Aufgabe 1

1.1 $E = \frac{U}{d} = \frac{6\,\text{kV}}{0{,}01\,\text{m}} = 600\,\frac{\text{kV}}{\text{m}}$ 1.2 $A = \frac{C_0\,d}{\varepsilon_0} = \frac{6\cdot 10^{-11}\,\frac{\text{As}}{\text{V}}\cdot 0{,}01\,\text{m}}{8{,}85\cdot 10^{-12}\,\frac{\text{As}}{\text{Vm}}} = 0{,}068\,\text{m}^2$

1.3.1 $C_L = \frac{\varepsilon_0 A}{d/2} = 2\,C_0$ $C_G = \frac{\varepsilon_0\varepsilon_r A}{d/2} = 10\,C_0$ $C = \frac{C_L\cdot C_G}{C_L + C_G} = \frac{2\,C_0\cdot 10\,C_0}{12\,C_0} = \frac{5}{3}C_0 = 100\,\text{pF}$

1.3.2 $E_G = \frac{D}{\varepsilon_0\varepsilon_r} = \frac{C\,U}{C_0\varepsilon_r d} = \frac{100\,\text{pF}\cdot 6\,\text{kV}}{60\,\text{pF}\cdot 5\cdot 0{,}01\,\text{m}} = 200\,\frac{\text{kV}}{\text{m}}$

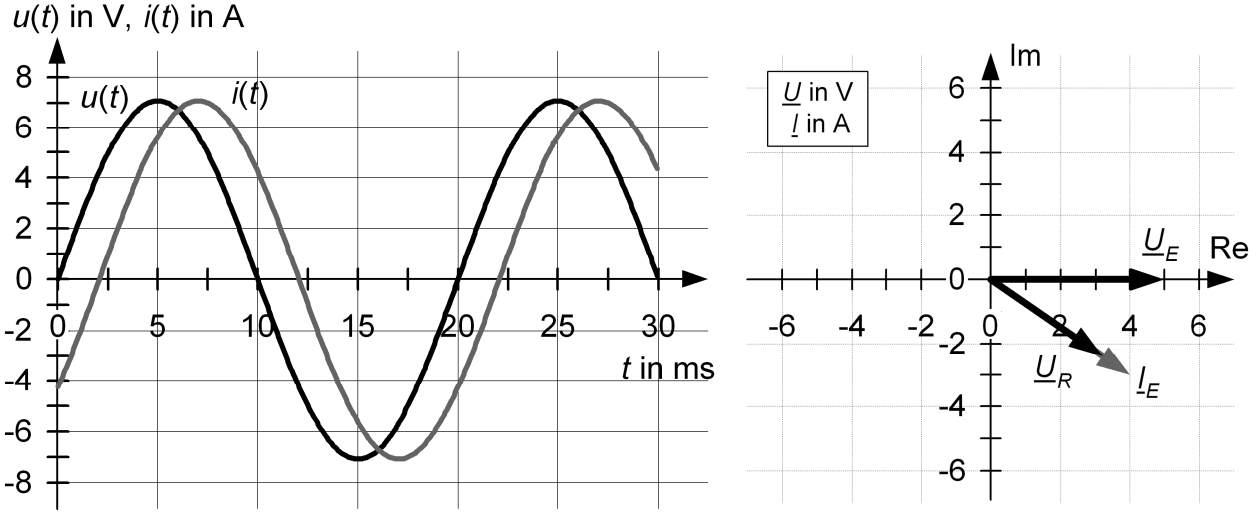
1.4.1 $C = 100\,\text{pF}$ 1.4.2 $U = \frac{Q}{C} = \frac{3{,}6\cdot 10^{-7}\,\text{As}}{10^{-10}\,\frac{\text{As}}{\text{V}}} = 3{,}6\,\text{kV}$

1.4.3 $E_G = \frac{D}{\varepsilon_0 e_r} = \frac{Q}{C_0\varepsilon_r d} = \frac{3{,}6\cdot 10^{-7}\,\text{As}}{6\cdot 10^{-11}\,\frac{\text{As}}{\text{V}}\cdot 5\cdot 0{,}01\,\text{m}} = 120\,\frac{\text{kV}}{\text{m}}$

