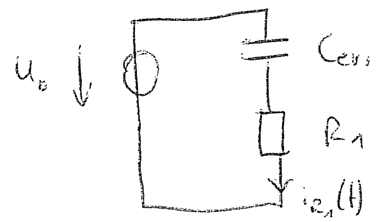
GET #08

Aufgabe 1

a)



$$\underline{i_{R_1}(t) = I_0\, e^{-\frac{t}{\tau}}} \quad \text{mit} \quad I_0 = \underline{\frac{U_0}{R_1}}, \quad \tau = R_1 \cdot C = \underline{R_1 \cdot \frac{2}{3} C}$$

b) Kapazitiver Spannungsteiler:

$$C_{ges} \cdot U_0 = C_1 \cdot U_1 \Rightarrow \frac{U_1}{U_0} = \frac{C_{ges}}{C_1} = \frac{\frac{C_1 C_2}{C_1 + C_2}}{C_1} = \frac{C_2}{C_1 + C_2}$$

$$= \frac{2}{3}$$

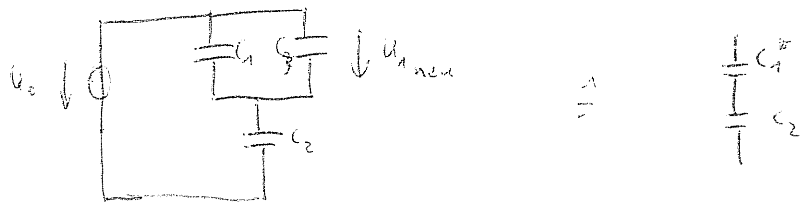
$$\Rightarrow U_1 = \frac{2}{3} U_0 = \underline{\underline{140\,V}}$$

c)

$$Q_{ges} = C_{ges} \cdot U_0 = \frac{2}{3} C \cdot U_0 \Rightarrow C = \frac{\frac{3}{2} Q_{ges}}{U_0} = 3\mu F$$

$$\Rightarrow C_2 = 2C = 3 \frac{Q_{ges}}{U_0} = \underline{\underline{6\mu F}}$$

d)



$C_1^* = C_1 + C_3$

Kapazitiver Spannungsteiler:

$$C_1^* = \frac{U_0}{U_{1neu}} \cdot C_2 \Rightarrow \underline{\underline{C_3}} = \frac{U_0}{U_{1neu}} \cdot C_2 - C_1$$

$$= 4C - C = \underline{\underline{3C}} = \underline{\underline{9\mu F}}$$

e.) Spannungsquelle angeschlossen $\Rightarrow$ Energiedifferenz durch Nachladen aus Quelle

W_1: Energie vor Schalten

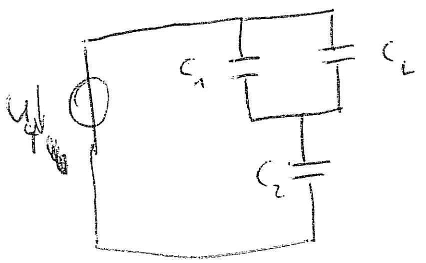
W_2: " nach "

$$\Delta W = \frac{1}{2} \Delta C \cdot U_0^2 = \frac{1}{2} \left(\frac{(1C+3C)\cdot 2C}{(1C+3C)+2C} - \frac{1C \cdot 2C}{1C+2C} \right) U_0^2$$

$$= \frac{1}{2} \cdot \frac{2}{3} C \cdot U_0^2 = \frac{1}{2} \cdot \frac{2}{3} \cdot 3\mu F \cdot 210^2 V^2 = \underline{44{,}1 \text{ mWs}}$$

Aufgabe 2

a.)



b.)

