STUDIJSKI PROGRAM ENERGETIKA, ELEKTRONIKA I TELEKOMUNIKACIJE

K TET Katedra za teorijsku elektrotehniku www.ktet.ftn.uns.ac.rs	Osnovi elektrotehnike 2 (II kolokvijum)	A 12.06.2019.

ZADACI

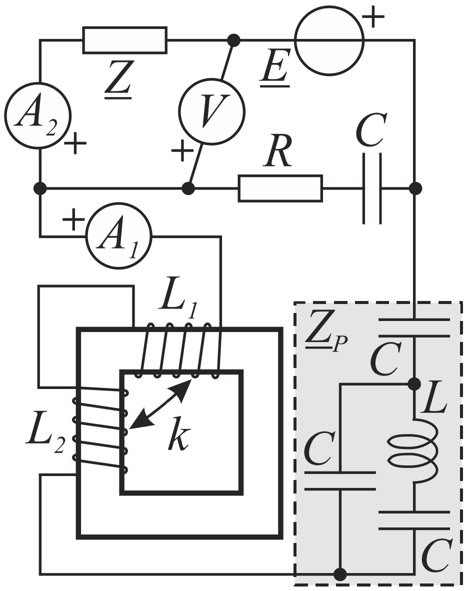
Zadatak 1. U mreži prostoperiodične struje prikazanoj na slici 1:

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

b) Nacrtati pojednostavljenu električnu šemu kola i u njoj označiti tip magnetske sprega koja postoji između namotaja induktivnosti L_1 i L_2.

c) Odrediti pokazivanja idealnih mernih instrumenata, u situaciji kada je ugaona učestanost generatora elektromotorne sile $\underline{E}$ jednaka većoj antirezonantnoj učestanosti prijemnika $\underline{Z}_P$.

Brojni podaci: $L = 10\ mH$, $C = 200\ \mu F$, $R = 4\ \Omega$, $\underline{Z} = (1 + j5)\ \Omega$, $\underline{E} = (15 + j5)\ V$, $L_1 = 2L$, $L_2 = 3L$, $k = 0{,}7$.



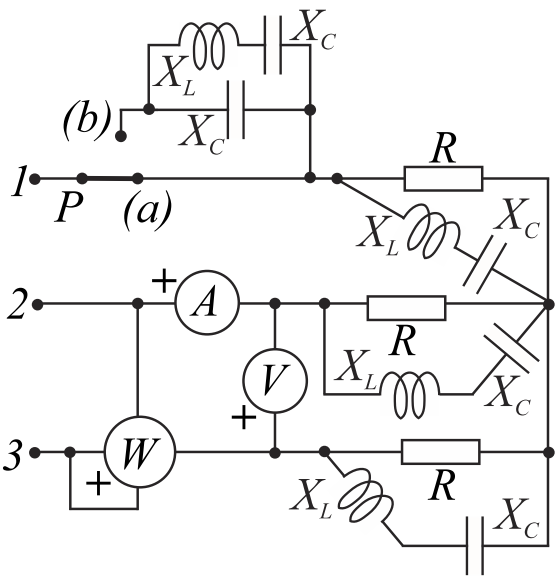
Slika 1.

Zadatak 2. Prijemnik sa slike 2 je sastavljen od otpornika otpornosti $R = 20\ \Omega$, kalemova reaktanse $X_L = 20\ \Omega$ i kondenzatora reaktanse $X_C = 10\ \Omega$, i priključen je na mrežu faznog napona $\underline{U}_1 = 230\ V$. Kada je prekidač P u položaju *(a)*, trofazni prijemnik je simetričan.

a) Odrediti pokazivanja idealnih mernih instrumenata kada je prekidač P u inicijalnom položaju *(a)*, kao na slici 2.

b) Odrediti pokazivanja idealnih mernih instrumenata nakon promene položaja prekidača P u položaj *(b)*.

c) Na istom fazorskom dijagramu prikazati fazore svih veličina od kojih zavise pokazivanja instrumenata.



