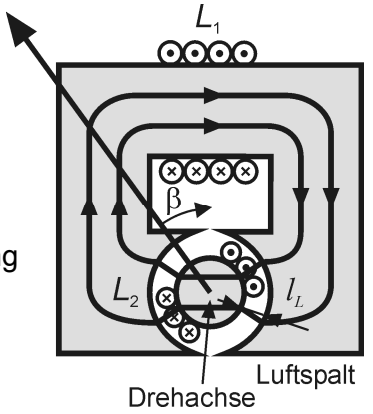
Aufgabe 1

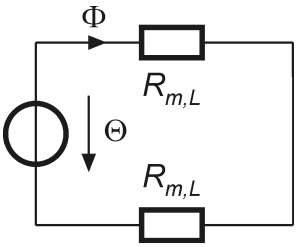
1.1 Feldlinien: siehe Abb.

Vorteile:
- l_L = const
- für alle β: $B \perp$ Wicklung

$\Rightarrow$ höheres M



1.2 $R_m = 2R_{m,L} = \dfrac{2l_L}{\mu_0 A_L} = 7{,}1 \cdot 10^6\ \mathrm{H^{-1}}$



1.3 $\Phi = BA_L = 9\,\mu\mathrm{Wb}$ $\quad N_1 = \dfrac{\Phi_1 R_m}{I_1} = 640$ $\quad L_1 = \dfrac{N_1^2}{R_{m,L}} = 58\,\mathrm{mH}$

1.4 Stromrichtung: siehe Abb. 1.1

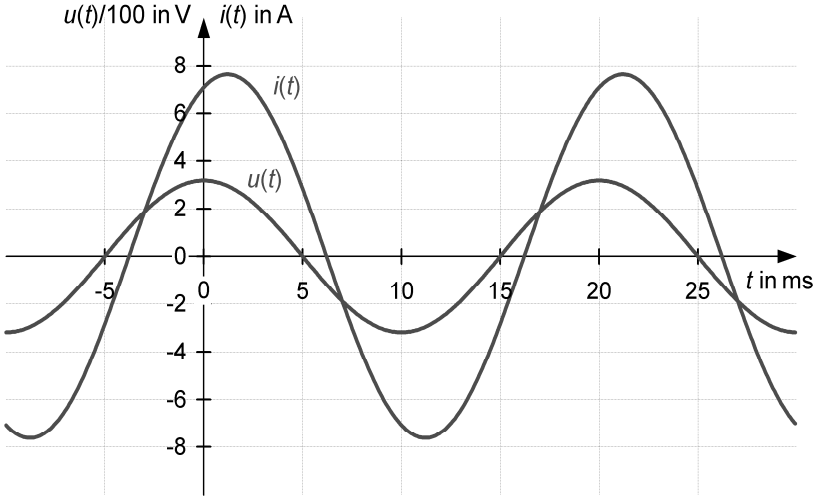
1.5 $F = lBI_2$ $\quad M = N_2 F d = N_2 l B I_2 d = 1{,}6\,\mu\mathrm{Nm}$

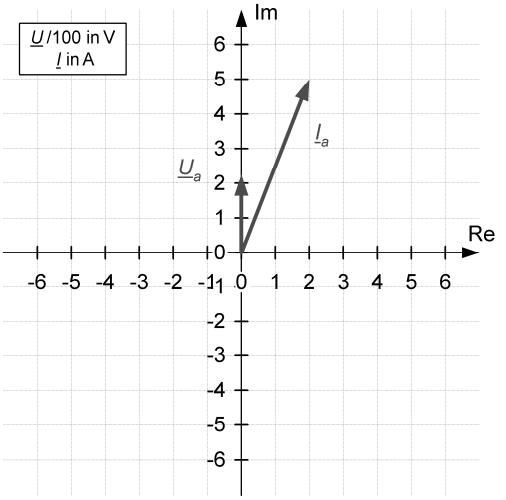
1.6 $M_F = c\beta = M \Rightarrow c = M/\beta_{max} = 18\,\mathrm{nN/°}$

