1A a)

$U_1 = 200V - 5V = 195V$

$Q_{ges_1} = U_1 C_{ges}$, $C_{ges} = C + C = 2C$ (parallel)

$= 195V \cdot 2 \cdot 3 \cdot 10^{-6} F = 1,17\ mC$

$$W_1 = \frac{1}{2} U^2 \cdot C = \frac{195^2 V^2 \cdot 6 \cdot 10^{-6} F}{2} = 0,114\ Ws$$

b) die Ladung bleibt erhalten, $Q = const.$

$Q = U_{1b} \cdot C_{ges_b}$ $C_{ges_b} = 2C + \frac{4C \cdot 2C}{6C} = 2C + \frac{4C}{3} = \frac{10}{3}C$

$$U_{1b} = \frac{Q}{C_{ges}} = \frac{1,17 \cdot 10^{-3} C}{\frac{10}{\cancel{3}} \cdot \cancel{3} \cdot 10^{-6} \cdot 3} = \underline{\underline{117V}}$$

für Reihenschaltung 4C und 2C gilt.

$U_2 \cdot 4C = U_3 2C$

parallel zu U_1.

$$U_2 = \frac{U_3 \cdot 2C}{4C} = \frac{U_3}{2} \Rightarrow U_2 + U_3 = U_1$$

$U_2 + 2U_2 = U_1$

$U_2 = \frac{117V}{3} = \underline{\underline{39V}} \Rightarrow \underline{\underline{U_3 = 78V}}$

$$W_2 = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}U^2 C = \frac{117^2 V^2}{2} \cdot \frac{\overset{5}{\cancel{10}}}{3} \cdot 3 \cdot 10^{-6} F$$

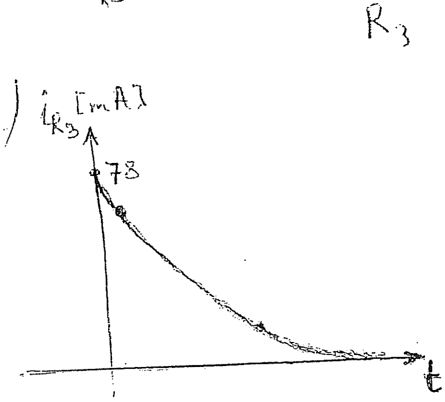
$= 0,0684\ Ws$

c) $\Delta W = 0,114\ Ws - 0,0684\ Ws = 0,0455\ Ws$

verluste im Leitern, wärme und H-Feld abschtralung.

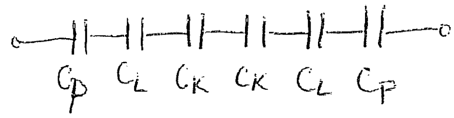
d) $$i_{R3}(t) = \frac{U_3}{R_3} e^{-\frac{t}{\tau}} \quad ; \quad \tau = R \cdot 2C$$

e)



t[ms]	i_{R3} [mA]
0	78 mA
0,1	76,7 mA
5	33,9 mA
∞	0

A2 a)



Reihenschaltung von Kondensatoren

b) C_{max} bei $X_0 = 0$, da $\varepsilon_{r1} > \varepsilon_0$

$$C_P = \frac{\varepsilon_{r2} \cdot \varepsilon_0 \cdot b \cdot h}{d} = \frac{2 \cdot 8{,}854 \cdot 10^{-12} \, As/Vm \cdot 0{,}02\,m \cdot 0{,}03\,m}{0{,}001\,m} = 10{,}62\,pF$$

$$C_L = \frac{\varepsilon_0 \cdot b \cdot h}{3d} = 1{,}77\,pF$$

$$C_K = \frac{\varepsilon_{r1} \cdot \varepsilon_0 \cdot b \cdot h}{3d} = 7{,}08\,pF \qquad \frac{1}{C_{max}} = \frac{1}{C_P} + \frac{1}{C_L} + \frac{1}{C_K} + \frac{1}{C_K} + \frac{1}{C_L} + \frac{1}{C_P}$$