Slika 2.

PRAVILA POLAGANJA

Za položen kolokvijum neophodno je tačno uraditi više od 50% svakog od zadataka. Svaki zadatak se boduje sa 25 poena. Kolokvijum traje jedan sat i trideset minuta.

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K TET

Katedra za teorijsku elektrotehniku
www.ktet.ftn.uns.ac.rs

Osnovi elektrotehnike 2 (II kolokvijum)

B

12.06.2019.

ZADACI

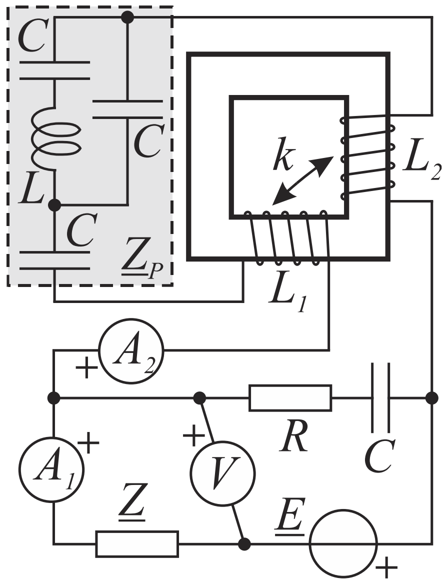
Zadatak 1. U mreži prostoperiodične struje prikazanoj na slici 1:

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

b) Nacrtati pojednostavljenu električnu šemu kola i u njoj označiti tip magnetske sprega koja postoji između namotaja induktivnosti L_1 i L_2.

c) Odrediti pokazivanja idealnih mernih instrumenata, u situaciji kada je ugaona učestanost generatora elektromotorne sile $\underline{E}$ jednaka većoj antirezonantnoj učestanosti prijemnika $\underline{Z}_P$.

Brojni podaci: $L = 10\ mH$, $C = 50\ \mu F$, $R = 4\ \Omega$, $\underline{Z} = (1 + j10)\ \Omega$, $\underline{E} = (20 + j10)\ V$, $L_1 = 2L$, $L_2 = 4L$, $k = 0{,}8$.



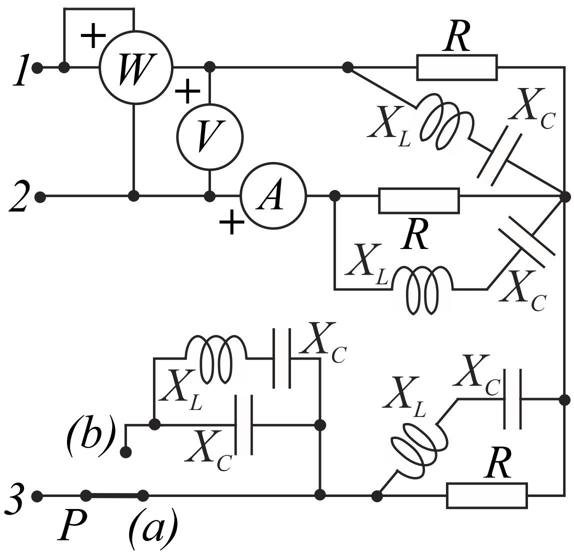
Slika 1.

Zadatak 2. Prijemnik sa slike 2 je sastavljen od otpornika otpornosti $R = 40\ \Omega$, kalemova reaktanse $X_L = 40\ \Omega$ i kondenzatora reaktanse $X_C = 20\ \Omega$, i priključen je na mrežu faznog napona $\underline{U}_1 = 230\ V$. Kada je prekidač P u položaju *(a)*, trofazni prijemnik je simetričan.

a) Odrediti pokazivanja idealnih mernih instrumenata kada je prekidač P u inicijalnom položaju *(a)*, kao na slici 2.

b) Odrediti pokazivanja idealnih mernih instrumenata nakon promene položaja prekidača P u položaj *(b)*.

c) Na istom fazorskom dijagramu prikazati fazore svih veličina od kojih zavise pokazivanja instrumenata.



