Rješenja s postupcima

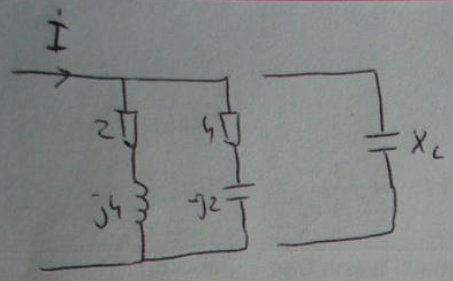
završnog ispita iz OE

12/13

Made by: giggs

1. *3 boda* Na sinusoidni izvor frekvencije 50 Hz paralelno su spojene dvije impedancije $\underline{Z}_1 = 2 + j4\ \Omega$ i $\underline{Z}_2 = 4 - j2\ \Omega$. Snaga na otporniku od 2 Ω je 18 W. Odrediti potreban kapacitet kondenzatora koji treba spojiti paralelno impedancijama da bi ukupni faktor snage spoja bio $\cos\varphi = 1$.

A) 141,6 μF B) 198,2 μF C) 232,4 μF D) 280,8 μF **E) 318,3 μF**

① 

$z_1 = 2 + j4$

$z_2 = 4 - j2$

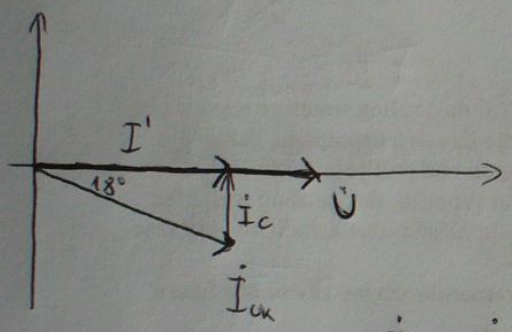
$P_1 = 18\ W$

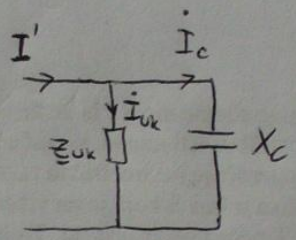
$f = 50\ Hz$

$P_1 = I_1^2 R_1 \Rightarrow I_1 = \sqrt{\frac{P_1}{R_1}} = 3\ A$

$U = I_1 z_1 = 6\sqrt{5}\ V \Rightarrow I_{UK} = \frac{U}{z_{UK}} = 3\sqrt{2}$

$z_{UK} = \frac{z_1 z_2}{z_1 + z_2} = 3 + i = \sqrt{10}\,\angle 18{,}44^\circ\ \Omega$





$\dot{I}_c = \dot{I}_{UK} \cdot \sin(18{,}44^\circ) = 1{,}342\ A$

$X_c = \frac{U}{I_c} = \frac{6\sqrt{5}}{1{,}342} = 9{,}99732$

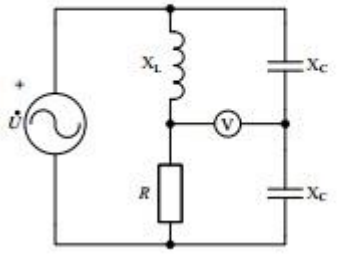
$\omega = 2\pi f$

$X_c = \frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega X_c} = 3{,}184 \cdot 10^{-4}\ F$

2. U mreži prema slici zadano je $X_L=X_C=R=10\ \Omega$. Ukoliko voltmetar pokazuje $U_V=10$ V, odredite napon izvora U.

2 boda

A) $U=20$ V
B) $U=15$ V
C) $U=30$ V
D) $U=10$ V
E) $U=25$ V



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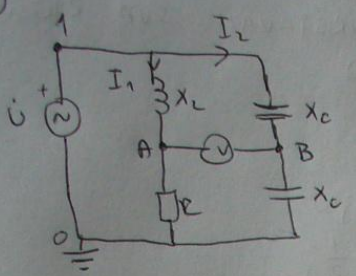
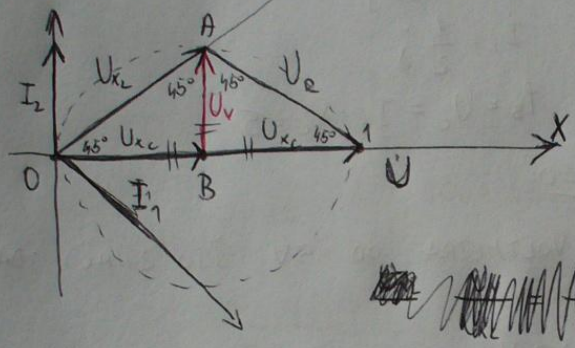


