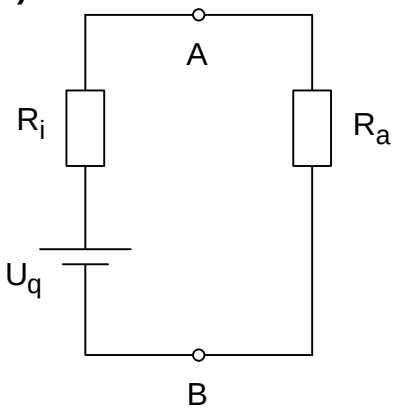
NEISSE - ELEKTRO 2000

LÖSUNGEN

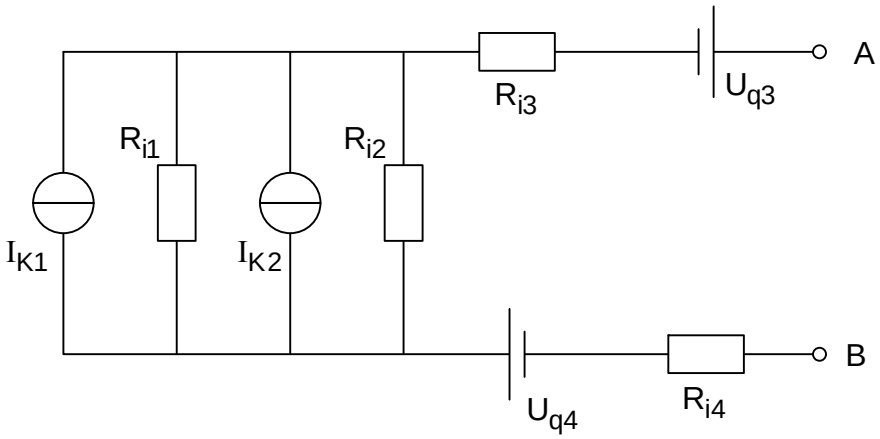
1

a)



b)

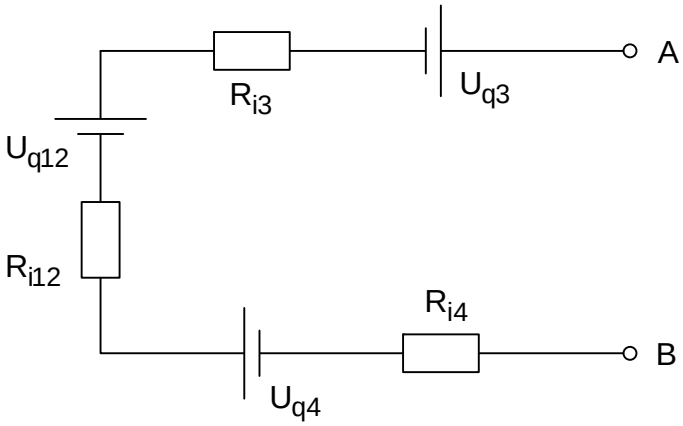
$$R_a = \left[\left(\left(R_4 \parallel R_5 \parallel R_6\right) + \left(R_2 \parallel R_3\right)\right) \parallel R_7\right] + R_1 = \underline{\underline{14{,}545\ \Omega}}$$



$$I_{K1} = \frac{U_{q1}}{R_{i1}} = 2\ \text{A}$$

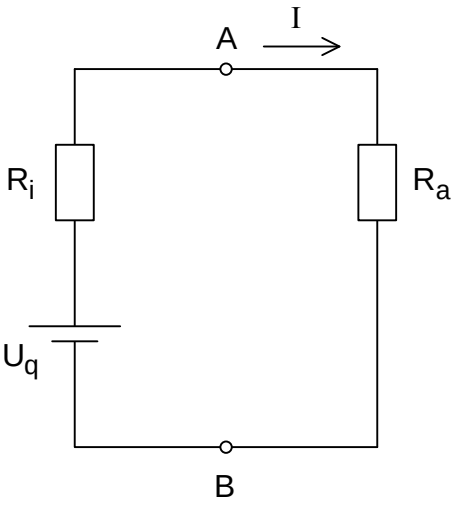
$$I_{K2} = \frac{U_{q2}}{R_{i2}} = 2\ \text{A}$$