Slika 2.

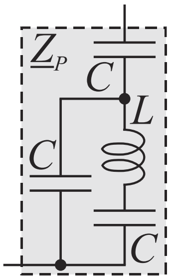
PRAVILA POLAGANJA

Za položen kolokvijum neophodno je tačno uraditi više od 50% svakog od zadataka. Svaki zadatak se boduje sa 25 poena. Kolokvijum traje jedan sat i trideset minuta.

Drugi kolokvijum iz OET2, 12.06.2019.

II-1 **A grupa**

a)



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

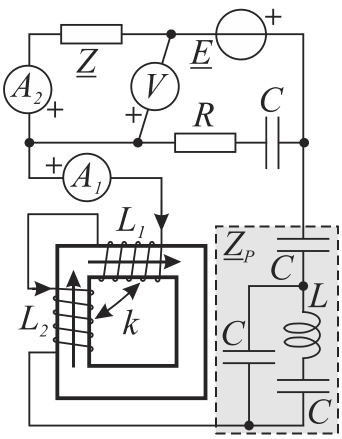
$$\underline{Z}_2 = \underline{Z}_1 \parallel \frac{1}{j\omega C} = \frac{\frac{1-\omega^2 LC}{j\omega C}\cdot\frac{1}{j\omega C}}{\frac{1-\omega^2 LC}{j\omega C}+\frac{1}{j\omega C}} = \frac{\frac{1-\omega^2 LC}{j\omega C}\cdot\frac{1}{j\omega C}}{\frac{2-\omega^2 LC}{j\omega C}} = \frac{1-\omega^2 LC}{j\omega C\left(2-\omega^2 LC\right)}$$

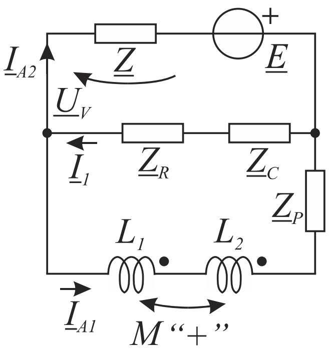
$$\underline{Z}_P = \underline{Z}_2 + \frac{1}{j\omega C} = \frac{1-\omega^2 LC}{j\omega C\left(2-\omega^2 LC\right)} + \frac{1}{j\omega C} = \frac{1-\omega^2 LC}{j\omega C\left(2-\omega^2 LC\right)} + \frac{2-\omega^2 LC}{j\omega C\left(2-\omega^2 LC\right)}$$

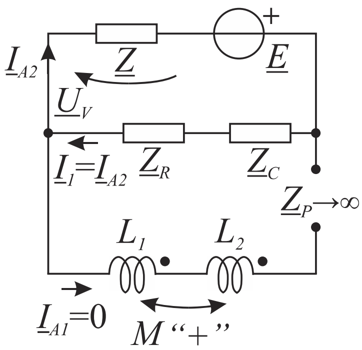
$$\boxed{\underline{Z}_P = -j\frac{3-2\omega^2 LC}{\omega C\left(2-\omega^2 LC\right)}} \qquad \mathrm{Im}\left\{\underline{Z}_P\right\}=0 \quad \Rightarrow \quad \boxed{\omega_{r1}=\sqrt{\frac{3}{2LC}}} \qquad \boxed{\omega_{r2}\to\infty}$$

