STUDIJSKI PROGRAM MEHATRONIKA

KTET

Katedra za teorijsku elektrotehniku

www.ktet.ftn.uns.ac.rs

Osnovi elektrotehnike 2 (II kolokvijum)

K2

11.02.2023

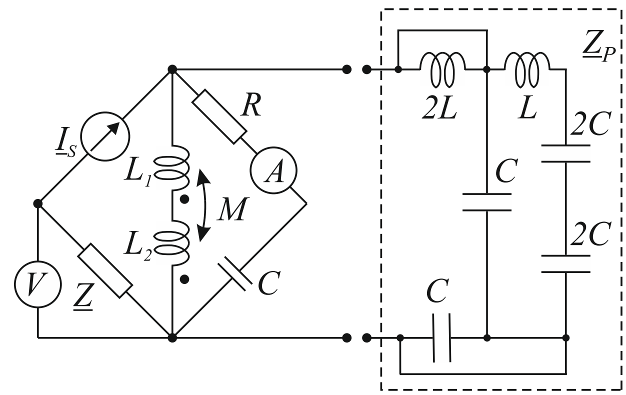
ZADACI

Zadatak 1. U mreži prostoperiodičnih struja prikazanoj na slici 2:

a) Odrediti sve rezonantne i antirezonantne kružne učestanosti prijemnika impedanse $\underline{Z}_P$.

b) Odrediti pokazivanja idealnih mernih instrumenata kada je prijemnik priključen na ulazni deo kola, pri čemu strujni generator $\underline{I}_S$ radi na <u>manjoj rezonantnoj učestanosti</u>.

Brojni podaci su: L = 10 mH, C = 40 nF, R = 1 kΩ, $\underline{Z}$ = (5 + j3) kΩ, $\underline{I}_S$= (1 + j) mA, $L_1 = L$, $L_2 = 4{,}5L$, k = 0,87.



Slika 1.

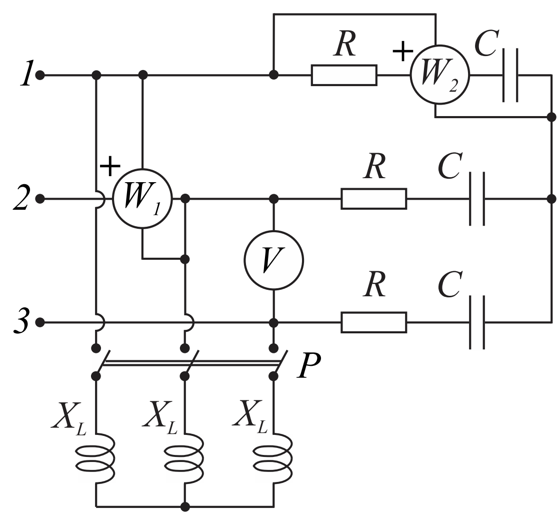
Zadatak 2. U simetričnom trofaznom sistemu, prikazanom na slici 2, prijemnik je sačinjen od jednog otpornika otpornosti R = 20 Ω i jednog kondenzatora kapacitivnosti C = 277 μF, i priključen je na gradsku mrežu faznog napona $\underline{U}_1$ = 230 V. Pomoću prekidača P u sistem se mogu priključiti kalemovi za popravku faktora snage prijemnika.

a) Odrediti pokazivanja idealnih vatmetara i voltmetra pre priključenja kalemova.

b) Izračunati reaktanse kalemova X_L kojima se faktor snage grupe povećava na jedinicu.

c) Odrediti pokazivanja idealnih vatmetara i voltmetra posle priključenja kalemova.

d) Za svaki vatmetar skicirati fazorski dijagram faznih napona mreže i svih fazora veličina od kojih zavisi njihovo pokazivanje, pre i posle kompenzacije.



Slika 2.

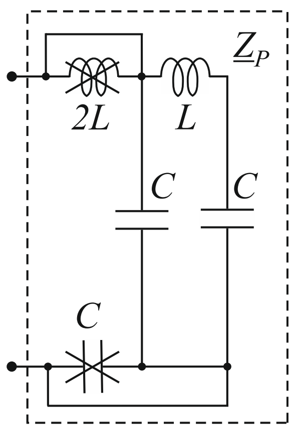
PRAVILA POLAGANJA

Za položen kolokvijum neophodno je sakupiti više od 50% od ukupnog broja poena na zadacima. Svaki zadatak se boduje sa 25 poena. Kolokvijum traje jedan sat i trideset minuta.

