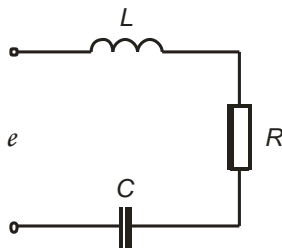


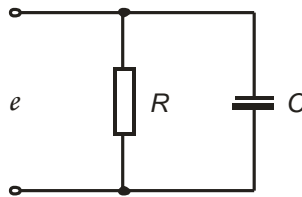
11. domaća zadaća iz Osnova elektrotehnike i elektronike

- U krugu na slici napišite izraze za struju i napone na otporniku, zavojnici i kondenzatoru. Izračunajte radnu, jalovu i prividnu snagu te nacrtajte fazorski dijagram i trokut snaga. Zadano je: $e = 310\sin 100\pi t$, V, $R = 7 \Omega$, $L = 10$ mH, $C = 220 \mu\text{F}$.
- U krugu na slici napišite izraze za sve struje, izračunajte radnu, jalovu i prividnu snagu te nacrtajte fazorski dijagram i trokut snaga. Zadano je: $e = \sin(2 \cdot 10^6 t - 150^\circ)$, V, $R = 560 \Omega$, $C = 470$ pF.
- Na izvor napona: $e = 500\sin(300t + 120^\circ)$, V priključen je paralelni RL spoj kao na slici. Poznato je da je efektivna struja $I = 20$ A, a vrijednost otpora $R = 20 \Omega$. Izračunajte induktivitet zavojnice te radnu, jalovu i prividnu snagu. Također nacrtajte trokut snaga i fazorski dijagram.

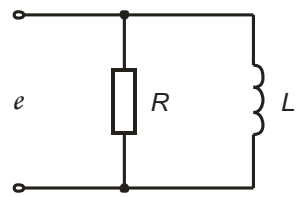
1.



2.



3.



Rješenja

$$1. \quad e = 310\sin 100\pi t, \text{ V}$$

$$E_m = 310 \text{ V} \quad \omega = 100\pi \text{ rad/s}$$

$$E = \frac{E_m}{\sqrt{2}} = 155\sqrt{2} = 219,2 \text{ V}$$

$$X_L = \omega L = 100\pi \cdot 10 \cdot 10^{-3} = \pi = 3,142 \Omega,$$

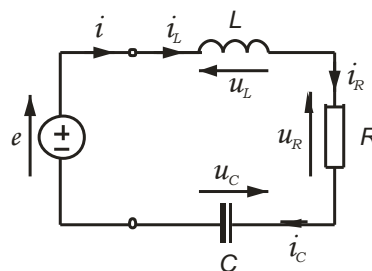
$$Z = \sqrt{R^2 + (X_L - X_C)^2} = 13,32 \Omega$$

$$I = \frac{E}{Z} = 16,46 \text{ A}$$

Opći oblik sinusnog napona je $e = E_m \sin(\omega t + \phi)$

$$\phi = 0 \rightarrow e = E_m \sin \omega t$$

$$X_C = \frac{1}{\omega C} = \frac{1}{100\pi \cdot 220 \cdot 10^{-6}} = 14,47 \Omega,$$



$$I_R = I_L = I_C = I$$

$$U_R = R \cdot I_R = 115,2 \text{ V}$$

$$U_L = X_L \cdot I_L = 51,72 \text{ V}$$

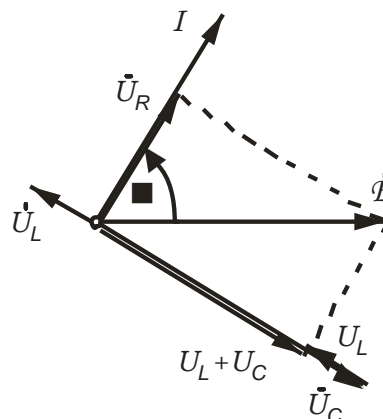
$$U_C = X_C \cdot I_C = 238,2 \text{ V}$$

Fazorski dijagram

$$\varphi = \arctg \frac{|U_L - U_C|}{U_R}$$

$$\varphi = \arctg \frac{(X_C - X_L) \cdot I}{R \cdot I} = \arctg \frac{X_C - X_L}{R}$$

$$\varphi = 58,28^\circ$$



U serijskom RLC spoju struja prethodi naponu izvora ako je $X_L < X_C$, a kasni za naponom ako je $X_L > X_C$.

