Übungsaufgaben Kap. 5 (Musterlösungen):

Aufgabe 1:

1.1. $P = U_6^2/R \Rightarrow U_6 = 4\,V \Rightarrow I_3 = U_6/R = 4\,mA$

1.2. grafisch → Vorlesung mit: $\underline{U}_6 = 4\,V \cdot e^{j0°}$, $\underline{I}_3 = 4\,mA \cdot e^{j0°}$

Maßstab: $1\,V \mathrel{\hat{=}} 1\,cm$ $1\,mA \mathrel{\hat{=}} 1\,cm$

1.3. $\underline{U}_6 = 4\,V \cdot e^{j0°}$ $\underline{I}_3 = 4\,mA \cdot e^{j0°}$

$\Rightarrow \underline{U}_5 = \underline{Z}_{L_2} \cdot \underline{I}_3 = j\omega L_2 \cdot \underline{I}_3 = j \cdot 3\,V$

$\underline{U}_4 = \underline{U}_5 + \underline{U}_6 = 4\,V + j\,3\,V = 5\,V \cdot e^{j36{,}87°}$

$\underline{I}_2 = \underline{U}_4 / \underline{Z}_{C_2} = \underline{U}_4 / \left(-j\frac{1}{\omega C_2}\right) = j \cdot \frac{5\,V \cdot e^{j36{,}87°}}{1{,}236\,k\Omega}$

$= 4{,}045\,mA \cdot e^{j126{,}87°} = (-2{,}43 + j\,3{,}24)\,mA$

$\underline{I}_1 = \underline{I}_2 + \underline{I}_3 = (1{,}57 + j\,3{,}24)\,mA = 3{,}6\,mA \cdot e^{j64{,}15°}$

$\underline{U}_2 = \underline{I}_1 \cdot \underline{Z}_{L_1} = \underline{I}_1 \cdot j\omega L_1 = 7{,}2\,V \cdot e^{j154{,}15°}$

$\underline{U}_3 = \underline{I}_1 \cdot \underline{Z}_{C_1} = \underline{I}_1 \cdot \left(-j\frac{1}{\omega C_1}\right) = 3{,}6\,V \cdot e^{-j25{,}85°}$

$\underline{U}_1 = \underline{U}_2 + \underline{U}_3 + \underline{U}_4 = 0{,}76\,V + j\,4{,}57\,V = 4{,}63\,V \cdot e^{j80{,}56°}$

1.4. grafisch: $|\underline{Z}| = Z = \frac{U_1}{I_1} \approx 1{,}28\,k\Omega$ (Zeigerlängen von $\underline{U}_1, \underline{I}_1$ aus der Grafik)

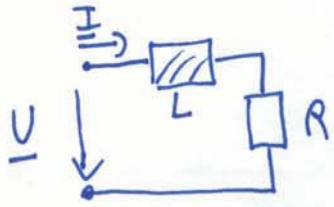
Phasenwinkel: $\varphi \approx 17°$ (Grafik: U_1 eilt voraus $\Rightarrow +17°$)

rechnerisch: $\underline{Z} = \frac{\underline{U}_1}{\underline{I}_1} = 1{,}29\,k\Omega \cdot e^{j16{,}41°}$

(oder: $\underline{Z} = \underline{Z}_{L_1} + \underline{Z}_{C_1} + (\underline{Z}_{C_2} \parallel (R + j\omega L_2))$

$= j\omega L_1 - j\frac{1}{\omega C_1} + \frac{\frac{1}{j\omega C_2} \cdot (R + j\omega L_2)}{\frac{1}{j\omega C_2} + R + j\omega L_2} = \ldots$)

Aufgabe 2:



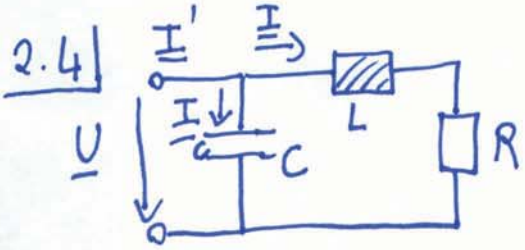
2.1 $\underline{S} = \underline{U} \cdot \underline{I}^*$ $\xrightarrow{\text{Beträge}}$ $S = U \cdot I = 230V \cdot 0{,}4A = 92VA$