$$C = \varepsilon_0 \varepsilon_r \frac{A}{d} \qquad C_1 = \varepsilon_0 \varepsilon_{r_1} \frac{h \cdot b}{3d}$$

$$C_L = \varepsilon_0 \frac{h \cdot b}{3d}$$

$$C_2 = \varepsilon_0 \varepsilon_{r_2} \frac{2h \cdot b}{3d}$$

$$C_{ges} = \frac{(C_1 + C_L) C_2}{C_1 + C_2 + C_L} = \varepsilon_0 \frac{h \cdot b}{3d} \cdot \frac{(\varepsilon_{r_1} + 1) \, 2\varepsilon_{r_2}}{\varepsilon_{r_1} + 1 + 2\varepsilon_{r_2}}$$

$$Q_{ges} = C_{ges} \cdot U_q = \varepsilon_0 \cdot \frac{h \cdot b}{3d} \cdot \frac{24}{11} \cdot U_q \approx \underline{\underline{1{,}93 \cdot 10^{-9}\, C}}$$

c.)

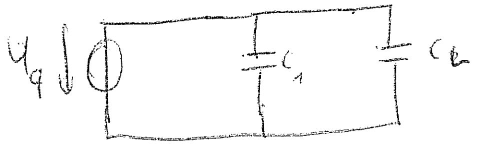
$$E_D = 30 \frac{kV}{cm} \Rightarrow U_{max}\Big|_{C_L} = E_D \cdot 3d \doteq 9\, kV$$

Kapazitiver Spannungsteiler

$$\frac{U_{max}\big|_{C_L}}{U_q} = \frac{C_{ges}}{C_1 + C_L} = \frac{\frac{(\varepsilon_{r_1} + 1) \, 2\varepsilon_{r_2}}{\varepsilon_{r_1} + 1 + 2\varepsilon_{r_2}}}{\varepsilon_{r_1} + 1} = \frac{2\varepsilon_{r_2}}{\varepsilon_{r_1} + 1 + 2\varepsilon_{r_2}} =$$

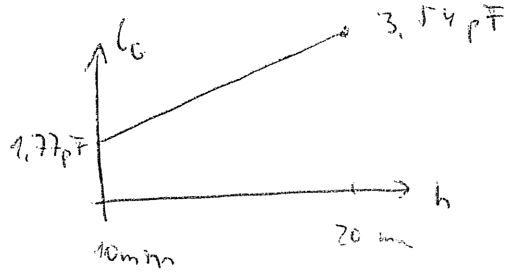
$$\Rightarrow \underline{\underline{U_q}} = E_d \cdot 3d \cdot \frac{11}{8} = \underline{\underline{12{,}375\, kV}}$$

d.)



e.)

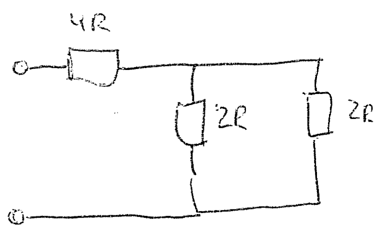
$$C_q = C_1 + C_2 = \underline{\varepsilon_0 (1 + \varepsilon_{r1}) \frac{h \cdot b}{3d}} = C_0' \cdot h$$



$C_0' = 117{,}08 \cdot 10^{-12} \frac{F}{m}$

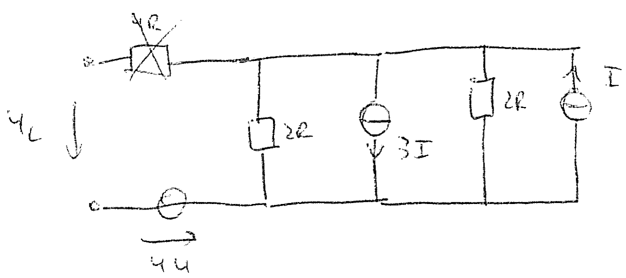
Aufgabe 3

a) $R_i \rightarrow$

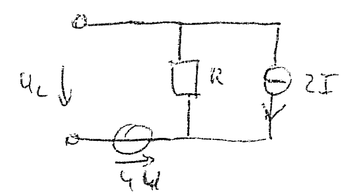


$R_i = 4R + (2R \| 2R) = \underline{\underline{5R}}$

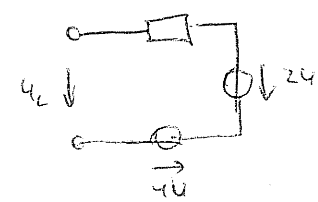
b)