1.7 Produkt $I_1 I_2$ Messung von $P = UI$ an Last R
L_1 in Serie zu R (Strommessung $I = I_1$)
L_2 mit Serienwiderstand $R_2 = 10\,\mathrm{k\Omega}$ parallel zur Last R (Spannungsmessung $U = R_2 I_2$)

Aufgabe 2

2.1 $T = 1/f = 20\,\mathrm{ms}$ $\quad \hat{U}_a = \sqrt{2}\,U_a = 318\,\mathrm{V}$ $\quad \varphi_u = 90°$





2.2 $\varphi = \arcsin\beta = 22°$ $\quad \underline{S} = S\mathrm{e}^{\mathrm{j}\varphi} = (1{,}12 + \mathrm{j}0{,}45)\,\mathrm{kVA} = P + \mathrm{j}Q \Rightarrow P = 1{,}12\,\mathrm{kW},\ Q = 0{,}45\,\mathrm{kvar} > 0 \Rightarrow$ induktiv

2.3 $\underline{I}_a^* = \dfrac{\underline{S}}{\underline{U}_a} = \dfrac{(1{,}12 + \mathrm{j}0{,}45)\,\mathrm{kVA}}{\mathrm{j}225\,\mathrm{V}} = (2 - \mathrm{j}5)\,\mathrm{A} \Rightarrow I_a = (2 + \mathrm{j}5)\,\mathrm{A}$

2.4 $\underline{Z}_a = \dfrac{\underline{U}_a}{\underline{I}_a} = \dfrac{\mathrm{j}225\,\mathrm{V}}{(2 + \mathrm{j}5)\,\mathrm{A}} = (40 + \mathrm{j}16)\,\Omega$ $\quad R$ in Serie mit L $\quad R_a = 40\,\Omega$ $\quad L_a = \dfrac{X_L}{\omega} = \dfrac{16\,\Omega}{2\pi \cdot 50\,\mathrm{Hz}} = 50\,\mathrm{mH}$

2.5 $\underline{Z}_e = 2\underline{Z}_L + \underline{Z}_C = 2\mathrm{j}\omega L + \dfrac{1}{\mathrm{j}\omega C}$ $\quad \underline{H}(f) = \dfrac{\underline{Z}_C}{\underline{Z}_e} = \dfrac{1/(\mathrm{j}\omega C)}{2\mathrm{j}\omega L + 1/(\mathrm{j}\omega C)} = \dfrac{1}{1 - 2\omega^2 LC}$

2.6 $H(f \to 0) = 1$ $\quad H(f \to \infty) = 0$ $\quad$ hochfrequente Störungen werden gesperrt

2.7 $L = \dfrac{1}{2(2\pi f_0)^2 C} = \dfrac{1}{2(2\pi \cdot 8\,\mathrm{kHz})^2 \cdot 0{,}1\,\mu\mathrm{F}} = 2\,\mathrm{mH}$

Aufgabe 3

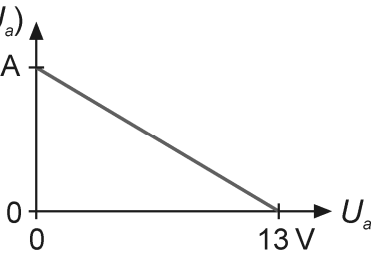
3.1 $R_{iP} = R_1 + R_2 = 8\ \Omega \qquad U_{0P} = U_1 + R_1 I_1 = 17\ \text{V}$