$$\left.\begin{aligned} I_{K12} &= I_{K1} + I_{K2} = 4\ \text{A} \\ R_{i12} &= \frac{R_{i1} R_{i2}}{R_{i1} + R_{i2}} = 0{,}5\ \Omega \end{aligned}\right\} \quad \Rightarrow \quad U_{q12} = I_{K12} \cdot R_{i12} = 2\ \text{V}$$



$$U_q = U_{q1} + U_{q2} + U_{q3} = 6\ \text{V}$$

$$R_i = R_{i12} + R_{i3} + R_{i4} = 2{,}5\ \Omega$$



$R_i = 2{,}5\ \Omega$

$R_a = 14{,}545\ \Omega$

$U_q = 6\ \text{V}$

$U_{AB} = I \cdot R_a = 0{,}352\ \text{A} \cdot 14{,}545\ \Omega$

$= 5{,}12\ \text{V}$

c)

$$I = I_1 = \frac{U_q}{R_a + R_i} = \frac{6\ \text{V}}{17{,}045\ \Omega} = \underline{\underline{0{,}352\ \text{A}}} \quad \Rightarrow \quad U_1 = 3{,}52\ \text{V}$$

$$\frac{I_7}{I_1} = \frac{(R_2 \parallel R_3) + (R_4 \parallel R_5 \parallel R_6)}{R_7 + (R_2 \parallel R_3) + (R_4 \parallel R_5 \parallel R_6)}$$

$$I_7 = 0{,}4545\ I_1 = 0{,}4545 \cdot 0{,}352\ \text{A}$$

$$= \underline{\underline{0{,}16\ \text{A}}} \quad \Rightarrow \quad U_7 = 1{,}6\ \text{V}$$

Knotensatz: $-I_1 + I_7 + I_{2-6} = 0$

$$I_{2-6} = I_1 - I_7 = 0{,}192\ \text{A}$$

$$I_2 = I_3 = 0{,}5 \cdot I_{2-6} = \underline{\underline{0{,}096\ \text{A}}} \quad \Rightarrow \quad U_2 = U_3 = 0{,}96\ \text{V}$$

$$I_4 = I_5 = I_6 = 0{,}3\overline{3} \cdot I_{2-6} = 0{,}064\ \text{A} \quad \Rightarrow \quad U_4 = U_5 = U_6$$

$R_a = 14{,}545\ \Omega$ $I_1 = 0{,}352$ A $U_1 = 3{,}52$ V

$R_i = 2{,}5\ \Omega$ $I_2 = 0{,}096$ A $U_2 = 0{,}96$ V

$U_q = 6$ V $I_3 = 0{,}096$ A $U_3 = 0{,}96$ V

$U_{AB} = 5{,}12$ V $I_4 = 0{,}064$ A $U_4 = 0{,}64$ V

$I = 0{,}352$ A $I_5 = 0{,}064$ A $U_5 = 0{,}64$ V

$I_6 = 0{,}064$ A $U_6 = 0{,}64$ V

$I_7 = 0{,}16$ A $U_7 = 1{,}6$ V

2

Figure 2a) series connection

a)

I = konst. = 100 A S = konst. $S = \frac{I}{A_\perp}$

$R = \frac{L}{\chi \cdot A}$ $A_\perp = 40\ mm^2$

$$R = \frac{L}{\chi \cdot A} \begin{cases} R_1 = \frac{L_1}{\chi_1 \cdot A} = 5\ \Omega \\ R_2 = \frac{L_2}{\chi_2 \cdot A} = 2{,}5\ \Omega \\ R_3 = \frac{L_3}{\chi_3 \cdot A} = 1{,}25\ \Omega \end{cases}$$