Struje i naponi u vremenskom obliku

$$i = I_m \sin(\omega t + \varphi)$$

Struja prethodi naponu, jer $X_L < X_C$.

$$I_m = I\sqrt{2} = 23,28 \text{ A}, \quad \varphi = 58,28^\circ$$

$$\boxed{i = 23,28 \sin(100\pi t + 58,28^\circ), \text{ A}}$$

$$u_R = U_R \sqrt{2} \sin(\omega t + \varphi_i)$$

$$\varphi_i = \varphi = 58,28^\circ$$

$$\boxed{u_R = 163,0 \sin(100\pi t + 58,28^\circ), \text{ V}}$$

Napon i struja otpornika su u fazi!

$$u_L = U_L \sqrt{2} \sin(\omega t + \varphi_i + 90^\circ)$$

$$\boxed{u_L = 73,14 \sin(100\pi t + 148,3^\circ), \text{ V}}$$

Napon na zavojnici prethodi struji za 90° !

$$u_C = U_C \sqrt{2} \sin(\omega t + \varphi_i - 90^\circ)$$

$$u_C = 336,8 \sin(100\pi t - 31,72^\circ), V$$

Napon na kondenzatoru zaostaje za strujom za 90° !

Snaga

$$P = I^2 \cdot R = 1,897 \text{ kW}$$

ili $P = E \cdot I \cdot \cos \varphi = 1,897 \text{ kW}$

$$Q = |Q_L - Q_C|$$

$$Q_L = I^2 \cdot X_L = 851,4 \text{ VAR}$$

$$Q_C = I^2 \cdot X_C = 3,921 \text{ kVAR}$$

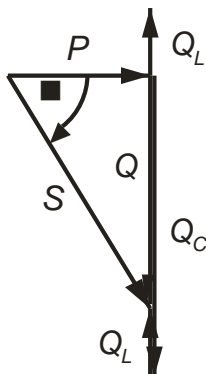
$$Q = 3,070 \text{ kVAR}$$

ili $Q = E \cdot I \cdot \sin \varphi = 3,070 \text{ kVAR}$

$$S = E \cdot I = 3,609 \text{ kVA}$$

ili $S = \sqrt{P^2 + Q^2} = 3,609 \text{ kVA}$

Trokut snaga



$$\varphi = \arctg \frac{Q}{P} = 58,28^\circ$$

Kut φ je ujedno i kut koji odgovara faznom pomaku između napona i struje izvora.

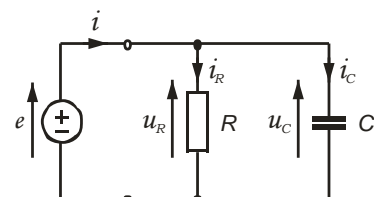
$$2. \quad e = \sin(2 \cdot 10^6 t - 150^\circ), V$$

$$E_m = 1 V \quad \omega = 2 \cdot 10^6 \text{ rad/s} \quad \phi = -150^\circ$$

Opći oblik sinusnog napona je $e = E_m \sin(\omega t + \phi)$

$$E = \frac{E_m}{\sqrt{2}} = 0,5\sqrt{2} = 707,1 \text{ mV}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2 \cdot 10^6 \cdot 470 \cdot 10^{-12}} = 1,064 \text{ k}\Omega,$$



$$U_R = U_C = E$$

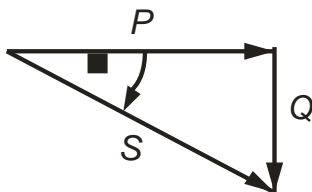
Snaga

$$P = P_R = U_R \cdot I_R = \frac{E^2}{R} = 892,9 \mu W$$

$$Q = Q_C = U_C \cdot I_C = \frac{E^2}{X_C} = 470 \mu VAR$$

$$S = \sqrt{P^2 + Q^2} = 1,009 mVA$$

Trokut snaga



$$\varphi = \arctg \frac{Q}{P} = 27,76^\circ$$

Ovaj kut je ujedno i kut koji odgovara faznom pomaku između napona i struje izvora.

Kod kondenzatora struja prethodi naponu za 90° . U paralelnom RC spoju struja će prethoditi za kut $0 < \varphi < 90^\circ$.