Aufgabe 2

2.1 $T = 1/f = 20\,\text{ms}$ $\hat{U} = \sqrt{2}\,U_{eff} = 7{,}07\,\text{V}$

2.2 $\underline{I}_E = \frac{\hat{I}}{\sqrt{2}}(\cos\varphi_i + \text{j}\sin\varphi_i) = (4 - \text{j}3)\,\text{A}$



2.3 $\underline{S} = \underline{U}_E\underline{I}_E^* = 5\,\text{V}\cdot(4 + \text{j}3)\,\text{A} = (20 + \text{j}15)\,\text{VA}$

2.4 $R = \frac{P}{I_{eff}^2} = \frac{20\,\text{W}}{5^2\,\text{A}^2} = 0{,}8\,\Omega$

2.5 $\underline{U}_R = R\,\underline{I}_E = 0{,}8\,\Omega\cdot(4 - \text{j}3)\,\text{A} = (3{,}2 - \text{j}2{,}4)\,\text{V}$

2.6 $C_{ges} = C/2$ $\underline{Z}_E = R + \text{j}\omega L + \frac{2}{\text{j}\omega C}$ $\underline{H}(f) = \frac{R + \text{j}2\pi f L}{\underline{Z}_E} = \frac{R + \text{j}2\pi f L}{R + \text{j}2\pi f L + \frac{2}{\text{j}2\pi f C}}$

2.7 $H(f \to 0) = 0$, $H(f \to \infty) = 1$

Signale mit niedriger Frequenz werden gesperrt,
Signale mit hoher Frequenz können nahezu ungedämpft passieren

2.8 $\omega_0 = \frac{1}{\sqrt{LC_{ges}}}$ $C = \frac{2}{4\pi^2 f_0^2 L} = \frac{1}{2\pi^2(53\,\text{Hz})^2\,10\,\text{mH}} = 1{,}8\,\text{mF}$

Aufgabe 3

3.1 $W_m = 0{,}5\,L\,I^2$

3.2 $L = \dfrac{2\,W_m}{I^2} = \dfrac{2 \cdot 3{,}6 \cdot 10^9\,\mathrm{J}}{(10^4\,\mathrm{A})^2} = 72\,\mathrm{H}$

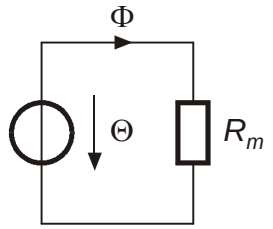
3.3 $L = \dfrac{N^2}{R_m} = \dfrac{N^2 \mu_0 \mu_r A}{l} = \dfrac{N^2 \mu_0 D_s^2}{4\,D_t}$

3.4 $N = \sqrt{\dfrac{L\,4\,D_t}{\mu_0 D_s^2}} = \sqrt{\dfrac{72\,\frac{\mathrm{Vs}}{\mathrm{A}} \cdot 4 \cdot 4\,\mathrm{m}}{4\pi \cdot 10^{-7}\,\frac{\mathrm{Vs}}{\mathrm{Am}} \cdot 4\,\mathrm{m}^2}} = 1{,}51 \cdot 10^4$

3.5 $R_m = \dfrac{l}{\mu_0 \mu_r A} = \dfrac{D_t \pi}{\mu_0 D_s^2 \pi / 4} = \dfrac{4\,\mathrm{m}}{\pi \cdot 10^{-7}\,\frac{\mathrm{Vs}}{\mathrm{Am}} \cdot 4\,\mathrm{m}^2} = 3{,}18 \cdot 10^6\,\mathrm{H}^{-1}$

$\theta = N\,I = 1{,}51 \cdot 10^4 \cdot 10^4\,\mathrm{A} = 151 \cdot 10^6\,\mathrm{A}$ $\quad \Phi = \dfrac{\theta}{R_m} = \dfrac{151 \cdot 10^6\,\mathrm{A}}{3{,}18 \cdot 10^6\,\frac{\mathrm{A}}{\mathrm{Vs}}} = 47{,}6\,\mathrm{Vs}$