3.2 $R_i = R_{iP} \square R_{iB} \qquad R_i = \dfrac{(R_1+R_2)R_{iB}}{R_1+R_2+R_{iB}} = 1{,}6\ \text{k}\Omega \qquad I_P = \dfrac{U_{0P}-U_{0B}}{R_1+R_2+R_{iB}} = \dfrac{5\ \text{V}}{10\ \Omega} = 0{,}5\ \text{A}$

$$U_0 = U_{0B} + R_{iB} I_P = U_{0B} + \frac{R_{iB}(U_{0P}-U_{0B})}{R_1+R_2+R_{iB}} = 13\ \text{V}$$

3.3 $I_{a,max} = I_k = \dfrac{U_0}{R_i} = \dfrac{13\ \text{V}}{1{,}6\ \Omega} = 8{,}1\ \text{A}$

3.4



3.5 $P_{max} = \dfrac{U_0^2}{4R_i} = \dfrac{13^2\ \text{V}^2}{6{,}4\ \Omega} = 26{,}4\ \text{W}$

Wirkungsgrad bei Anpassung nur $\eta = 0{,}5 \Rightarrow$ nicht energieeffizient

3.6 $\eta = \dfrac{P}{P_0} = \dfrac{R_a}{R_a+R_i} \Rightarrow R_a(1+\eta^{-1}) = R_i \Rightarrow R_a = R_i \dfrac{\eta}{1-\eta} \qquad R_{a,min} = \dfrac{0{,}95}{1-0{,}95} R_i = 19 \cdot 1{,}6\ \Omega = 30{,}4\ \Omega$

3.7 $P_0 = \dfrac{U_0^2}{R_a+R_i} = \dfrac{13^2\ \text{V}^2}{30{,}4\ \Omega + 1{,}6\ \Omega} = 5{,}3\ \text{W} \qquad P = \eta P_0 = 5\ \text{W}$

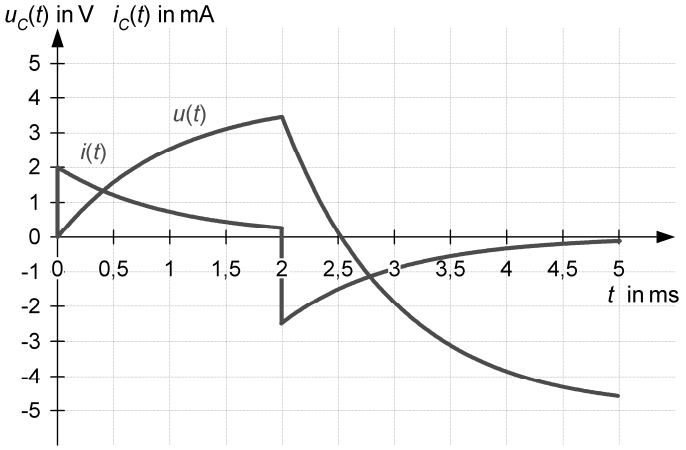
$$I_a = \frac{U_0}{R_a+R_i} = \frac{13\ \text{V}}{30{,}4\ \Omega + 1{,}6\ \Omega} = 0{,}41\ \text{A} \qquad U_a = I_a R_a = 0{,}41\ \text{A} \cdot 30{,}4\ \Omega = 12{,}4\ \text{V}$$

3.8 $W = Pt = UIt \Rightarrow t_{laden} = \dfrac{W}{U_0 I_P} = 1{,}7\ \text{h} \qquad t_{entladen} = \dfrac{W}{U_a I_a} = 2\ \text{h}$

Aufgabe 4

4.1 $\tau = RC = 1\,\text{ms} \qquad I_0 = \dfrac{U_0}{R} = 2\ \text{mA} \qquad u_C(T_0) = U_0(1-\text{e}^{-T_0/\tau}) = 3{,}5\ \text{V}$