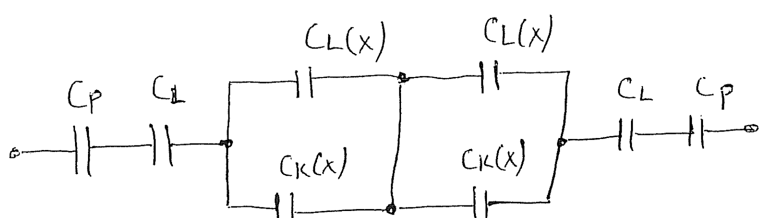
$$\frac{1}{C_{max}} = \frac{2}{C_P} + \frac{2}{C_L} + \frac{2}{C_K} = \frac{2(C_L C_K + C_P C_K + C_P C_L)}{C_P C_L C_K} \Rightarrow$$

$$C_{max} = \frac{C_P C_L C_K}{2(C_L C_K + C_P C_K + C_P C_L)} = \frac{10{,}62\,pF \cdot 1{,}77\,pF \cdot 7{,}08\,pF}{2(1{,}77\,pF \cdot 7{,}08\,pF + 10{,}62\,pF \cdot 7{,}08\,pF + 10{,}62\,pF \cdot 1{,}77\,pF)} =$$

$$C_{max} = \frac{133{,}08}{2 \cdot 106{,}5}\,pF = 0{,}62\,pF$$

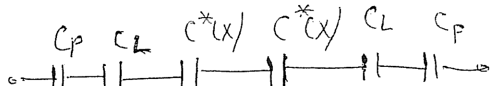
c) $Q = C_m U_q = 0{,}62\,pF \cdot 500\,V = 310\,pC$

d)



e) $C^*(x) = C_L(x) + C_K(x) \Rightarrow$

Parallelgeschaltet



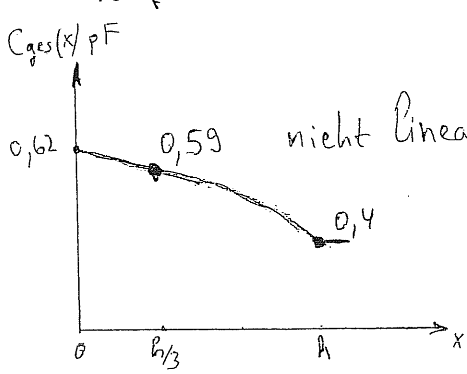
Reihenschaltung

$$C_{ges} = \frac{C_P C_L C^*(x)}{2(C_L \cdot C^*(x) + C_P C^*(x) + C_P C_L)}$$

$$C_L(x) = \frac{\varepsilon_0 \cdot x \cdot b}{3d}$$

$$C_K(x) = \frac{\varepsilon_0 \varepsilon_{r1} (h-x) \cdot b}{3d}$$

f)



nicht linear!

$$C^*(x) = \frac{\varepsilon_0 \cdot b}{3d} \left(x + \varepsilon_{r1}(h-x) \right)$$

① bei $x = h/3 = 0{,}01\,m$

$C^*(x) = 5{,}31\,pF \Rightarrow C_{ges}(h/3) = 0{,}5\,pF$

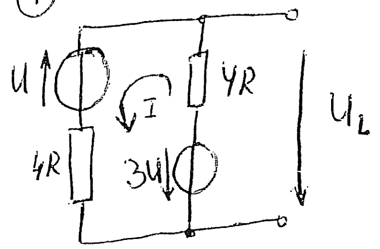
② bei $x = h$

$C^*(x) = C_L = 1{,}77\,pF \Rightarrow C_{ges} = 0{,}4\,pF$

A 3

a)

(1)