3.6



3.7 $F = \dfrac{\mu_0 I^2 l}{2\pi a}$

3.8 $l = D_s \pi = 6{,}28\,\mathrm{m}$ $\quad F = \dfrac{4\pi \cdot 10^{-7}\,\frac{\mathrm{Vs}}{\mathrm{Am}} \cdot 10^8\,\mathrm{A}^2 \cdot 6{,}28\,\mathrm{m}}{2\pi \cdot 0{,}002\,\mathrm{m}} = 62{,}8\,\mathrm{kN}$

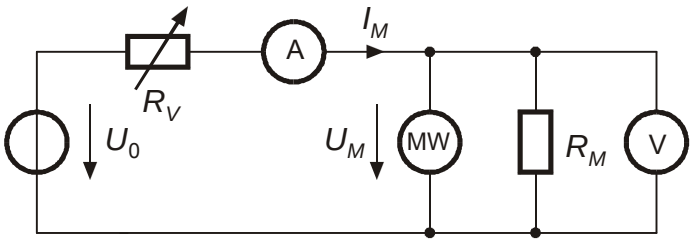
3.9 anziehend, da parallele Stromrichtung

Aufgabe 4

4.1 $P = U\,I = 25\,\mathrm{V} \cdot 750\,\mathrm{A} = 18{,}75\,\mathrm{kW}$, $P_0 = P / \eta = 20{,}8\,\mathrm{kW}$, je Phase $P_L = 20{,}8\,\mathrm{kW} / 3 = 6{,}94\,\mathrm{kW}$

$I = P_L / U = 6{,}94\,\mathrm{kW} / 230\,\mathrm{V} = 30{,}2\,\mathrm{A}$ → Sicherung 32 A

4.2



Batterie mit Spannung $U_0 = 1{,}2\,\mathrm{V}$ an Messwerk MW anschließen und mit veränderlichem Widerstand R_V auf Vollausschlag einstellen. Danach Strom I_M und Spannung U_M über dem Messwerk messen.

4.3 Widerstand und Messwerk bilden Spannungsteiler für Batteriespannung: $U_M = U_0 - R_V I_M$

$U_M = 1{,}2\,\mathrm{V} - 70\,\mathrm{k\Omega} \cdot 10\,\mu\mathrm{A} = 0{,}5\,\mathrm{V}$ bei Vollausschlag des Messwerks

$R_M = U_M / I_M = 0{,}5\,\mathrm{V} / 10\,\mu\mathrm{A} = 50\,\mathrm{k\Omega}$

4.4 Vorwiderstand einbauen, so dass bei $U_{max} = 25\,\mathrm{V}$ ein Strom von $I_M = 10\,\mu\mathrm{A}$ durch Vorwiderstand und Messwerk fließt:

$$R_V = \left(\frac{25\,\mathrm{V}}{0{,}5\,\mathrm{V}} - 1\right) \cdot 50\,\mathrm{k\Omega} = 49 \cdot 50\,\mathrm{k\Omega} = 2{,}45\,\mathrm{M\Omega}$$

4.5 Shunt in den Schweißstromkreis einbauen und Messwerk parallel dazu schalten.
Erforderlicher Spannungsabfall am Shunt $U_M = 0{,}5\,\mathrm{V}$ bei $I_{max} = 750\,\mathrm{A}$:

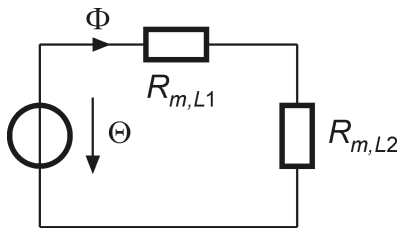
$$R_S = \frac{U_M}{I_{max}} = \frac{0{,}5\,\mathrm{V}}{750\,\mathrm{A}} = 0{,}67\,\mathrm{m\Omega}$$

entspricht $L_K = R_S A \kappa = 0{,}67\,\mathrm{m\Omega} \cdot 100\,\mathrm{mm}^2 \cdot 2\,\frac{\mathrm{m}}{\Omega\,\mathrm{mm}^2} = 13{,}3\,\mathrm{cm}$ Konstantan-Stange

Grundlagen der Elektrotechnik Wintersemester 2012/13 – Kurzlösung

Aufgabe 1

1.1



1.2 $R_{m1,offen} = \dfrac{l_{1,offen}}{\mu_0 A_1} = 15{,}9 \cdot 10^6 \ \dfrac{\text{A}}{\text{Vs}}$