$R=X_L=X_C=10\ \Omega$
$U_V=10$ V

$\dot{U}=?$
$\underline{z}=$

Crtamo topografski diagram



Postavimo $\dot{U}$ na X-os. U prvoj grani je $\underline{z}_1=10+10j=10\sqrt{2}\angle 45°$ što znači da I_1 zaostaje za 45° za $\dot{U}$. Znamo da na induktivitetu napon prethodi struji za 90°. Znamo i da je napon na otporu u fazi sa strujom. To sve nacrtamo.
Druga grana je čisti kapacitet što znači da I_2 prethodi $\dot{U}$ za 90°. Pošto imamo dva ista kapaciteta vidljivo je da će oni dijeliti napon $\dot{U}$ na pola. Sada ucrtamo U_V.

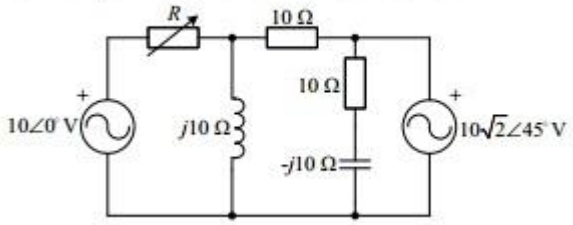
Pošto su svi kuteri 45° jasno je da su to dva jednakokračna trokuta sa krakovima 10V. (označeni na slici sa //)
I dobije se da je $\dot{U}=20$V.

NAPOMENA: Mogu se uvrštavat rješenja i vidjeti kaj se poklapa...
ako ovo neznate

3. Odredite maksimalnu snagu koja se može razvijati na otporu R u mreži prema slici.

3 boda

A) $P = 4{,}6$ W
B) $P = 6{,}2$ W
C) $P = 8{,}3$ W
D) $P = 9{,}7$ W
E) $P = 11{,}4$ W



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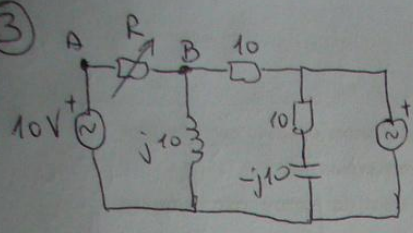
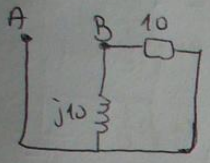
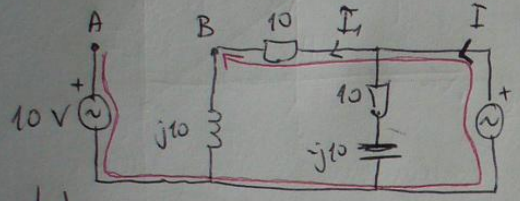


$P_{R\,max} = ?$

Thevenin



$\underline{Z}_T = 5 + 5j = 5\sqrt{2}\ \angle 45°$



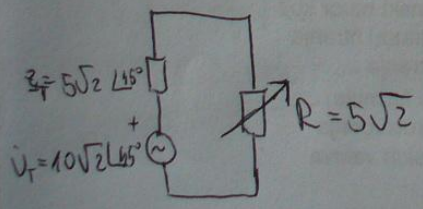
gledamo samo desni dio → $\underline{Z} = \dfrac{(10+j10)(10-j10)}{20} = 10$ ⇒ ovo nam zapravo ni ne treba

$$I_1 = \frac{10\sqrt{2}\ \angle 45°}{10 + j10} = 1\ A$$

CRVENO JE OZNAČEN PUT PO KOJEMU ĆU RAČUNATI $\dot{U}_T$

$$\dot{U}_T = -10\,V + 10\sqrt{2}\ \angle 45° + \underbrace{1 \cdot 10}_{I_1 \cdot R} = 10\sqrt{2}\ \angle 45°\ V$$