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

b)







c)

$$\omega = \omega_{ar2} = \sqrt{\frac{2}{LC}} = \sqrt{\frac{2}{10\cdot 10^{-3}\cdot 200\cdot 10^{-6}}} = 1000\,\frac{rad}{s}$$

$$M = k\sqrt{L_1 L_2} = k\sqrt{2L\cdot 3L} = 0{,}7\cdot\sqrt{20\cdot 10^{-3}\cdot 30\cdot 10^{-3}} = 17{,}15\,mH$$

$$\underline{Z}_R = R = 4\,\Omega, \qquad \underline{Z}_C = -j\frac{1}{\omega C} = -j5\,\Omega$$

$$\underline{Z}_P \to \infty \quad \Rightarrow \quad \boxed{I_{A1}=0\,A}$$

$$-\underline{E} + \underline{Z}_C \underline{I}_{A2} + \underline{Z}_R \underline{I}_{A2} + \underline{Z}\,\underline{I}_{A2} = 0 \quad \Rightarrow \quad \underline{I}_{A2} = \frac{\underline{E}}{\underline{Z}_C + \underline{Z}_R + \underline{Z}} = \frac{15+j5}{-j5+4+\left(1+j5\right)} = \left(3+j\right)A$$

$$I_{A2} = \left|\underline{I}_{A2}\right| = \sqrt{3^2+1^2} \qquad \boxed{I_{A2}=3{,}16\,A}$$

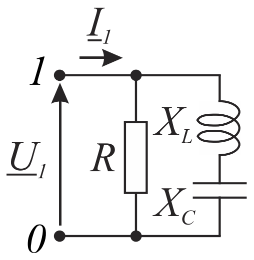
$$\underline{U}_V = \underline{Z}\,\underline{I}_{A2} = \left(1+j5\right)\cdot\left(3+j\right) = 3-5+j+j15 = \left(-2+j16\right)V$$

$$U_V = \left|\underline{U}_V\right| = \sqrt{\left(-2\right)^2+16^2} \qquad \boxed{U_V = 16{,}12\,V}$$

Drugi kolokvijum iz OET2, 12.06.2019.

II-2 **A grupa**

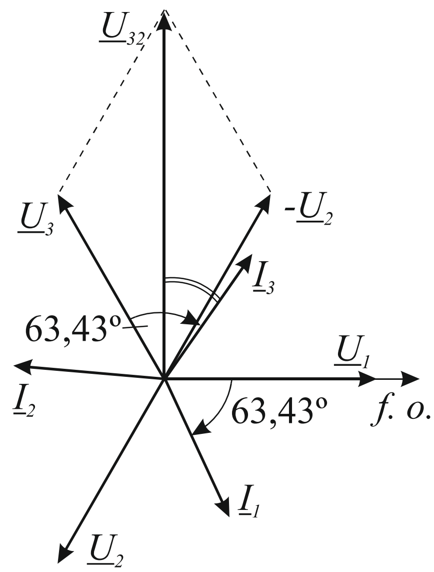
a)



$$\underline{Z}=\frac{R\left(jX_L-jX_C\right)}{R+\left(jX_L-jX_C\right)}=\frac{20\cdot\left(j20-j10\right)}{20+\left(j20-j10\right)}$$

$$\underline{Z}=\left(4+j8\right)\Omega=8{,}94\,e^{j63{,}43^\circ}\ \Omega$$

$$\underline{I}_1=\frac{\underline{U}_1}{\underline{Z}}=\frac{U_1\,e^{j0^\circ}}{Z\,e^{j\varphi}}=\frac{230}{8{,}94\,e^{j63{,}43^\circ}}=25{,}73\,e^{-j63{,}43^\circ}\ A$$



$$\boxed{I_A^{(a)}=\left|\underline{I}_2\right|=\left|\underline{I}_1\right|=25{,}73\,A}$$