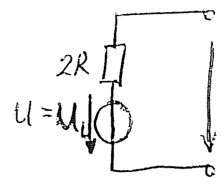


$I(4R+4R) - U - 3U = 0$

$I = \frac{4U}{8R} = \frac{U}{2R}$

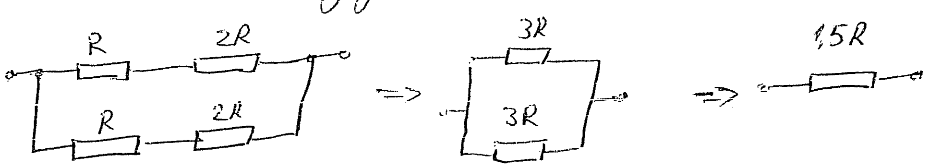
$U_L = 3U - I \cdot 4R = 3U - 2U = U$

$R_i = \frac{4R \cdot 4R}{8R} = 2R$

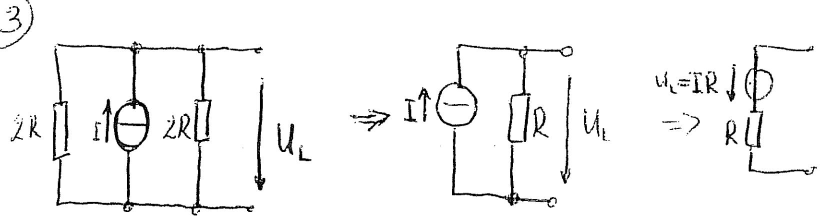


(2) Die Brücke ist abgeglichen => Brückenstrom = 0

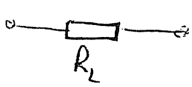
ESB.



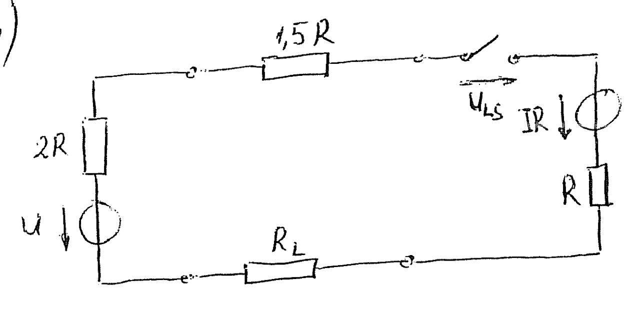
(3)



(4)



b)

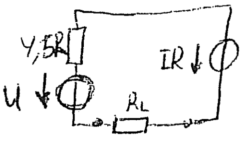


c) $U_{LS} = U - IR = U - \frac{3U}{R} \cdot R = -2U$

d) $R_L = R_i$ Leistungsanpassung

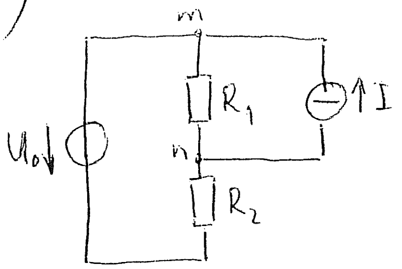
e) $P_{R_L} = \frac{(2U)^2}{4R_L} = \frac{4U^2}{18R} = \frac{2U^2}{9R}$

$R_i = 4,5R = R_L$

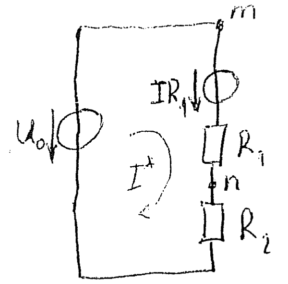


A4

a)



$\Longrightarrow$



$$U_{mn} = IR_1 + I^* R_1$$

$$I^* = \frac{U_0 - IR_1}{R_1 + R_2}$$

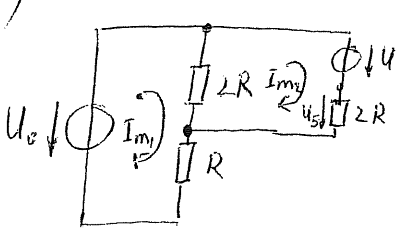
$$U_{mn} = IR_1 + \left(\frac{U_0 - IR_1}{R_1+R_2}\right) R_1$$

$$U_{mn} = \frac{\cancel{IR_1^2} + IR_1R_2 + U_0R_1 \cancel{- IR_1^2}}{R_1 + R_2} = \frac{R_1}{R_1+R_2}\left(IR_2 + U_0\right)$$

b) $U_2 = U_0 - U_{mn} = 20 - \left[\frac{20}{50}\left(0{,}2 \cdot 30 + 20\right)\right] = 20 - \left(\frac{2}{5} \cdot 26\right) =$