ISPIT iz OET2, 11.02.2023.

K2 Z1

a)



$$\underline{Z}_1 = j\omega L + \frac{1}{j\omega C} = \frac{1-\omega^2 LC}{j\omega C}$$

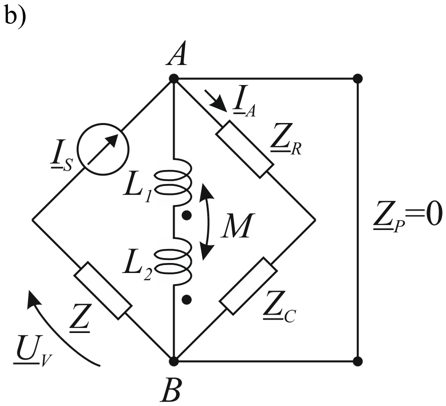
$$\underline{Z}_2 = \underline{Z}_1 \parallel \frac{1}{j\omega C} = \frac{\dfrac{1-\omega^2 LC}{j\omega C}\,\dfrac{1}{j\omega C}}{\dfrac{1-\omega^2 LC}{j\omega C} + \dfrac{1}{j\omega C}} = \frac{\dfrac{1-\omega^2 LC}{j\omega C}\,\dfrac{1}{j\omega C}}{\dfrac{2-\omega^2 LC}{j\omega C}}$$

$$\boxed{\underline{Z}_P = \frac{1-\omega^2 LC}{j\omega C\left(2-\omega^2 LC\right)}}$$

$$\mathrm{Im}\{\underline{Z}_P\} = 0 \quad \Rightarrow \quad \boxed{\omega_{r1} = \sqrt{\frac{1}{LC}}} \qquad \boxed{\omega_{r2} \to \infty}$$

$$\mathrm{Im}\{\underline{Y}_P\} = 0 \quad \Rightarrow \quad \boxed{\omega_{ar1} = 0} \qquad \boxed{\omega_{ar2} = \sqrt{\frac{2}{LC}}}$$

b)



$$\omega_{r1} = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10\cdot 10^{-3}\cdot 40\cdot 10^{-9}}} = 5\cdot 10^4\ \frac{\text{rad}}{\text{s}} = \omega$$

$$\underline{Z}_P = 0$$

$$\underline{U}_{AB} = 0 \quad \Rightarrow \quad \underline{I}_A = 0$$

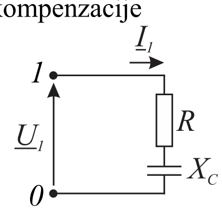
$$\boxed{I_A = \left|\underline{I}_A\right| = 0\ \text{A}}$$

$$\underline{U}_V = \underline{Z}\,\underline{I}_S = (5+j3)\cdot(1+j) = 5-3+j3+j5 = (2+j8)\ \text{V}$$

$$U_V = \left|\underline{U}_V\right| = \sqrt{2^2+8^2} \qquad \boxed{U_V = 8{,}25\ \text{V}}$$

K2 Z2

a) Pre kompenzacije



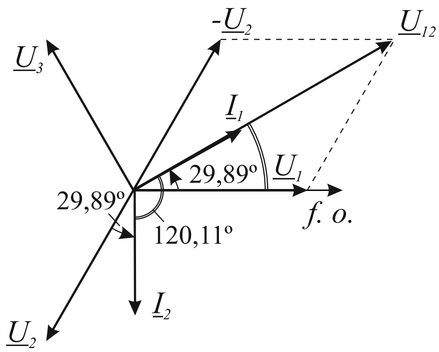
$$\underline{Z} = \underline{Z}_R + \underline{Z}_C = R + \left(\frac{-j}{\omega C}\right) = \left(20 - j11,47\right)\ \Omega = 23,1 \cdot e^{-j29,89^\circ}\ \Omega$$

$$\underline{I}_1 = \frac{\underline{U}_1}{\underline{Z}} = \frac{U_1\, e^{j0^\circ}}{Z\, e^{j\varphi}} = \frac{230}{23,1\, e^{-j29,89^\circ}} = 9,96\, e^{j29,89^\circ}\ \text{A}$$

$$P_{W1}{}^{pre} = \operatorname{Re}\left\{\underline{U}_{12}\ \underline{I}_2^{*}\right\} = U_{12}\, I_2 \cos\sphericalangle\left(\underline{U}_{12}, \underline{I}_2\right) = \sqrt{3} U_1 I_1 \cos\sphericalangle\left(\underline{U}_{12}, \underline{I}_2\right)$$