1.3 $\dfrac{R_{m1,offen}}{R_{m2,offen}} = \dfrac{l_{1,offen} A_2}{l_{2,offen} A_1} = \dfrac{2\ \text{mm} \cdot 0{,}5\ \text{cm}^2}{0{,}5\ \text{mm} \cdot 1\ \text{cm}^2} = 2$

1.4 $B = \sqrt{\dfrac{2\mu_0 F}{A}} = \sqrt{\dfrac{2 \cdot 4\pi \cdot 10^{-7}\ \frac{\text{Vs}}{\text{Am}} \cdot 5\ \text{N}}{1\ \text{cm}^2}} = 0{,}35\ \text{T}$ $\quad \Phi = BA = 0{,}35\ \dfrac{\text{Vs}}{\text{m}^2} \cdot 1\ \text{cm}^2 = 35\ \mu\text{Wb}$

1.5 $I_{offen} = \dfrac{R_{m,offen}\,\Phi}{N} = \dfrac{24 \cdot 10^6\ \frac{\text{A}}{\text{Vs}} \cdot 35 \cdot 10^{-6}\ \text{Vs}}{500} = 1{,}7\ \text{A}$

1.6 gleiche Kraft F erfordert gleiche Flussdichte B und somit gleichen Fluss Φ im Luftspalt

$$\frac{I_{offen} N}{I_{zu} N} = \frac{R_{m,offen}\,\Phi}{R_{m,zu}\,\Phi} = \frac{R_{m,offen}}{R_{m,zu}} \ \rightarrow I_{zu} = \frac{I_{offen} R_{m,zu}}{R_{m,offen}} = \frac{1{,}7\ \text{A}}{10} = 0{,}17\ \text{A}$$

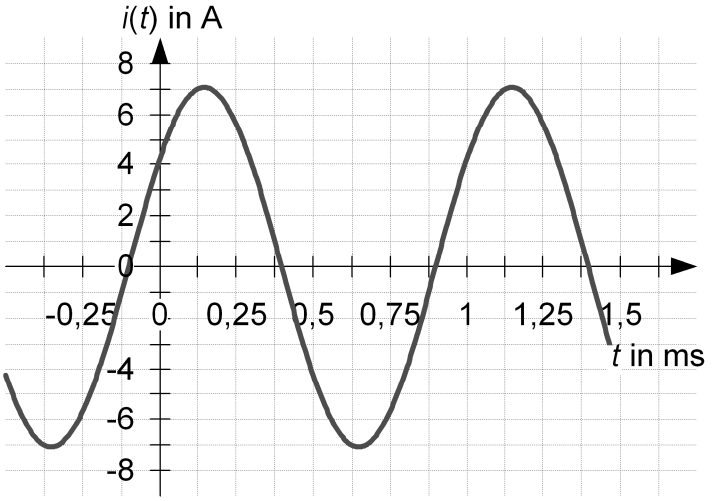
1.7 $P_{zu} = I_{offen}^2 R = 0{,}17^2\,\text{A}^2 \cdot 6\ \Omega = 0{,}17\ \text{W}$

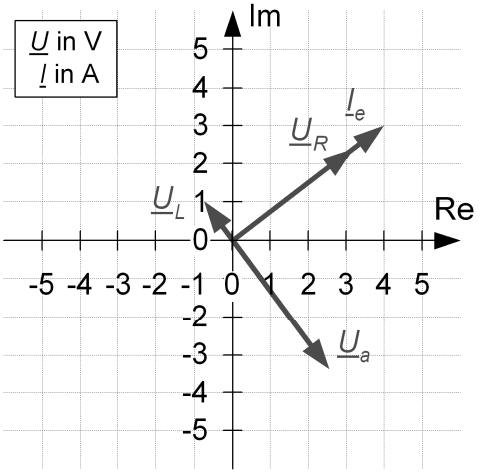
1.8 $\dfrac{P_{offen}}{P_{zu}} = \dfrac{I_{offen}^2}{I_{zu}^2} = \left(\dfrac{1{,}7\ \text{A}}{0{,}17\ \text{A}}\right)^2 = 100$