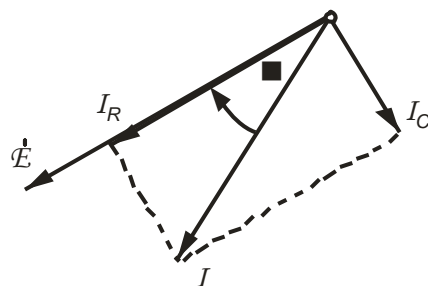
Fazorski dijagram

Zajednička veličina je napon pa se najprije nacrtava fazor napona. Struja kroz otpornik je u fazi s naponom, a struja kroz kondenzator mu prethodi za 90° (i zakrenuta je suprotno od kazaljke na satu.) Struja izvora je zbroj struje kroz otpornik i struje kroz kondenzator.

$$I_R = \frac{E}{R} = 1,263 mA$$

$$I_C = \frac{E}{X_C} = 664,7 \mu A$$

$$I = \sqrt{I_R^2 + I_C^2} = 1,427 mA$$



Provjera za S i I $S = E \cdot I = 1,009 mVA$

Provjera za φ $\varphi = \arctg \frac{I_C}{I_R} = \arctg \frac{\frac{E}{X_C}}{\frac{E}{R}} = \arctg \frac{R}{X_C} = 27,76^\circ$

Struje u vremenskom obliku

$$i_R = \frac{U_R}{R} = 1,786 \sin(2 \cdot 10^6 t - 150^\circ), \text{ mA}$$

ili $i_R = I_R \sqrt{2} \sin(\omega t + \varphi_{iR})$

Kut φ_i je fazni kut struje.

$$\varphi_{iR} = \phi = -150^\circ$$

$$i_R = 1,786 \sin(2 \cdot 10^6 t - 150^\circ), \text{ mA}$$

$$i_C = I_C \sqrt{2} \sin(\omega t + \phi + 90^\circ)$$

$$i_C = 940 \sin(2 \cdot 10^6 t - 60^\circ), \mu\text{A}$$

$$i = I \sqrt{2} \sin(\omega t + \phi + \varphi)$$

$$\phi = -150^\circ$$

$$\varphi = 27,76^\circ$$

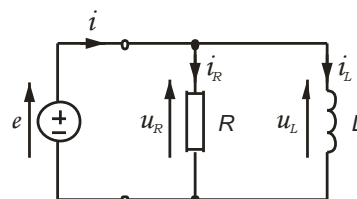
Kut φ se zbraja s početnim kutem napona, jer struja **prethodi** naponu izvora!

$$i = 2,018 \sin(2 \cdot 10^6 t - 122,2^\circ), \text{ mA}$$

3. $e = 500 \sin(300t + 120^\circ), \text{ V}$

$$E = \frac{E_m}{\sqrt{2}} = 250\sqrt{2} = 353,6 \text{ V}$$

$$U_R = U_L = E$$



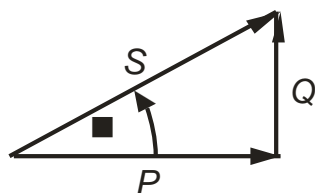
Snage

$$S = E \cdot I = 7,071 \text{ kVA}$$

$$P = \frac{E^2}{R} = 6,25 \text{ kW}$$

$$Q = \sqrt{S^2 - P^2} = 3,307 \text{ kVAr}$$

Trokut snaga



$$\varphi = \arctg \frac{Q}{P} = 27,89^\circ$$

Ovaj kut je ujedno i kut koji odgovara faznom pomaku između napona i struje izvora.

Kod zavojnice napon prethodi struji za 90° . U paralelnom RL spoju struja će kasniti za naponom za kut $0 < \varphi < 90^\circ$.

Induktivitet

$$Q = Q_L = \frac{E^2}{X_L}$$

$$X_L = \frac{E^2}{Q} = 37,80 \Omega$$

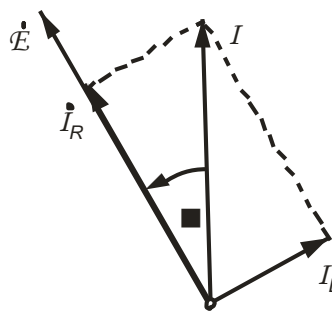
$$X_L = \omega L$$

$$L = \frac{X_L}{\omega} = 126,0 \text{ mH}$$

Fazorski dijagram

$$I_R = \frac{E}{R} = 17,69 \text{ A}$$

$$I_L = \frac{E}{X_L} = 9,354 \text{ A}$$



Provjera struja $I = \sqrt{I_R^2 + I_L^2} = 20 \text{ A}$

Provjera kuta φ $\varphi = \arctg \frac{I_L}{I_R} = \arctg \frac{\frac{E}{X_L}}{\frac{E}{R}} = \arctg \frac{R}{X_L} = 27,89^\circ$