$= 20 - 10{,}4 = 9{,}6\ V$

c) Maschenstromverfahren mit zwei ausgewählte Maschen



$$\begin{cases} I_{m_1}(2R+R) - I_{m_2} 2R - U_0 = 0 \\ -I_{m_1} 2R + I_{m_2}(2R+2R) + U = 0 \end{cases}$$

$$I_{m_1} = \frac{U_0 + I_{m_2} 2R}{3R}$$

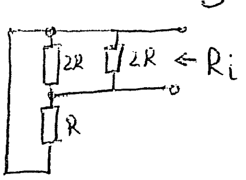
$$-\frac{U_0 2R}{3R} - \frac{I_{m_2} 2R \cdot 2R}{3R} + 4R I_{m_2} + U = 0$$

$$\frac{2}{3}U_0 - U = I_{m_2}\left(4R - \frac{4}{3}R\right) \Longrightarrow I_{m_2} = \frac{\frac{2U_0 - 3U}{3}}{\frac{12R - 4R}{3}} = \frac{2U_0 - 3U}{8R}$$

$$\boxed{U_5 = I_{m_2} \cdot 2R} = \frac{(2U_0 - 3U) \cdot 2\cancel{R}}{8\cancel{R}} =$$

$$= \frac{2U_0 - 3U}{4}$$

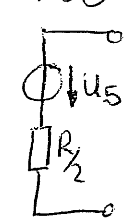
d) $U_L = U_5$



$\leftarrow R_i = R \,\|\, 2R \,\|\, 2R$

$$R_i = \frac{\frac{R \cdot 2R}{3R} \cdot 2R}{\frac{2}{3}R + 2R} = \frac{R}{2}$$

ESB



5A

a) $R = \frac{1}{\kappa}\cdot\frac{2(a+b)}{A} = \frac{20\,\cancel{m}}{58\cdot10^{6}\,\frac{S}{\cancel{m}}\cdot 3,44\cdot10^{-6}\,\cancel{m^2}} = 0,1\,\Omega$

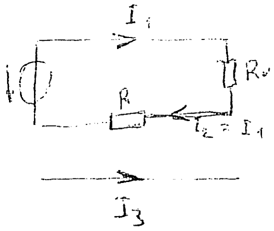
b) $I_1 = I_2 = \frac{500}{250,1}\sin(\omega t) = 2A\cdot\sin\omega t$

c)

$F_3 = B_3\cdot a\cdot I_2 = \frac{\mu_0\, I_3}{2\pi c}\cdot a\cdot I_2 \Rightarrow$

$c = \frac{\mu_0\cdot I_3\cdot a\cdot I_2}{2\pi\cdot F_3} = \frac{1,257\cdot10^{-6}\,\frac{H}{m}\cdot 10A\cdot 6m\cdot 2A}{2\cdot 3,14\cdot 5\cdot 10^{-5}\,N} = 0,48\,m$

d)



$F_{31} = \frac{I_3\cdot\mu_0}{2\pi\cdot(b+c)}\cdot a\cdot I_1$; $F_{21} = \frac{I_2\cdot\mu_0}{2\pi\cdot b}\cdot a\cdot I_1$

$F_M = F_{31} - F_{21}$

e) $U_i = -\cancel{N}\frac{d\Phi}{dt}$ $\quad \Phi = \iint B\,dA$; B const. für $\forall A \Rightarrow \Phi = BA$

$\vec{B} \perp \vec{A}$

$\frac{d\Phi}{dt} = \overbrace{\cancel{\frac{B\,dA}{dt}}}^{0,\ A=\text{const.}} + \frac{A\,dB(t)}{dt} = -A\cdot B_0\cdot\omega\cdot\sin\omega t$