2.2 $\cos\varphi = \lambda = \frac{P}{S} = \frac{40W}{92VA} = 0{,}435$

2.3 $R = P/I^2 = 250\,\Omega$ $\quad Q = \sqrt{S^2 - P^2} = 82{,}85\,var$

$\omega L = \frac{Q}{I^2} = 518\,\frac{V}{A}$

2.4

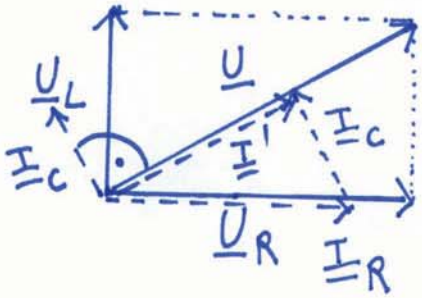


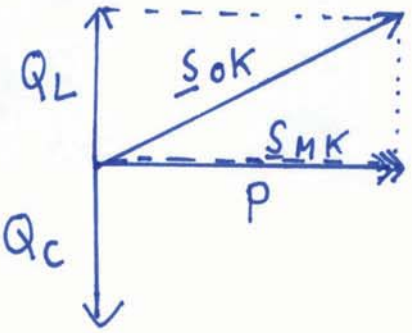
2.5 $|Q_C| = |Q_L| = Q = U \cdot I_C$

$= U^2 \cdot \omega C$

$\Rightarrow C = \frac{Q}{\omega \cdot U^2} = 4{,}99\,\mu F$

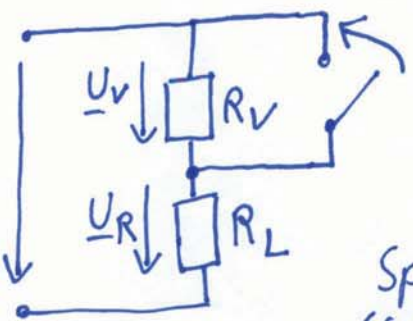
2.6 Spg.- und Stromzeiger: (→ Spannung, --> Strom) oder Leistungsdreieck:





Aufgabe 3:

3.1



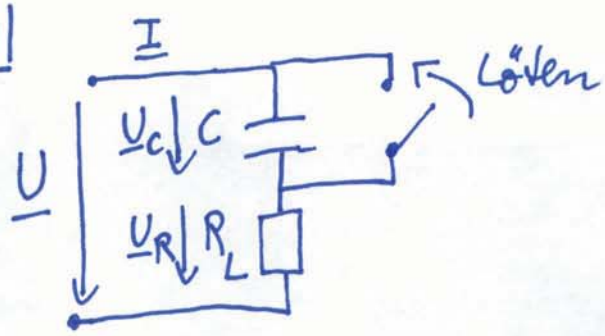
Löten $\underline{U}$, $\underline{U}_V$ und $\underline{U}_R$ liegen alle in Phase zueinander

$R_L = \frac{U^2}{P} = \frac{(230V)^2}{100W} = 529\,\Omega$

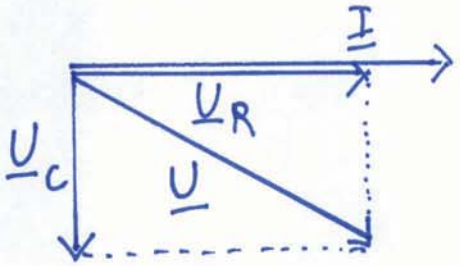
Spannungsteiler (Schalter offen): $\frac{R_V}{U_V} = \frac{R_L}{U_L}$

$\Rightarrow R_V = \frac{U_V}{U_R} \cdot R_L = \frac{80V}{150V} \cdot 529\,\Omega = 282\,\Omega$

3.2]



(Schalter offen)