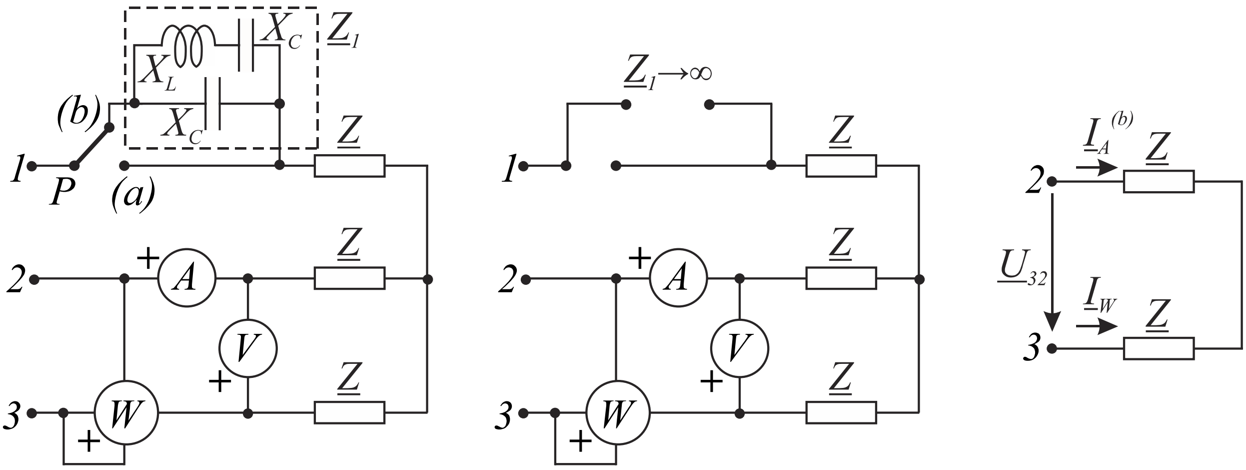
$$\boxed{U_V^{(a)}=\left|\underline{U}_{32}\right|=\sqrt{3}\left|\underline{U}_1\right|=398{,}4\,V}$$

$$P_W^{(a)}=\mathrm{Re}\left\{\underline{U}_{32}\ \underline{I}_3^{\ *}\right\}=U_{32}\,I_3\cos\sphericalangle\left(\underline{U}_{32},\underline{I}_3\right)$$

$$P_W^{(a)}=\sqrt{3}U_1\,I_1\cos\left(63{,}43^\circ-30^\circ\right)=\sqrt{3}\cdot230\cdot25{,}73\cdot\cos33{,}43^\circ$$

$$\boxed{P_W^{(a)}=8554{,}32\,W}$$

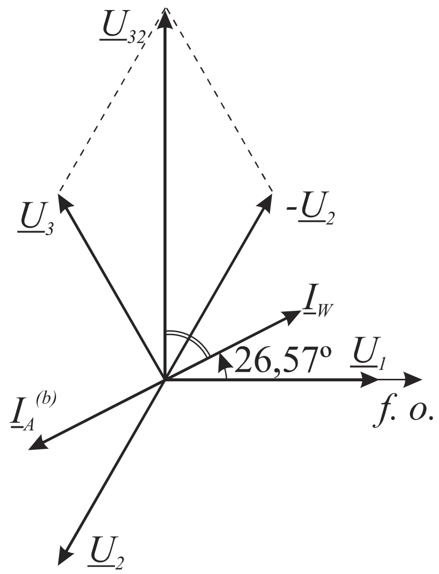
b)



$$\underline{Z}_1=\frac{\left(jX_L-jX_C\right)\cdot\left(-jX_C\right)}{\left(jX_L-jX_C\right)+\left(-jX_C\right)}=\frac{\left(j20-j10\right)\cdot\left(-j10\right)}{\left(j20-j10\right)+\left(-j10\right)}\qquad\underline{Z}_1\to\infty$$

$$\underline{I}_W=\frac{\underline{U}_{32}}{2\underline{Z}}=\frac{\sqrt{3}\cdot230\,e^{j90^\circ}}{2\cdot8{,}94\,e^{j63{,}43^\circ}}=22{,}28\,e^{j26{,}57^\circ}\ A$$

$$\underline{I}_A^{(b)}=-\underline{I}_W=-22{,}28\,e^{j26{,}57^\circ}=22{,}28\,e^{-j153{,}43^\circ}\ A$$



$$\boxed{I_A^{(b)}=\left|\underline{I}_A^{(b)}\right|=22{,}28\,A}$$

$$\boxed{U_V^{(b)}=\left|\underline{U}_{32}\right|=\sqrt{3}\left|\underline{U}_1\right|=398{,}4\,V}$$

$$P_W^{(b)}=\mathrm{Re}\left\{\underline{U}_{32}\ \underline{I}_W^{\ *}\right\}=U_{32}\,I_W\cos\sphericalangle\left(\underline{U}_{32},\underline{I}_W\right)$$