$U_i = B_0 A\cdot\omega\cdot\sin\omega t$

$\odot\ \vec{B}(t)$, nach dem Lenzsche Regel (induzierte Strom gegen Richt.) U_i addiert sich mit $U(t)$

A6

a)

$$\Theta_1 = H_1 l_1 + H_2 l_2 = H_1 l_1 + H_3 l_3 \Rightarrow H_2 l_2 = H_3 l_3$$

$$\Phi_1 = \Phi_2 + \Phi_3$$

für $\Phi_2 = B_2 A \Rightarrow B_2 = \frac{0{,}1 \cdot 10^{-3}\,Wb}{100 \cdot 10^{-6}\,m^2} =$

$B_2 = 1T \xrightarrow{\text{magn. Linie}} H_2 = 10{,}4\,A/cm \Rightarrow$

$$H_3 = \frac{H_2 \cdot l_2}{l_3} = \frac{10{,}4 \cdot 80}{240} = \frac{10{,}4}{3} = 3{,}46\,A/cm$$

$\xrightarrow{\text{aus magn. Linie}} B_3 = 0{,}27\,T \Rightarrow \Phi_3 = B_3 A$

$$\Phi_3 = 0{,}27\,T \cdot 100 \cdot 10^{-6}\,m^2 = 0{,}027\,mWb$$

$\Phi_1 = 0{,}1\,mWb + 0{,}027\,mWb =$
$= 0{,}127\,mWb$

b) $\Theta_1 = H_1 l_1 + H_2 \cdot l_2$

$$B_1 = \frac{\Phi_1}{A} = \frac{0{,}127 \cdot 10^{-3}\,Wb}{100 \cdot 10^{-6}\,m^2} = 1{,}27\,T$$

$\xrightarrow{\text{aus magn. Linie}} H_1 = 17{,}5\,A/cm$

$\Rightarrow \Theta_1 = 17{,}5 \cdot 24 + 10{,}4 \cdot 8 =$
$\cong 503\,A$

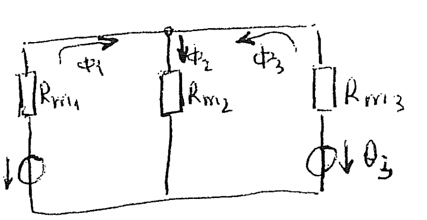
c) $V_m = H_m \cdot l_m = R_m \cdot \Phi_m$

$$R_{m1} = \frac{H_1 l_1}{\Phi_1} = \frac{17{,}5\,A/cm \cdot 24\,cm}{0{,}127 \cdot 10^{-3}\,Wb} = 3307 \cdot 10^3\,A/Vs$$

$$R_{m2} = \frac{H_2 l_2}{\Phi_2} = \frac{10{,}4\,A/cm \cdot 8\,cm}{0{,}1 \cdot 10^{-3}\,Wb} = 832 \cdot 10^3\,A/Vs$$

$$R_{m3} = \frac{H_3 l_3}{\Phi_3} = \frac{3{,}46\,A/cm \cdot 24\,cm}{0{,}027 \cdot 10^{-3}\,Wb} = 3075 \cdot 10^3\,A/Vs$$

d)



e) $\boxed{\Theta_3 = H_3 l_3 + H_2 l_2}$, $H_2 \cdot l_2$ **bleibt**, weil $\Phi_2 = 0{,}1\,mWb$
$= 10{,}4 \cdot 80 = 83{,}2\,A$

$$H_3 = \frac{\Theta_3 - H_2 l_2}{l_3} = \frac{150\,A - 83{,}2\,A}{24\,cm} = 2{,}78\,A/cm \xrightarrow{\text{aus magn. Linie}} B_3 = 0{,}18\,T \Rightarrow \Phi_3 = B_3 A_3$$

$\Phi_3 = 0{,}18 \cdot 100 \cdot 10^{-6} =$
$= 0{,}018\,mWb$

da, $\boxed{\Phi_2 = \Phi_1 + \Phi_3} \Rightarrow \boxed{\Phi_1 = \Phi_2 - \Phi_3} = 0{,}1\,mWb - 0{,}018\,mWb$