Aufgabe 2

2.1 $\underline{I}_e = \dfrac{\underline{S}^*}{\underline{U}_e} = \dfrac{(20 + \text{j}15)\ \text{VA}}{5\ \text{V}} = (4 + \text{j}3)\ \text{A}$

2.2 $T = 1/f = 1\,\text{ms}$ $\quad I_e = \sqrt{4^2 + 3^2}\ \text{A} = 5\ \text{A}$ $\quad \hat{I}_e = \sqrt{2} \cdot 5\ \text{A} = 7{,}1\ \text{A}$ $\quad \varphi_i = \arctan\dfrac{3\ \text{A}}{4\ \text{A}} = 37°$





2.3 $\underline{U}_R = R\,\underline{I}_e = 0{,}8\ \Omega \cdot (4 + \text{j}3)\ \text{A} = (3{,}2 + \text{j}2{,}4)\ \text{V}$ $\quad \underline{U}_L = \text{j}\omega L \cdot \underline{I}_e = \text{j}0{,}25\ \Omega \cdot (4 + \text{j}3)\ \text{A} = (-0{,}75 + \text{j})\ \text{V}$

$\underline{U}_a = \underline{U}_C = \underline{U}_e - \underline{U}_R - \underline{U}_L = (2{,}55 - \text{j}3{,}4)\ \text{V}$

2.4 $\underline{I}_C = \underline{I}_e = 5\ \text{A}$ $\quad U_C = \sqrt{2{,}55^2 + 3{,}4^2}\ \text{V} = 4{,}25\ \text{V}$ $\quad C = \dfrac{I_C}{\omega U_C} = \dfrac{5\ \text{A}}{2\pi \cdot 1\,\text{kHz} \cdot 4{,}25\ \text{V}} = 0{,}19\,\text{mF}$

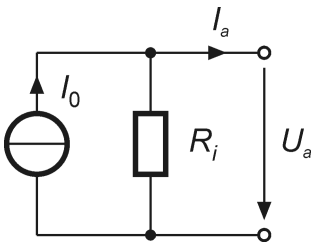
2.5 $f_0 = \dfrac{1}{2\pi \cdot \sqrt{LC}} = \dfrac{1}{2\pi \cdot \sqrt{4 \cdot 10^{-5}\ \frac{\text{Vs}}{\text{A}} \cdot 1{,}9 \cdot 10^{-3}\ \frac{\text{As}}{\text{V}}}} = 1{,}8\,\text{kHz}$

2.6 $U_{a,DC} = R_a / (R + R_a) \cdot U_e = 0{,}5\,U_e$ $\quad U_{a,\infty} = 0$ $\quad U_{a,DC} = U_{e,DC}$ *für* $R << R_a$

Aufgabe 3

3.1 $A = \dfrac{\rho\, l}{R} = \dfrac{0{,}018\ \mu\Omega \cdot \mathrm{m} \cdot 200\ \mathrm{m}}{25\ \Omega} = 0{,}14\ \mathrm{mm}^2$ 3.2 $R_1 = \dfrac{U_e}{I_{0,1} + I_{0,2}} = \dfrac{24\ \mathrm{V}}{20\ \mathrm{mA}} = 1{,}2\ \mathrm{k}\Omega$

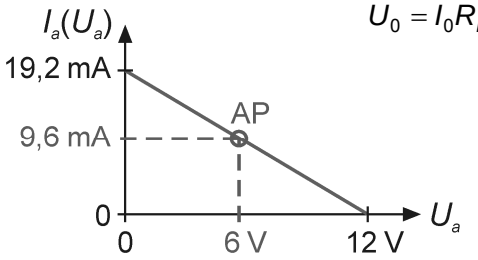
3.3



$I_0 = \dfrac{I_{0,1} + I_{0,2}}{1 + \dfrac{2R_L}{R_2}} = \dfrac{20\ \mathrm{mA}}{1 + \dfrac{50}{1200}} = 19{,}2\ \mathrm{mA}$