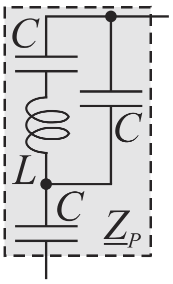
$$P_W^{(b)}=\sqrt{3}U_1\,I_W\cos\left(90^\circ-26{,}57^\circ\right)=\sqrt{3}\cdot230\cdot22{,}28\cdot\cos63{,}43^\circ$$

$$\boxed{P_W^{(b)}=3970{,}03\,W}$$

<u>Drugi kolokvijum iz OET2, 12.06.2019.</u>

II-1 **B grupa**

a)



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

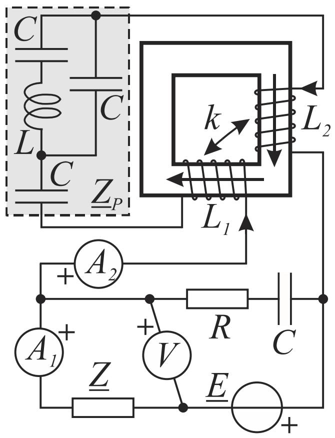
$$\underline{Z}_2 = \underline{Z}_1 \parallel \frac{1}{j\omega C} = \frac{\dfrac{1-\omega^2 LC}{j\omega C}\,\dfrac{1}{j\omega C}}{\dfrac{1-\omega^2 LC}{j\omega C} + \dfrac{1}{j\omega C}} = \frac{\dfrac{1-\omega^2 LC}{j\omega C}\,\dfrac{1}{j\omega C}}{\dfrac{2-\omega^2 LC}{j\omega C}} = \frac{1-\omega^2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

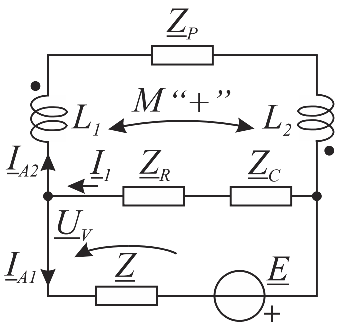
$$\underline{Z}_P = \underline{Z}_2 + \frac{1}{j\omega C} = \frac{1-\omega^2 LC}{j\omega C\left(2-\omega^2 LC\right)} + \frac{1}{j\omega C} = \frac{1-\omega^2 LC}{j\omega C\left(2-\omega^2 LC\right)} + \frac{2-\omega^2 LC}{j\omega C\left(2-\omega^2 LC\right)}$$

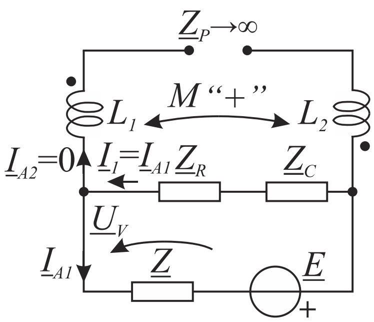
$$\boxed{\underline{Z}_P = -j\frac{3-2\omega^2 LC}{\omega C\left(2-\omega^2 LC\right)}} \qquad \mathrm{Im}\left\{\underline{Z}_P\right\} = 0 \quad \Rightarrow \quad \boxed{\omega_{r1} = \sqrt{\frac{3}{2LC}}} \qquad \boxed{\omega_{r2} \to \infty}$$