$$U = I \cdot R \begin{cases} U_1 = I \cdot R_1 = 100\ A \cdot 5\ \Omega = 500\ V \\ U_2 = I \cdot R_2 = 100\ A \cdot 2{,}5\ \Omega = 250\ V \\ U_3 = I \cdot R_3 = 100\ A \cdot 1{,}25\ \Omega = 125\ V \end{cases}$$

b)

$$E = \frac{U}{d} \begin{cases} E_1 = \frac{U_1}{d_1} = \frac{500\ V}{20\ mm} = 250 \frac{V}{cm} = 25 \frac{V}{mm} \\ E_2 = \frac{U_2}{d_2} = \frac{250\ V}{20\ mm} = 125 \frac{V}{cm} = 12{,}5 \frac{V}{mm} \\ E_3 = \frac{U_3}{d_3} = \frac{125\ V}{20\ mm} = 62{,}5 \frac{V}{cm} = 6{,}25 \frac{V}{mm} \end{cases}$$

Alternativ

$$S = \frac{I}{A} = 2{,}5\,\frac{A}{mm^2} \qquad E = \frac{S}{\chi}$$

$$\begin{cases} E_1 = \dfrac{S}{\chi_1} = 25\,\dfrac{V}{mm} \\ E_2 = \dfrac{S}{\chi_2} = 12{,}5\,\dfrac{V}{mm} \\ E_3 = \dfrac{S}{\chi_3} = 6{,}25\,\dfrac{V}{mm} \end{cases}$$

Figure 2b) parallel connection

c)

U = constant

$$U = I \cdot R = \frac{I}{G}$$

$$G = G_1 + G_2 + G_3$$

$$G = \frac{\chi \cdot A}{L}$$

$$A_1 = A_2 = A_3 = 20\,mm^2 \qquad L_1 = L_2 = L_3 = 40\,mm$$

$$\begin{cases} G_1 = \dfrac{\chi_1 \cdot A_1}{L_1} = 0{,}05\ S \\ G_2 = \dfrac{\chi_2 \cdot A_2}{L_2} = 0{,}1\,S \\ G_3 = \dfrac{\chi_3 \cdot A_3}{L_3} = 0{,}2\ S \end{cases}$$

G = 0,35 S

$$U = \frac{I}{G} = 285{,}71\,V$$

$$I = U \cdot G \begin{cases} I_1 = U \cdot G_1 = 14{,}285\ A \\ I_2 = U \cdot G_2 = 28{,}57\ A \\ I_3 = U \cdot G_3 = 57{,}143\ A \end{cases}$$

d)

$$S = \frac{I}{A} \begin{cases} S_1 = \dfrac{I_1}{A} = 0{,}714\,\dfrac{A}{mm^2} \\ S_2 = \dfrac{I_2}{A} = 1{,}4285\,\dfrac{A}{mm^2} \\ S_3 = \dfrac{I_3}{A} = 2{,}857\,\dfrac{A}{mm^2} \end{cases}$$

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Figure 3a)

spannungsrichtige Messung: (Parallelschaltung)

$$R' = \frac{U}{I} = \frac{9{,}0\ V}{76\ mA} = 118\ \Omega \qquad \left(\frac{1}{R'} = \frac{1}{R} + \frac{1}{R_{MU}}\right)$$

$$R = \frac{1}{\frac{1}{R'} - \frac{1}{R_{MU}}} = \frac{1}{\frac{1}{118\ \Omega} - \frac{1}{9{,}0\ k\Omega}} = 120\ \Omega$$

Figure 3b)

stromrichtige Messung: (Reihenschaltung)

$$R'' = \frac{U}{I} = \frac{10{,}0\ V}{80\ mA} = 125\ \Omega \qquad R'' = R + R_{MI}$$

$$R = R'' - R_{MI}$$

$$R_{MI} = R'' - R = 125\ \Omega - 120\ \Omega = 5{,}00\ \Omega$$

4

a) series connection

$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$C_{Kond.} = \frac{2\pi L\ \varepsilon_0 \varepsilon_r}{Ln\ \frac{r_o}{r_i}}$$