4.2 $u_C(t) = U_0(1-\text{e}^{-t/\tau}) \qquad i_C(t) = I_0\,\text{e}^{-t/\tau}$



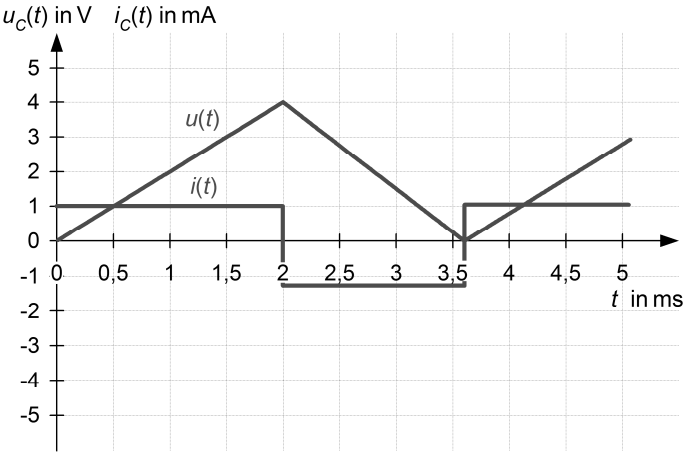
4.3 $u_C(t) = \dfrac{q(t)}{C} = \dfrac{I_0 t}{C} = \dfrac{Uk}{C} t$

$i_C(t) = k U = 0{,}25 \dfrac{\text{mA}}{\text{V}} U = \text{const}$

$u_C(T_0) = \dfrac{U_0 k}{C} T_0 = 2 \dfrac{\text{V}}{\text{ms}}\ 2\,\text{ms} = 4\ \text{V}$

$i_C(T_0) = k U_0 = 0{,}25 \dfrac{\text{mA}}{\text{V}}\ 4\ \text{V} = 1\,\text{mA}$

4.4



Grundlagen der Elektrotechnik Wintersemester 2015/16 – Kurzlösung

Aufgabe 1

1.1 im Uhrzeigersinn 1.2 $\Phi = N I = 800 \cdot 0{,}1\,\text{A} = 80\,\text{A}$

1.3 $H = \frac{\theta}{l} = \frac{80\,\text{A}}{0{,}16\,\text{m}} = 500\,\frac{\text{A}}{\text{m}}$ 1.4 $B = 0{,}2\,\text{T}$

1.5 $\mu_r = \frac{B}{\mu_0 H} = \frac{0{,}2\,\frac{\text{Vs}}{\text{m}^2}}{4\pi \cdot 10^{-7}\,\frac{\text{Vs}}{\text{Am}} \cdot 500\,\frac{\text{A}}{\text{m}}} = 318$

1.6 $R_m = \frac{l}{\mu_0 \mu_r A} = \frac{16\,\text{cm}}{4\pi \cdot 10^{-7}\,\frac{\text{Vs}}{\text{Am}} \cdot 318 \cdot 1{,}8\,\text{cm}^2} = 2{,}2 \cdot 10^6\,\text{H}^{-1}$ $L = \frac{N^2}{R_m} = \frac{800^2}{2{,}2 \cdot 10^6\,\text{H}^{-1}} = 0{,}29\,\text{H}$

1.7 $\Phi = \frac{\theta}{R_m} = \frac{80\,\text{A}}{2{,}2 \cdot 10^6\,\frac{\text{A}}{\text{Vs}}} = 36\,\mu\text{Wb}$ $W = 0{,}5 L I^2 = 0{,}5 \cdot 0{,}29\,\text{H} \cdot 0{,}1^2\,\text{A}^2 = 1{,}4\,\text{mJ}$

1.8 $H = 4\,\frac{\text{kA}}{\text{m}}$ $B = 0{,}6\,\text{T}$

Aufgabe 2

2.1 $\underline{Z}_R = R = 100\,\Omega$ $\underline{Z}_L = \text{j}2\pi f L = \text{j}125{,}7\,\Omega$ $\underline{Z}_C = \frac{1}{\text{j}2\pi f C} = -\text{j}79{,}6\,\Omega$

$$\underline{Z} = (\underline{Z}_R + \underline{Z}_L) \,\|\, \underline{Z}_C = \frac{(100 + \text{j}125{,}7)\,\Omega \cdot (-\text{j}79{,}6\,\Omega)}{(100 + \text{j}125{,}7)\,\Omega + (-\text{j}79{,}6\,\Omega)} = (52{,}3 - \text{j}103{,}7)\,\Omega = 116\,\text{e}^{-\text{j}63°}\,\Omega$$