$\Rightarrow \Phi_1 = 0{,}082\,mWb \Rightarrow B_1 = 0{,}82\,T \xrightarrow{\text{aus magn. Linie}} H_1 = 7{,}7\,A/cm \Rightarrow \Theta_1 = H_1 l_1 + H_2 l_2$

$$\Theta_1 = 7{,}7\,A/cm \cdot 24\,cm + 83{,}2\,A = \underline{268\,A}$$

A1

a) $\underline{I}_1 = \frac{\underline{U}_0}{R_1 + j\omega L_1} = \frac{100 \cdot e^{j0°}}{(100 + j2 \cdot 10^3 \cdot 400 \cdot 10^{-3})} = \frac{100\,V}{(100 + j800)} = \frac{100\,e^{j0}}{806{,}2\,e^{j82{,}7}} = 0{,}124\,e^{j-82°}$

$\underline{I}_2 = \frac{\underline{U}_0}{R_2 + j(\omega L_2 - \frac{1}{\omega C})} = \frac{100\,e^{j0}}{50\Omega + j(2 \cdot 10^3 \cdot 100 \cdot 10^{-3} - \frac{1}{2 \cdot 10^3 \cdot 10^{-6}})} = \frac{100\,e^{j0}}{50 - j300} = \frac{100\,e^{j0}}{304\,e^{j-80{,}5}} =$

$= 0{,}328\,e^{j80{,}5°}$

$\underline{I}_0 = \underline{I}_1 + \underline{I}_2 = 0{,}124\,e^{j-82} + 0{,}328\,e^{j80{,}5} = 0{,}017 - j0{,}122 + 0{,}054 + j0{,}32 = 0{,}213\,e^{j70°}$

b) $\underline{U}_{R1} = \underline{I}_1 \cdot R_1 = 12{,}4\,V\,e^{j-82}$

$\underline{U}_{L1} = \underline{I}_1 \cdot j\omega L_1 = 99{,}2\,V\,e^{j8}$

$\underline{U}_{R2} = \underline{I}_2 \cdot R_2 = 16{,}4\,V\,e^{j80{,}5°}$

$\underline{U}_{L2} = \underline{I}_2 \cdot j\omega L_2 = 65{,}6\,V\,e^{j170{,}5°}$

$\underline{U}_C = \underline{I}_2(-j\frac{1}{\omega C}) = 164\,e^{j-9{,}5}$

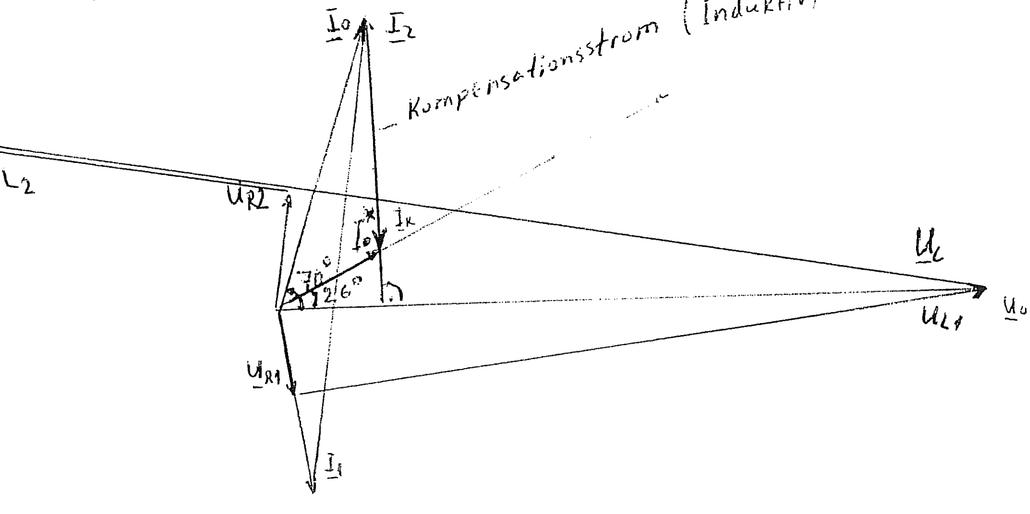
d) $P_0 = U_0 I_0 \cdot \cos 70° = 7{,}28\,W$