$\Rightarrow$



$\Rightarrow$



$\Rightarrow \underline{\underline{U_L = 6U}}$

c) Leistungsanpassung $\Rightarrow R_L = R_i \underline{\underline{= 5R}}$

d) $U_{AB} = \frac{R_L}{R_i + R_L} U_L = \frac{5R}{10R} 6U = \underline{\underline{3U}}$

e) $P_{R_L} = \frac{U_{AB}^2}{R_L} = \frac{9}{5}\frac{U^2}{R}$

f) $I_{R_L} = 0 \Rightarrow U_L = 0$ bzw. $I_{KS} = 0$

Überlagerung: $I_{KS} = I \cdot \frac{R}{5R} - \frac{6U}{2R} \cdot \frac{R}{5R} - \frac{4U}{5R} \overset{!}{=} 0$

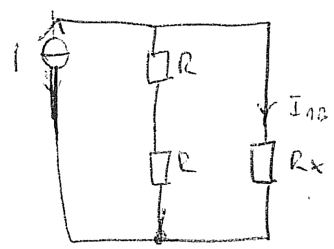
$\Leftrightarrow \underline{\underline{I}} = \left(\frac{4}{5}\frac{U}{R} + \frac{3}{5}\frac{U}{R}\right) 5 = \underline{\underline{7\frac{U}{R}}}$

9.) $P_{Q_i} = I_v^{2} \cdot 5R = \left(\frac{7U}{R}\right)^2 \cdot 5R = \underline{\underline{245 \frac{U^2}{R}}}$

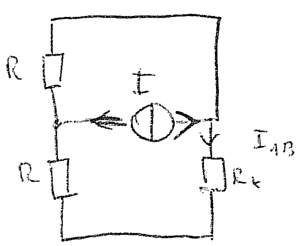
Aufgabe 4

a.) Überlagerung:

- U → nur Spannungsabfall über Stromquelle → kein Einfluß!

- 

$$I_{AB} = +\frac{R_{ges}}{R_x} I = +\frac{\frac{2RR_x}{2R+R_x}}{R_x} I = +\frac{2R}{2R+R_x}$$

- 

$$I_{AB} = +\frac{R}{2R+R_x} I$$

$$\Rightarrow \quad \underline{\underline{I_{AB} = +\frac{3R}{2R+R_x} I}}$$

b.) ~~I_{AB}~~ $U_{AB} = R_x \cdot I_{AB} \overset{!}{=} I \cdot R$

$$\Leftrightarrow \quad R_x \cdot \left(+\frac{3R}{2R+R_x}\right) I = I \cdot R$$

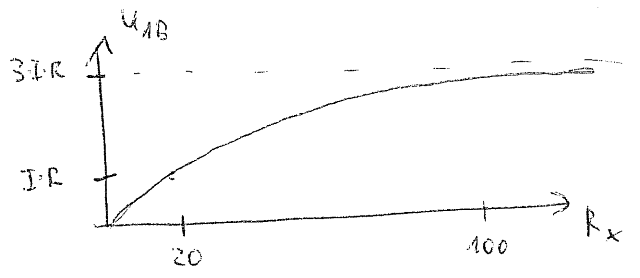
$$\Leftrightarrow \quad 3RR_x = (2R+R_x)R \quad \Leftrightarrow \quad \underline{\underline{R_x = R}}$$

c.) $P_{AB} = \frac{U_{AB}^2}{R_x} = \underline{\underline{I^2 \cdot R}}$

d.) $U_{AB} = R_x I_{AB} = \frac{3RR_x}{2R+R_x} I \quad \Rightarrow \quad$ $R_x \to 0: \; U_{AB} = 0$

$R_x \to \infty: \; U_{AB} = 3I \cdot R$

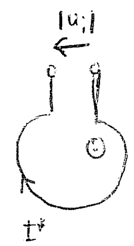
e.)