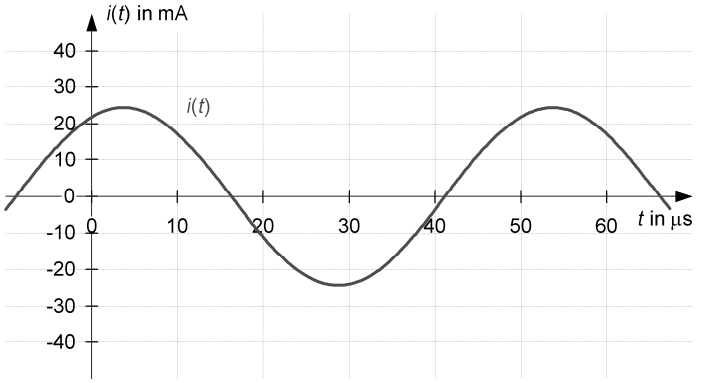
2.2 $Z = 116\,\Omega$ $\varphi_Z = -63°$

2.3 $R = \text{Re}\{\underline{Z}\} = 52{,}3\,\Omega$ $X = \text{Im}\{\underline{Z}\} = -103{,}7\,\Omega$ kapazitiv wegen $X < 0$

2.4 $G = \text{Re}\{\underline{Z}^{-1}\} = 3{,}9\,\text{mS}$ $B = \text{Im}\{\underline{Z}^{-1}\} = 7{,}7\,\text{mS}$

2.5 $\underline{I} = \frac{\underline{U}}{\underline{Z}} = \frac{2\,\text{V}}{116\,\text{e}^{-\text{j}63°}\,\Omega} = 17{,}2\,\text{e}^{\text{j}63°}\,\text{mA} = (7{,}8 + \text{j}15{,}4)\,\text{mA}$

2.6 $i(t) = \sqrt{2} \cdot 17{,}2\,\sin(\omega t + 63°)\,\text{mA} = 24{,}3\,\sin(2\pi \cdot 20\,\text{kHz} \cdot t + 63°)\,\text{mA}$



2.7 $\underline{I}_C = \frac{\underline{U}}{\underline{Z}_C} = \frac{2\,\text{V}}{-\text{j}79{,}6\,\Omega} = -\text{j}25{,}1\,\text{mA}$ $\underline{I}_R = \underline{I} - \underline{I}_C = (7{,}8 + \text{j}15{,}4)\,\text{mA} - \text{j}25{,}1\,\text{mA} = (7{,}8 - \text{j}9{,}7)\,\text{mA}$

Aufgabe 3

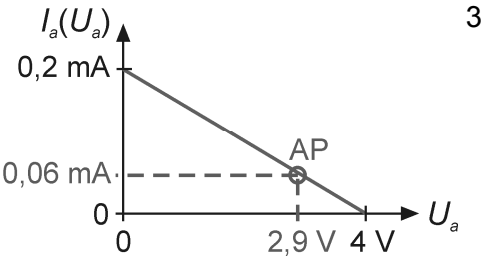
3.1 $R_{iV} \to \infty$

3.2 $U_0 = R_2 I_1 = U_a = 4\ \text{V} \qquad R_i = R_2 + R_3 = 20\ \text{k}\Omega \qquad I_1 = \dfrac{U_0}{R_2} = \dfrac{U_a}{R_2} = \dfrac{4\ \text{V}}{10\,\text{k}\Omega} = 0{,}4\ \text{mA}$