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

b)







c)

$$\omega = \omega_{ar2} = \sqrt{\frac{2}{LC}} = \sqrt{\frac{2}{10\cdot 10^{-3}\cdot 50\cdot 10^{-6}}} = 2000\,\frac{rad}{s}$$

$$M = k\sqrt{L_1 L_2} = k\sqrt{2L\cdot 4L} = 0{,}8\cdot\sqrt{20\cdot 10^{-3}\cdot 40\cdot 10^{-3}} = 22{,}63\,mH$$

$$\underline{Z}_R = R = 4\,\Omega, \qquad \underline{Z}_C = -j\frac{1}{\omega C} = -j10\,\Omega$$

$$\underline{Z}_P \to \infty \qquad \Rightarrow \qquad \boxed{I_{A2} = 0\ A}$$

$$-\underline{E} + \underline{Z}_C \underline{I}_{A1} + \underline{Z}_R \underline{I}_{A1} + \underline{Z}\,\underline{I}_{A1} = 0 \qquad \Rightarrow \qquad \underline{I}_{A1} = \frac{\underline{E}}{\underline{Z}_C + \underline{Z}_R + \underline{Z}} = \frac{20+j10}{-j10+4+\left(1+j10\right)} = \left(4+j2\right)A$$

$$I_{A1} = \left|\underline{I}_{A1}\right| = \sqrt{4^2+2^2} \qquad \boxed{I_{A1} = 4{,}47\ A}$$

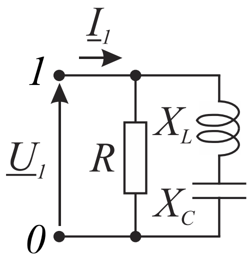
$$\underline{U}_V = \underline{Z}\,\underline{I}_{A1} = \left(1+j10\right)\cdot\left(4+j2\right) = 4-20+j2+j40 = \left(-16+j42\right)V$$

$$U_V = \left|\underline{U}_V\right| = \sqrt{\left(-16\right)^2+42^2} \qquad \boxed{U_V = 44{,}94\,V}$$

Drugi kolokvijum iz OET2, 12.06.2019.

II-2 **B grupa**

a)



$$\underline{Z}=\frac{R\left(jX_L-jX_C\right)}{R+\left(jX_L-jX_C\right)}=\frac{40\cdot\left(j40-j20\right)}{40+\left(j40-j20\right)}$$

$$\underline{Z}=\left(8+j16\right)\Omega=17{,}89\,e^{j63{,}43^\circ}\ \Omega$$

$$\underline{I}_1=\frac{\underline{U}_1}{\underline{Z}}=\frac{U_1\,e^{j0^\circ}}{Z\,e^{j\varphi}}=\frac{230}{17{,}89\,e^{j63{,}43^\circ}}=12{,}86\,e^{-j63{,}43^\circ}\ A$$

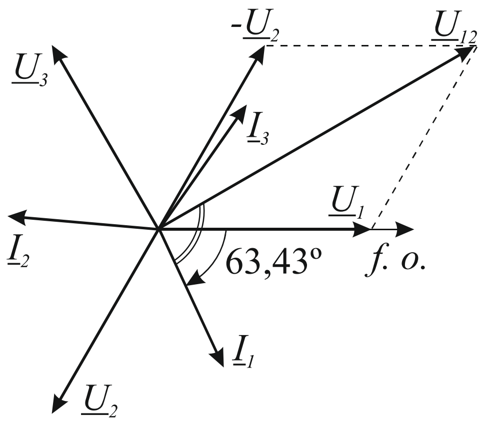
$$\boxed{I_A{}^{(a)}=\left|\underline{I}_2\right|=\left|\underline{I}_1\right|=12{,}86\ A}$$

$$\boxed{U_V{}^{(a)}=\left|\underline{U}_{12}\right|=\sqrt{3}\left|\underline{U}_1\right|=398{,}4\,V}$$