Aufgabe 5

a) $$u_i(t) = -N\frac{d\phi}{dt} = -\dot{B}\cdot A = \underline{-B_0\cdot A = -B_0\pi r^2}$$

u_i stets so gerichtet, dass Ursache der Induktion entgegengerichtet wird:



$\to$ Strom I^* zur Feldschwächung im Uhrzeigersinn

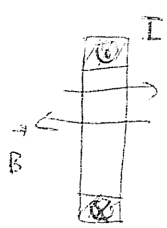
b) homogen $\to$ Plattenkondensator

$$E(t) = \frac{u(t)}{d} = -\frac{B_0\pi r^2}{d}$$

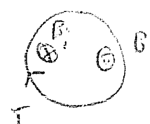
c) $$R = \rho\cdot\frac{l}{A} = \frac{l}{\varkappa\cdot A} = \frac{2\pi\frac{r+r_1}{2} - d}{\varkappa\cdot\frac{\pi\cdot(r_1-r)^2}{4}} = \frac{4(r+r_1) - \frac{4d}{\pi}}{\varkappa(r_1-r)^2} = 4\frac{r+r_1-\frac{d}{\pi}}{\varkappa(r_1-r)}$$

$$= \underline{\underline{199{,}4\ \mu\Omega}}$$

d)



$\hat{=}$

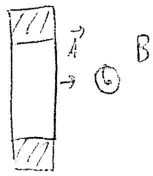


e) $$H(r_1) = \frac{I}{2\pi r^*},\quad r^* = 3\,mm \qquad I = \frac{u}{R} = J\cdot A \quad \text{(homogenes Feld)}$$

$$\Rightarrow \quad I = 2\pi r^*\cdot H(r_1) = 2{,}6P\,\mu A$$

$$J = \frac{I}{A} = \frac{2\pi r^* H(r_1)}{\pi\frac{(r_1-r)^2}{4}} = \frac{8\cdot r^*}{(r_1-r)^2}H(r_1) \approx 94{,}67\,\frac{A}{m^2}$$

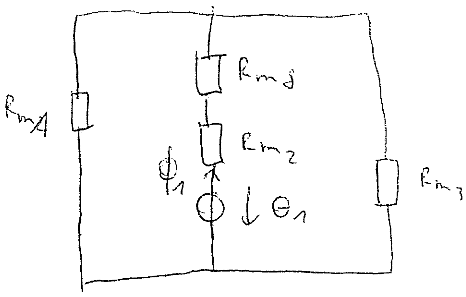
f.) Ring $\parallel \vec{B}$, so daß $\vec{A} \perp \vec{B}$



Aufgabe 6

GET TOP

a.)



b.)

$$N_1 \cdot I_1 = \Theta = \phi_1 \cdot R_{mges}$$

$$\Rightarrow \phi_1 = \frac{N_1 I_1}{R_{mges}} = \frac{N_1 I_1}{R_{m\delta} + R_{m2} + \frac{R_{m1}}{2}} \qquad R_{m1} = R_{m3}$$

$$R_{m1} = R_{m3} = \frac{l_1}{\mu_0 \mu_r h^2} \qquad l_1 = l_3 = l_2 + \delta + \frac{h}{2} + 2b \ldots$$

$$R_{m\delta} = \frac{\delta}{\mu_0 h^2}$$

$$R_{m2} = \frac{l_2}{\mu_0 \mu_r h^2}$$

c.)

$$R_m = \frac{R_{m1}}{2} + R_{m2} + R_{m\delta}$$

$$= \frac{\left(\frac{l_1}{2} + l_2\right) + \mu_r \delta}{\mu_0 \mu_r h^2} \approx 120{,}14 \cdot 10^6 \ \frac{A}{Vs}$$

d.)

$$L_1 = \frac{N_1^2}{R_m} \approx \underline{1{,}33 \text{ mH}}$$

$$L_2 = \frac{N_2^2}{R_m} \approx \underline{30 \ \mu\text{H}}$$

e.)