$$P_{W1}{}^{pre} = \sqrt{3} \cdot 230 \cdot 9,96 \cdot \cos(\underbrace{120 + 30 - 29,89^\circ}_{120,11^\circ}) = -1990,48\,\text{W}$$

$$\boxed{P_{W1}{}^{pre} = -1990,48\,\text{W}}$$



$$P_{W2}{}^{pre} = \operatorname{Re}\left\{\underline{U}_1\ \underline{I}_1^{*}\right\} = U_1\, I_1 \cos\sphericalangle\left(\underline{U}_1, \underline{I}_1\right)$$

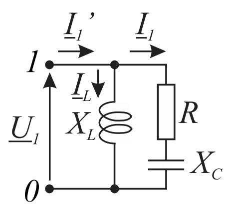
$$P_{W2}{}^{pre} = U_1\, I_1 \cos 29,89^\circ = 230 \cdot 9,96 \cdot \cos 29,89^\circ = 1986,07\,\text{W}$$

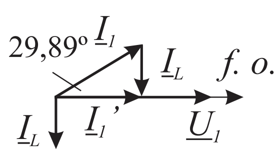
$$\boxed{P_{W2}{}^{pre} = 1986,07\,\text{W}}$$

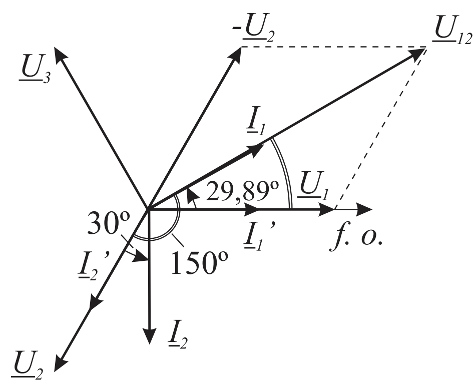
$$U_V{}^{pre} = \left|\underline{U}_{23}\right| = \sqrt{3} \cdot U_1 = \sqrt{3} \cdot 230$$

$$\boxed{U_V{}^{pre} = 398,37\ \text{V}}$$

b) Posle kompenzacije







I KZ: $\underline{I}_1{}' = \underline{I}_1 + \underline{I}_L$

$$\underline{I}_L = \frac{\underline{U}_1\, e^{j0}}{jX_L} = \frac{U_1\, e^{j0}}{X_L\, e^{j\frac{\pi}{2}}} = \frac{U_1}{X_L}\, e^{-j\frac{\pi}{2}}\ \text{A}$$

$$I_L = I_1 \sin 29,89^\circ$$

$$\frac{U_1}{X_L} = \frac{U_1}{Z} \sin 29,89^\circ \rightarrow \frac{1}{X_L} = \frac{\sin 29,89^\circ}{Z} \rightarrow X_L = \frac{23}{\sin 29,89^\circ}$$

$$\boxed{X_L = 46,15\,\Omega}$$

$$I_1' = I_1 \cos 29,89^\circ = 9,96 \cdot 0,87 = 8,64\,\text{A}$$

$$P_{W1}{}^{posle} = \operatorname{Re}\left\{\underline{U}_{12}\ \underline{I}_2^{\prime *}\right\} = U_{12}\, I_2' \cos\sphericalangle\left(\underline{U}_{12}, \underline{I}_2'\right) = \sqrt{3} U_1 I_1' \cos\sphericalangle\left(\underline{U}_{12}, \underline{I}_2'\right)$$

$$P_{W1}{}^{posle} = \sqrt{3} \cdot 230 \cdot 8,64 \cdot \cos(\underbrace{30^\circ + 120^\circ}_{150^\circ}) = -2980,8\,\text{W}$$

$$\boxed{P_{W1}{}^{posle} = -2980,8\,\text{W}}$$

$$P_{W2}{}^{posle} = \operatorname{Re}\left\{\underline{U}_1\ \underline{I}_1^{*}\right\} = P_{W2}{}^{pre}$$

$$\boxed{P_{W2}{}^{posle} = 1986,07\,\text{W}}$$

$$U_V{}^{posle} = \left|\underline{U}_{23}\right| = U_V{}^{pre}$$

$$\boxed{U_V{}^{posle} = 398,37\ \text{V}}$$