$$C_1 = \frac{2\pi L\ \varepsilon_0\ \varepsilon_{r1}}{Ln\ \frac{r_1}{r_i}}$$

$$C_1 = 24{,}07\ nF$$

$$C_2 = \frac{2\pi L\ \varepsilon_0\ \varepsilon_{r2}}{Ln\ \frac{r_a}{r_1}}$$

$$C_2 = 8{,}02\ nF$$

$$C_{total} = \frac{C_1 \cdot C_2}{C_1 + C_2}$$

b)

$$Q = C \cdot U$$

$$Q = 6{,}015\,\text{nF} \cdot 10\,\text{kV} = 6{,}015 \cdot 10^{-5}\,\text{As}$$

$$Q = Q_1 = Q_2$$

c)

$$\left.\begin{aligned} U_1 &= \frac{Q}{C_1} = 2{,}5\,\text{kV} \\ U_2 &= \frac{Q}{C_2} = 7{,}5\,\text{kV} \end{aligned}\right\} \quad U_1 + U_2 = U$$

5

a) Figure 5a)

$$H_{P_1} = H_{P_2} = H_{P_3} = \frac{I}{2\pi r}$$

$$H = \frac{1000\,\text{A}}{2\pi \cdot 0{,}5\,\text{m}} = 318{,}31\,\frac{\text{A}}{\text{m}}$$

b) Figure 5b)

P_1:

$$H_{P_1} = H_{P_1(A)} + H_{P_1(B)}$$

$$H_{P_1(A)} = \frac{I}{4\pi r}\left(\cos\alpha_1 - \cos\alpha_2\right)$$

$$= \frac{I}{4\pi r}\left(\underbrace{\cos 0^o}_{1} - \cos 45^o\right)$$

$$= \frac{1000\,\text{A}}{4\pi\,50\,\text{cm}}\left(1 - 0{,}707\right) = 0{,}466\,\frac{\text{A}}{\text{cm}} = 46{,}6\,\frac{\text{A}}{\text{m}}$$

$$H_{P_1(B)} = \frac{I}{4\pi r}\left(\cos 135^o - \underbrace{\cos 180^o}_{-1}\right)$$

$$= \frac{1000\,\text{A}}{4\pi 50\,\text{cm}}\left(-0{,}707 + 1\right) = 0{,}466\,\frac{\text{A}}{\text{cm}} = 46{,}6\,\frac{\text{A}}{\text{m}}$$

$$H_{P_1} = 93{,}2\,\frac{\text{A}}{\text{m}}$$

P_2:

$$H_{P_2} = H_{P_2(A)} + H_{P_2(B)}$$

$$H_{P_2(A)} = 0$$

$$H_{P_2(B)} = \frac{I}{4\pi \cdot 50\ cm}\left(\underbrace{\cos 90^o}_{0} - \underbrace{\cos 180^o}_{-1} \right)$$

$$H_{P_2} = \frac{1000\ A}{4\pi \cdot 50\ cm} = 1{,}59\ \frac{A}{cm} = 159{,}1\frac{A}{m}$$

P_3: $H_{P_3} = H_{P_3(B)} - H_{P_3(A)}$

$$H_{P_3(A)} = H_{P_1(A)} = 46{,}6\ \frac{A}{m}$$

$$H_{P_3(B)} = \frac{I}{4\pi \cdot 50\ cm} \cdot \left(\cos 45^o - \underbrace{\cos 180^o}_{-1} \right)$$

$$H_{P_3(B)} = \frac{1000\ A}{4\pi \cdot 50\ cm}(0{,}707 + 1) = 2{,}71\frac{A}{cm} = 271{,}7\ \frac{A}{m}$$

$$H_{P_3} = 225{,}1\frac{A}{m}$$

c)

$$B = \mu_0\ H$$

$$B_{P1} = \mu_0 \cdot H_{P1} = 1{,}257 \cdot 10^{-6}\ \frac{Vs}{m} \cdot 93{,}2\ \frac{A}{m} = 1{,}17 \cdot 10^{-4}\ T$$