$Q_0 = U_0 I_0 \cdot \sin 70 = 20\,VAr$

$S_0 = U_0 I_0 = 21{,}3\,VA$

e) $\varphi^* = \arccos 0{,}9 \hat{=} 26°$

c) $10\,V \hat{=} 1\,cm$; $0{,}05\,A \hat{=} 1\,cm$



f) $\underline{I}_0^* = 0{,}085\,e^{j26}$ (aus ZD abgelesen)

$\underline{I}_K = 0{,}155\,A\,e^{j-90}$ (Induktiv)

Bauelement Induktivität: $\underline{U_0 = I_K \cdot j\omega L}$ $\Rightarrow L = \frac{U_0}{I_K \cdot \omega} = \frac{100}{0{,}155 \cdot 2 \cdot 10^3}$

$L = 322{,}5\,mH$

A8

a) $$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10\cdot 10^{-3}\cdot 10^{-6}}} = \frac{1}{10^{-4}} = \underline{\underline{10\,kHz.}}$$

Blindleistung

$$Q = \frac{Q_B}{P} = \frac{U_L^2}{\omega_0 L}\cdot\frac{R_2}{U_{R_2}^2} \overset{!}{=} \frac{R_2}{\omega_0 L} \quad \text{oder} \quad R_2\cdot\omega_0 C$$

Wirkleistung

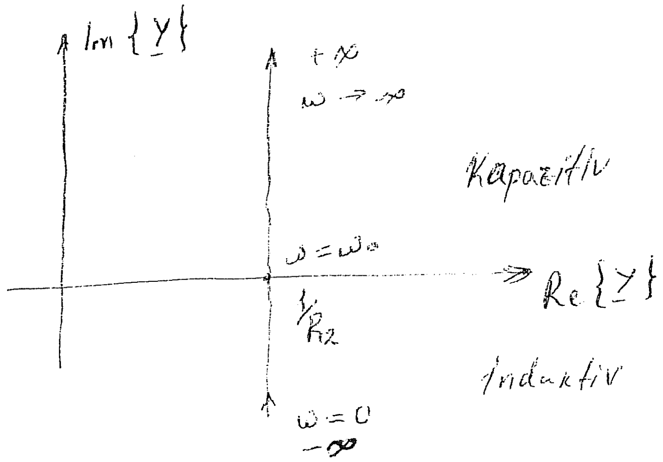
Parallelschwingkreis

$$U_L = U_R = U_C$$

$$Q = \frac{500}{10\cdot 10^{3}\cdot 10\cdot 10^{-3}} = \underline{\underline{5}}$$

b) $$\underline{Y} = \frac{1}{R_2} + \frac{1}{j\omega L} + j\omega C = \frac{1}{R_2} + j\left(\omega C - \frac{1}{\omega L}\right)$$

c)



d) $$\frac{\underline{U}_2}{\underline{U}_1} = \frac{\frac{1}{\underline{Y}(\omega)}}{R_1 + \frac{1}{\underline{Y}(\omega)}} = \frac{\frac{1}{\underline{Y}(\omega)}}{\frac{R_1\underline{Y}(\omega)+1}{\underline{Y}(\omega)}} = \frac{1}{\cancel{\underline{Y}}}\cdot\frac{\cancel{\underline{Y}}}{R_1\underline{Y}(\omega)+1} = \frac{1}{R_1\underline{Y}(\omega)+1}$$

e) $$\left|\frac{\underline{U}_2}{\underline{U}_1}\right| = \left|\frac{1}{\frac{R_1}{R_2} + jR_1\left(\omega C - \frac{1}{\omega L}\right)}\right| = \frac{1}{\sqrt{\left(\frac{R_1}{R_2}\right)^2 + \left(\frac{R_1(\omega^2 LC - 1)}{\omega L}\right)^2}}$$