$$B = \frac{\phi_1}{h^2} = \frac{N_1 I_1}{R_m h^2} \quad \Rightarrow \quad \hat{I}_1 = \frac{R_m h^2}{N_1} \hat{B} \approx \underline{\underline{12{,}0 A}}$$

$$\Rightarrow I_1 = \frac{\hat{I}}{\sqrt{2}} \approx \underline{\underline{8{,}49}} \ A$$

f.) $|\hat{u}_1| = \omega L_1 \hat{I}_1 = 2\pi f L_1 \hat{I}_1 \approx \underline{0{,}42\,\Omega \cdot \hat{I}_1}$

$|\hat{u}_2| = \frac{N_2}{N_1} \hat{u}_1 \approx \underline{6{,}3 \cdot 10^{-3}\,\Omega \cdot \hat{I}_1}$

g.) $\sigma = 1 - k^2 = 1 - 0{,}9^2 = \underline{0{,}19}$

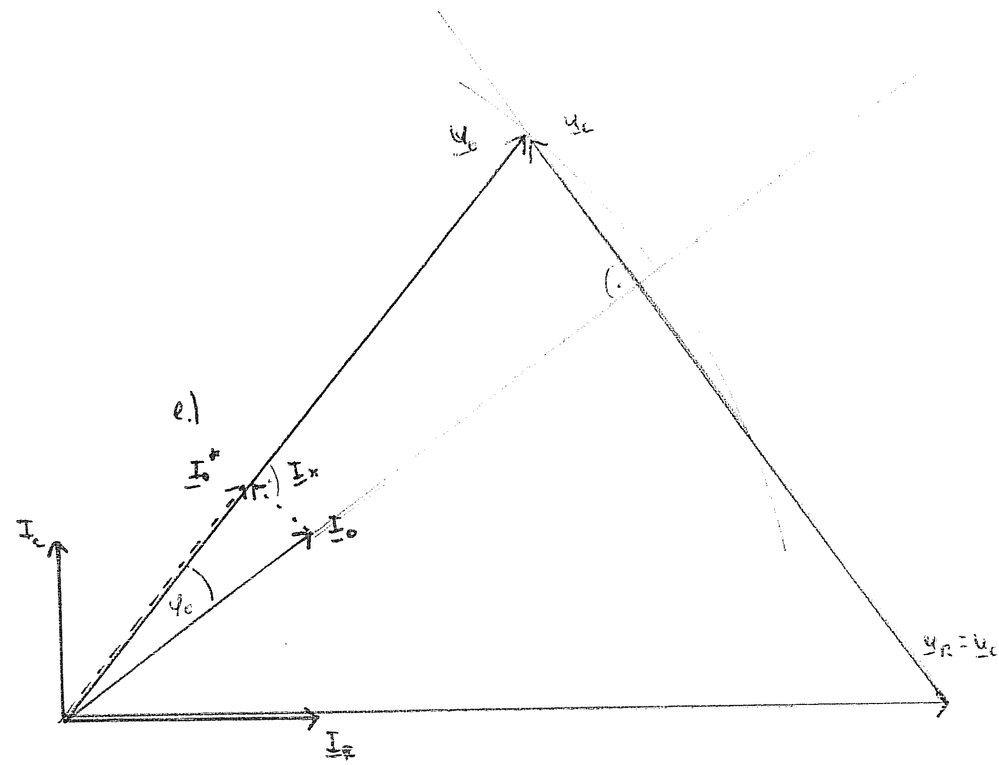
$M = k\sqrt{L_1 L_2} \approx \underline{180\,\mu H}$

Aufgabe 7

a.) $\underline{U}_R = R_R \cdot \underline{I}_R = \underline{\underline{11{,}9\ V}}$

$$|\underline{I}_c| = \frac{|\underline{U}_c|}{\frac{1}{\omega C}} = \omega C\ |\underline{U}_c| = 2\pi f\ C\ |\underline{U}_R| = \underline{\underline{23{,}8\ mA}}$$

b.)