$R_i = \dfrac{(R_1 + 2R_L) \cdot R_2}{R_1 + 2R_L + R_2} = 625\ \Omega$

3.4



$U_0 = I_0 R_i = 19{,}2\ \mathrm{mA} \cdot 625\ \Omega = 12\ \mathrm{V}$

3.5 $R_a = R_i = 625\ \Omega$ $I_a = \dfrac{I_0}{2} = 9{,}6\ \mathrm{mA}$ $P_{a,max} = \dfrac{U_0^2}{4R_a} = 57{,}6\ \mathrm{mW}$

3.6 $\dfrac{1}{5}\dfrac{U_0}{2} \le U_a \le \dfrac{U_0}{2} \rightarrow 1{,}2\ \mathrm{V} \le U_a \le 6\ \mathrm{V}$

3.7 $R_1 \rightarrow \infty$, da R_a in diesem Fall über eingeprägten Konstantstrom gespeist

Aufgabe 4

4.1 $U_0 = I_0 R_1 = 70\ \mathrm{V}$

4.2 $\tau_1 = R_1 C = 7\ \mathrm{ms}$ $u_C(3\ \mathrm{ms}) = U_0(1 - \mathrm{e}^{-3\ \mathrm{ms}/t_1}) = 70\ \mathrm{V} \cdot (1 - \mathrm{e}^{-3/7}) = 24{,}4\ \mathrm{V}$

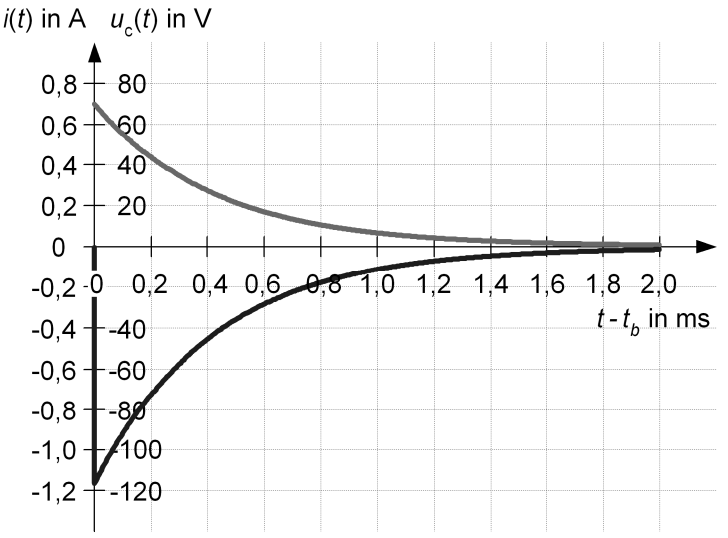
4.3 $R = 60\ \Omega$

$\tau_2 = RC = 0{,}42\ \mathrm{ms}$

$I_0 = \dfrac{U_0}{R} = 1{,}16\ \mathrm{A}$

$i(t) = -1{,}16\ \mathrm{A} \cdot \mathrm{e}^{-(t - t_b)/0{,}42\ \mathrm{ms}}$

$u_C(t) = 70\ \mathrm{V} \cdot \mathrm{e}^{-(t - t_b)/0{,}42\ \mathrm{ms}}$



4.4 $u_C(t_b + 0{,}1\ \mathrm{ms}) = 70\ \mathrm{V} \cdot \mathrm{e}^{-0{,}1\ \mathrm{ms}/0{,}42\ \mathrm{ms}} = 55\ \mathrm{V}$

$Q_{ab} = Q(0\ \mathrm{ms}) - Q(0{,}1\ \mathrm{ms}) = 7\ \mu\mathrm{F} \cdot (70\ \mathrm{V} - u_C(0{,}1\ \mathrm{ms})) = 490\ \mu\mathrm{C} - 385\ \mu\mathrm{C} = 105\ \mu\mathrm{C}$

4.5 $R_3 = 0\ \Omega$

4.6 $\tau = R_4 C = 70\ \mu\mathrm{s}$

$u_C(t_b + t_c) = 70\ \mathrm{V} \cdot \mathrm{e}^{-t_c/70\ \mu\mathrm{s}} = 55\ \mathrm{V} \rightarrow t_c = -\ln\dfrac{55\ \mathrm{V}}{70\ \mathrm{V}} \cdot 70\ \mu\mathrm{s} = 16\ \mu\mathrm{s}$