega RC)^2}} \\ &= \underline{I}^2 \sqrt{\frac{R^2}{(1-(\omega RC)^2)^2}} = \underline{I}^2 \frac{R}{1+(\omega RC)^2}\end{aligned}$$

vi) $F_p = \frac{P}{S} = \frac{1}{\sqrt{1+(\omega RC)^2}}$

$$\begin{aligned}1 + (\omega RC)^2 &= \frac{1}{F_p^2} \\ \omega RC &= \sqrt{\frac{1}{F_p^2} - 1} \\ f &= \frac{1}{2\pi RC} \sqrt{\frac{1}{F_p^2} - 1} = 75 \text{ Hz}\end{aligned}$$

Aufgabe 1.

$$a) \quad I_4 = E \cdot \frac{R_3}{R_2 R_3 + R_2 R_4 + R_3 R_4}$$

$$b) \quad U_1 = E_1 + E_2 \cdot \frac{R_2}{R_2 + R_3} \\ = E_1 + E_2 - E_2 \cdot \frac{R_3}{R_2 + R_3}$$

$$U_2 = E_1 + (I_3 - I_2) R_4$$

$$U_3 = E_1 + (I_3 - I_2) R_4 + (I_3 - I_2 - I_1) R_5$$

$$U_4 = U_3 + I_3 R_6$$

$$= E_1 + (I_3 - I_2) R_4 + (I_3 - I_2 - I_1) R_5 + I_3 R_6$$

$$U_5 = U_4 - E_3 - I_4 R_7$$

$$c) \quad i) \quad R_{th} = \frac{R_3 (R_1 + R_2)}{R_1 + R_2 + R_3}$$

$$ii) \quad E_{th} = -R_3 \frac{E + I R_1}{R_1 + R_2 + R_3}$$

$$d) \quad i) \quad R_{th} = R_L = R_1$$

$$ii) \quad E_{th} = E + I R_1 \\ P_L = \frac{U_L^2}{R_L} = \frac{\left(\frac{E_{th}}{2}\right)^2}{R_L} = \frac{(E + I R_1)^2}{4 R_1}$$

$$e) \quad i) \quad I_1 = I$$

$$R_{23} = R_2 \parallel R_3$$

$$0 = E_2 + I_4 R_4 + (I_4 - I) R_{23}$$

$$I_4 = \frac{I R_{23} - E_2}{R_4 + R_{23}} = \frac{I R_2 R_3 - E_2 (R_2 + R_3)}{R_2 R_3 + R_2 R_4 + R_3 R_4}$$

↑ Diese Darstellung reicht aus für max Pkt-Zahl.

ii)

$$I_{23} = I_4 - I_1$$

$$I_3 = I_{23} \cdot \frac{R_2}{R_2 + R_3} = - \frac{E_2 + I_4 R_4}{R_3}$$

Aufgabe 2:

a)

$$\tau = R \cdot C$$

$$V_0 e^{-\frac{t}{\tau}} = V_x$$

$$V_0 = V_x \cdot e^{\frac{t_x}{\tau}} = 609,12 \text{ V}$$

$$I \cdot t_A = 2 \cdot C \cdot V_0$$

$$t_A = \frac{2 C V_0}{I} = 2,436 \text{ ms}$$

b)

i)

$$A \stackrel{\text{def}}{=} \frac{j\omega L \parallel \frac{R}{2}}{Z_{\text{total}}}$$

$$= \frac{j\omega L R}{3j\omega L R + R^2}$$

$$= \frac{j\omega \frac{L}{R}}{1 + 3j\omega \frac{L}{R}}$$

$$|A| = \frac{\omega \frac{L}{R}}{\sqrt{1 + (3\omega \frac{L}{R})^2}}$$

$$\angle(A) = \arctan\left(\frac{\omega \frac{L}{R}}{3(\omega \frac{L}{R})^2}\right)$$

$$= \arctan\left(\frac{1}{3\omega \frac{L}{R}}\right)$$

ii)

$$V_L(t) = 0 + E_1 \frac{\omega_1 \frac{L}{R}}{\sqrt{1 + (3\omega_1 \frac{L}{R})^2}} \sin\left(\omega_1 t + \arctan\left(\frac{1}{3\omega_1 \frac{L}{R}}\right)\right) + E_2 \cdot \frac{\omega_2 \frac{L}{R}}{\sqrt{1 + (3\omega_2 \frac{L}{R})^2}} \cos\left(\omega_2 t + \arctan\left(\frac{1}{3\omega_2 \frac{L}{R}}\right)\right)$$

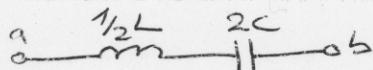
iii)

$$V_L \Big|_{\substack{\omega_1 \rightarrow \infty \\ \omega_2 \rightarrow \infty}} = \frac{1}{3} (E_1 \sin(\omega_1 t) + E_2 \cos(\omega_2 t))$$

iv)

$$V_L \Big|_{\substack{\omega_1 \rightarrow 0 \\ \omega_2 \rightarrow 0}} = 0$$

c)



Aufgabe 3

a) i) Es handelt sich um ein Parallelschwingkreis,
da Spulen und Kondensatoren parallel zueinander geschaltet sind.

ii)

- $\frac{R_L}{2} + \frac{R_L}{2} = R_L$
- $R_2 + R_3 = R_{23}$
- Serieschaltung von 2mal C ergibt $\frac{C}{2}$

iii)

$$Q_L = \frac{\omega_0 L}{R_L} = 15,708$$

iv)

$$R_L' = R_L (1 + Q_L^2) = 495,480 \Omega$$

v)

$$f_0 = \frac{1}{2\pi} \omega_0 = \frac{1}{2\pi} \frac{1}{\sqrt{\frac{L}{2} \frac{C}{2}}} = \frac{1}{\pi} \frac{1}{\sqrt{LC}}$$
$$C = \frac{1}{\pi^2} \frac{1}{f_0^2} \cdot \frac{1}{L} = 40,528 \cdot \text{nF}$$

vi)

$$Q_0 = (R_L' \parallel (R_2 + R_3)) \omega_0 \frac{C}{2} = 17,277$$

vii)

$$Z_{ab}|_{f_{src}=f_0} = (R_L' \parallel (R_2 + R_3)) + R_1 = 371,377 \Omega$$

viii)

$$Z_{ab}|_{f_{src}=0} = R_1$$
$$= 100 \Omega$$

ix)

$$Z_{ab}|_{f_{src} \rightarrow \infty} = R_1$$
$$= 100 \Omega$$

b) i) Kondensator

ii)

$$H_1 = - \frac{R_2}{R_1} \frac{1}{1 + j\omega C R_2}$$

iii) Spule

iv)

$$H_2 = - \frac{j\omega \frac{L}{R_1}}{1 + j\omega \frac{L}{R_2}}$$

Aufgabe 3

b)

v) $f_1 = 1 \text{ MHz}$

$$\omega_1 = 2\pi f_1 = 6,283 \text{ M} \frac{\text{rad}}{\text{s}}$$

$$C = \frac{1}{\omega_1 R_1} = 159,155 \text{ pF}$$

$$f_2 = 100 \text{ Hz}$$

$$\omega_2 = 2\pi f_2 = 628,3 \frac{\text{rad}}{\text{s}}$$

$$L = \frac{R_2}{\omega_2} = 38,197 \text{ mH}$$

vi)