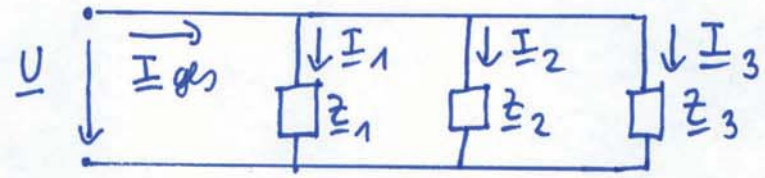
$$U^2 = U_R^2 + U_C^2 \Rightarrow U_C = \sqrt{U^2 - U_R^2} = \sqrt{(230V)^2 - (150V)^2}$$
$$= 174{,}4\,V$$

$$I = \frac{U_R}{R_L} = 0{,}284\,A$$

$$Z_C = \frac{1}{\omega C} = \frac{U_C}{I} \quad (\text{Beträge!}) \Rightarrow C = \frac{I}{U_C \cdot \omega} = 5{,}19\,\mu F$$

3.3] bei C: keine Verlustleistung an R_V (nur Blindleistung an C)

Aufgabe 4:



$$\underline{I}_{ges} = \underline{I}_1 + \underline{I}_2 + \underline{I}_3$$

Annahme: $\varphi_u = 0°$: $\underline{U} = U \cdot e^{j0°}$

I_1: induktiv $\Rightarrow$ Spg. eilt voraus
$\cos\varphi_1 = 0{,}8 \Rightarrow |\varphi_1| = 37°$
$\Rightarrow \underline{I}_1 = 10\,A \cdot e^{-j37°}$

I_2: kapazitiv $\Rightarrow$ Strom eilt voraus
$\cos\varphi_2 = 0{,}43 \Rightarrow |\varphi_2| = 64{,}5°$
$\Rightarrow \underline{I}_2 = 2\,A \cdot e^{+j64{,}5°}$

I_3: ohmisch $\Rightarrow$ Spg. und Strom in Phase $\Rightarrow \underline{I}_3 = 5\,A \cdot e^{j0°}$

$\underline{I}_{ges} = \underline{I}_1 + \underline{I}_2 + \underline{I}_3$ (grafisch oder rechnerisch addieren)

WS 99/00: Nr. 3:

3.1] $$\underline{Z} = \underline{Z}_{R_1} + \frac{\underline{Z}_C \cdot (\underline{Z}_{R_2} + \underline{Z}_L)}{\underline{Z}_C + (\underline{Z}_{R_2} + \underline{Z}_L)}$$

$$= R_1 + \frac{\left(-j\frac{1}{\omega C}\right) \cdot (R_2 + j\omega L)}{-j\frac{1}{\omega C} + R_2 + j\omega L}$$

$$= 220\,\Omega + \frac{(-j\,1k\Omega) \cdot (1k\Omega + j\,0{,}5\,k\Omega)}{(-j\,1k\Omega) + 1k\Omega + j\,0{,}5\,k\Omega}$$

$$= (1{,}02 - j\,0{,}6)\,k\Omega = 1{,}18 \cdot e^{-j\,30{,}47^\circ}\,k\Omega$$

3.2] $$\underline{I}_q = \frac{\underline{U}_q}{\underline{Z}} = \frac{230V}{1{,}18k\Omega \cdot e^{-j30{,}47^\circ}} = 194{,}91\,mA \cdot e^{j30{,}47^\circ}$$

$$= (168 + j\,99{,}1)\,mA$$

$$\underline{U}_{R_1} = \underline{I}_q \cdot R_1 = (36{,}96 + j\,21{,}8)\,V$$

$$\underline{U}_a = \underline{U}_q - \underline{U}_{R_1} = (193{,}04 - j\,21{,}8)\,V$$

3.3] $$\varphi_q = \varphi_u - \varphi_i = -30{,}47^\circ$$

3.4] $$S = U_q \cdot I_q = 44{,}83\,VA$$

$$P = S \cdot \cos\varphi = 38{,}64\,W$$

$$Q = S \cdot \operatorname{sen}\varphi = -22{,}73\,var$$