3.3 $I_{max} = I_k = \dfrac{U_0}{R_i} = \dfrac{4\ \text{V}}{20\ \text{k}\Omega} = 0{,}2\ \text{mA}$

3.4 $P_{max} = \dfrac{U_0^2}{4R_i} = \dfrac{16\ \text{V}^2}{80\ \text{k}\Omega} = 0{,}2\ \text{mW}$ für $R_a = R_i = 20\ \text{k}\Omega$

3.5



3.6 $U_a = U_0 \dfrac{R_a}{R_a + R_i} = 4\ \text{V}\ \dfrac{50\ \text{k}\Omega}{50\ \text{k}\Omega + 20\ \text{k}\Omega} = 2{,}9\ \text{V}$

$I_a = \dfrac{U_a}{R_a} = \dfrac{2{,}9\ \text{V}}{50\ \text{k}\Omega} = 0{,}06\ \text{mA}$

3.7 $R_a^* = R_a \| R_{iV} = \dfrac{R_a \cdot R_{iV}}{R_a + R_{iV}} = \dfrac{50\ \text{k}\Omega \cdot 200\ \text{k}\Omega}{50\ \text{k}\Omega + 200\ \text{k}\Omega} = 40\ \text{k}\Omega$

$U_a^* = U_0 \dfrac{R_a^*}{R_a^* + R_i} = 4\ \text{V}\ \dfrac{40\ \text{k}\Omega}{40\ \text{k}\Omega + 20\ \text{k}\Omega} = 2{,}7\ \text{V}$

3.8 $f_r = \dfrac{\Delta U}{U_a} = \dfrac{-0{,}2\ \text{V}}{2{,}9\ \text{V}} = -7\ \%$

Aufgabe 4

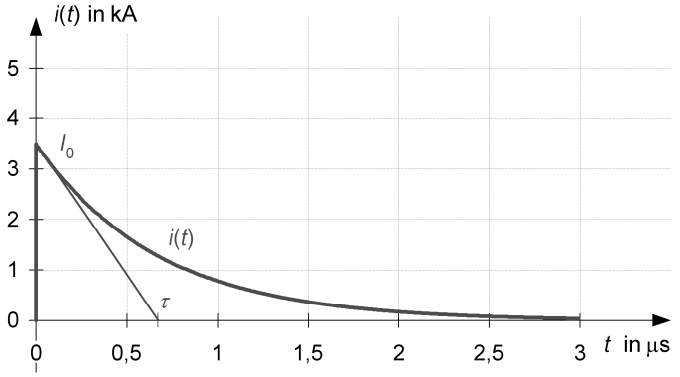
4.1 $C_S = \dfrac{C_1}{8} = 25\ \text{nF}$

4.2 $U_S = 8\,U_0 = 560\ \text{kV}$

4.3 $C = \dfrac{C_S \cdot C_P}{C_S + C_P} = \dfrac{25\ \text{nF} \cdot 5\ \text{nF}}{25\ \text{nF} + 5\ \text{nF}} = 4{,}2\ \text{nF} \qquad U_L = U_S$ da $Q_P = 0$ und somit $U_P = 0$

4.4 $\tau = RC = 160\ \Omega \cdot 4{,}2\ \text{nF} = 0{,}67\ \mu\text{s}$

4.5



$I_0 = \dfrac{U_L}{R} = \dfrac{560\ \text{kV}}{160\ \Omega} = 3{,}5\ \text{kA}$

4.6 $Q = C_S U_L = 25\ \text{nF} \cdot 560\ \text{kV} = 14\ \text{mC}$

4.7 $U_S = U_P = \dfrac{Q}{C_S + C_P} = \dfrac{14\ \text{mC}}{25\ \text{nF} + 5\ \text{nF}} = 467\ \text{kV} \qquad \Delta Q = Q_P = C_P U_P = 5\ \text{nF} \cdot 467\ \text{kV} = 2{,}3\ \text{mC}$