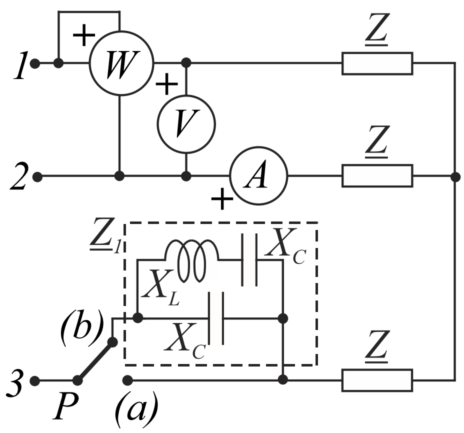
$$P_W{}^{(a)}=\mathrm{Re}\left\{\underline{U}_{12}\ \underline{I}_1{}^*\right\}=U_{12}\,I_1\cos\sphericalangle\left(\underline{U}_{12},\underline{I}_1\right)$$

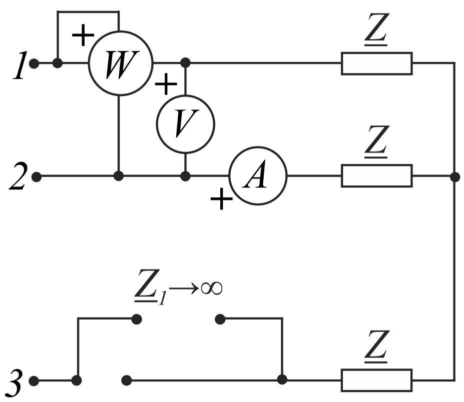
$$P_W{}^{(a)}=\sqrt{3}U_1\,I_1\cos\left(63{,}43^\circ+30^\circ\right)=\sqrt{3}\cdot230\cdot12{,}86\cdot\cos93{,}43^\circ$$

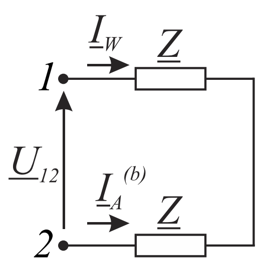
$$\boxed{P_W{}^{(a)}=-306{,}51\,W}$$



b)







$$\underline{Z}_1=\frac{\left(jX_L-jX_C\right)\cdot\left(-jX_C\right)}{\left(jX_L-jX_C\right)+\left(-jX_C\right)}=\frac{\left(j40-j20\right)\cdot\left(-j20\right)}{\left(j40-j20\right)+\left(-j20\right)}\qquad \underline{Z}_1\to\infty$$

$$\underline{I}_W=\frac{\underline{U}_{12}}{2\,\underline{Z}}=\frac{\sqrt{3}\cdot230\,e^{j30^\circ}}{2\cdot17{,}89\,e^{j63{,}43^\circ}}=11{,}13\,e^{-j33{,}43^\circ}\ A$$

$$\underline{I}_A{}^{(b)}=-\underline{I}_W=-11{,}13\,e^{-j33{,}43^\circ}=11{,}13\,e^{j146{,}57^\circ}\ A$$

$$\boxed{I_A{}^{(b)}=\left|\underline{I}_A{}^{(b)}\right|=11{,}13\ A}$$

$$\boxed{U_V{}^{(b)}=\left|\underline{U}_{12}\right|=\sqrt{3}\left|\underline{U}_1\right|=398{,}4\,V}$$

$$P_W{}^{(b)}=\mathrm{Re}\left\{\underline{U}_{12}\ \underline{I}_W{}^*\right\}=U_{12}\,I_W\cos\sphericalangle\left(\underline{U}_{12},\underline{I}_W\right)$$

$$P_W{}^{(b)}=\sqrt{3}U_1\,I_W\cos\left(30^\circ+33{,}43^\circ\right)=\sqrt{3}\cdot230\cdot11{,}13\cdot\cos63{,}43^\circ$$

$$\boxed{P_W{}^{(b)}=1983{,}23\,W}$$