$\underline{U}_R = \underline{U}_c$

$\underline{I}_0 = \underline{I}_R + \underline{I}_c = 41{,}5\ mA$ (aus ZD abgelesen)

$\underline{U}_L \perp \underline{I}_0$, $\underline{U}_0$ eilt $\underline{I}_0$ vor (induktive Belastung)

$\underline{U}_0 = \underline{U}_R + \underline{U}_L$ → größerer Wert von $\underline{U}_L$ als Lsg.

→ $U_L = 9{,}8\ V$ (aus ZD abgelesen)

$\varphi_0 = 43°$ (aus ZD abgelesen)

c.) $L = \frac{|\underline{U}_L|}{\omega\ |\underline{I}_0|} \approx 236\ mH$

d.) Schein: $S_0 = U_0 \cdot I_0 = \underline{415\ mVA}$

Wirk: $P_0 = U_0 \cdot I_0 \cdot \cos\varphi = \underline{404\ mW}$

Blind: $Q_0 = U_0 \cdot I_0 \cdot \sin\varphi = 93\ mVA$

e.) U_0 induktiv belastet $\Rightarrow$ X_P muß kapazitiv wirken

Blindstromkompensation $\Rightarrow \varphi_0 = 0$

$|I_x| = 1{,}1\,mA$ (aus ZP abgelesen)

$\Rightarrow \quad C = \dfrac{|I_x|}{\omega |U_0|} \approx \underline{\underline{1{,}1\,\mu F}}$

f.) ~~Sch~~ $S_0 = P_0 = \underline{U}_0 \cdot \underline{I}_0^* = \underline{\underline{404\,mW}}$ (siehe d.)

$\underline{\underline{Q_0 = 0\,VA}}$

Aufgabe 8 GET F08

a.) $\underline{Z} = j\omega L + \frac{1}{j\omega C} + R$

$= j\omega L - j\frac{1}{\omega C} + R = R + j\left(\omega L - \frac{1}{\omega C}\right)$

b.) Resonanz $\Rightarrow \operatorname{Im}\{\underline{Z}\} = 0 \Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$

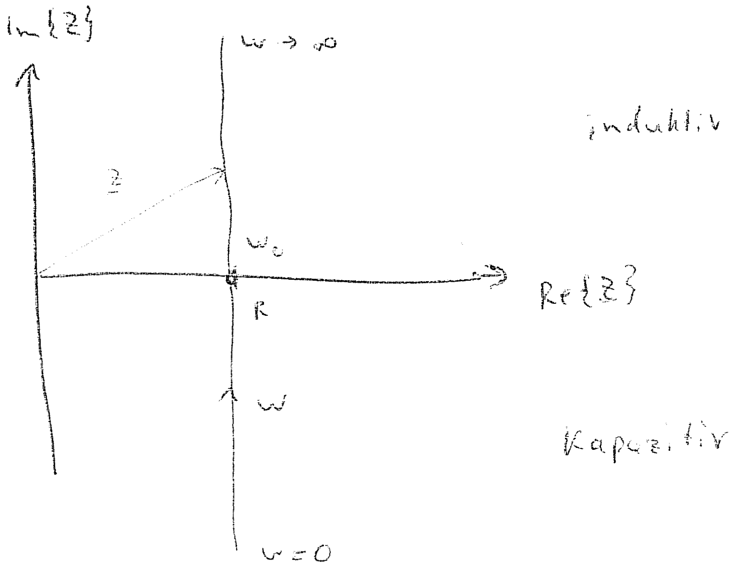
$\Rightarrow$ Reihenresonanz

c.) $\underline{Z}(\omega = 0) = R - j\infty$

$\underline{Z}(\omega = \omega_0) = R$

$\underline{Z}(\omega \to \infty) = R + j\infty$

d.)



e.) Resonanz $\rightarrow \omega = \omega_0$

Leistungsanpassung $\rightarrow R = R_i$

$\left|\frac{u}{u_0}\right|(\omega = 0) = 0$ $\left|\frac{u}{u_0}\right|(\omega \to \infty) = 0$

$\left|\frac{u}{u_0}\right|(\omega = \omega_0) = \frac{R}{R_i + R} = \frac{1}{2}$

f.)