NOVA SKICA



$P_{R\,max} = ?$

$\underline{Z} = 13{,}07\ \angle 22{,}5°$

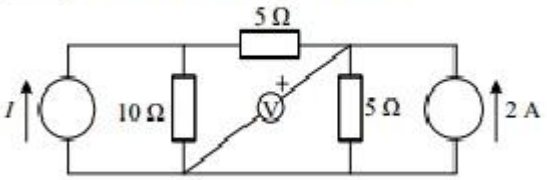
$I = 1{,}08\ \angle 22{,}5°$

$$P_{max} = I^2 \cdot R = 1{,}08^2 \cdot 5\sqrt{2} = 8{,}3\ W$$

4. Kolika je struja izvora I ako voltmetar pokazuje $U_v = 15$ V označenog polariteta?

3 boda

A) $I = 1{,}0$ A
B) $I = 2{,}5$ A
C) $I = 3{,}0$ A
D) $I = 4{,}5$ A
E) $I = 5{,}7$ A



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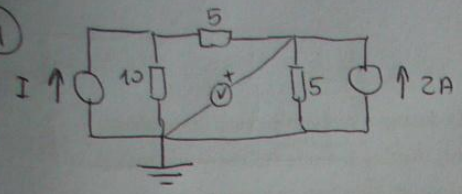
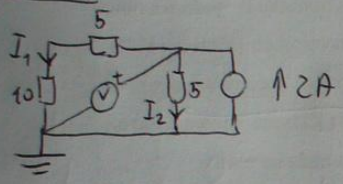


$U_v = 15$ V

Primjetimo da ako donju točku uzemljimo voltmetar mjeri samo pad napona na desnom otporu. To se lako izračuna superpozicijom.

1. slučaj

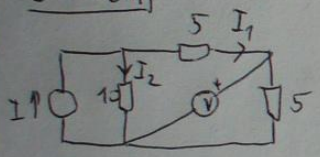


$$I_1 = I\,\frac{5}{20} = 0{,}5\ \text{A}$$

$$I_2 = 1{,}5\ \text{A}$$

$$U_v = I_2 \cdot 5 = 7{,}5\ \text{V}$$

2. slučaj



$$I_1 = I_2 = \frac{I}{2}$$

$$U_v = \frac{I}{2} \cdot 5$$

sada zbrojimo ta dva slučaja i izjednačimo sa zadanim

$$7{,}5 + \frac{I}{2} \cdot 5 = 15$$

$$\frac{I}{2} \cdot 5 = 7{,}5 \mid \cdot 2$$

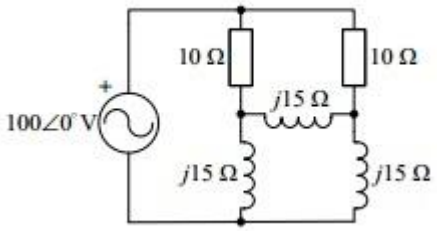
$$5I = 15 \mid :5$$

$$I = 3\ \text{A}$$

5. Odrediti struju izvora u mreži prema slici.

3 boda

A) $I = 12{,}5$ A
B) $I = 11{,}1$ A
C) $I = 9{,}7$ A
D) $I = 7{,}4$ A
E) $I = 6{,}1$ A



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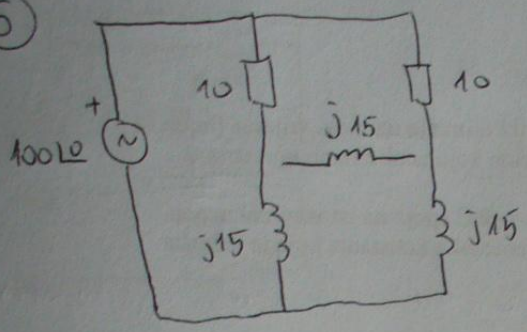


$I = ?$

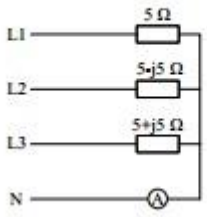
Most je u ravnoteži tako da se srednja grana može odspojiti

$$\underline{Z}_{uk} = \frac{(10+j15)^2}{20+j30} = 5 + \frac{15}{2}j$$

$$I_{uk} = \frac{\dot{U}}{\underline{Z}} = \frac{100\angle 0}{5+\frac{15}{2}j} = 11{,}09\angle -56^\circ \text{ A}$$

6. Trošilo prema slici priključeno je na trofazni simetrični izvor linijskog napona U_L=380 V. Odredite
3 boda pokazivanje ampermetra.

A) I = 40 A
B) I = 50 A
C) I = 60 A
D) I = 70 A
E) I = 80 A



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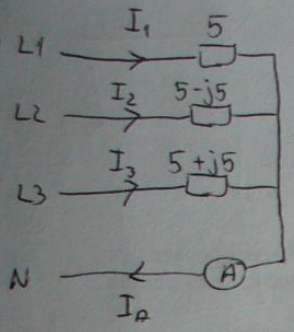


$U_L = 380\ V$

$I_A = ?$

$U_f = 220\ V$

$I_A = I_1 + I_2 + I_3$

$I_1 = \frac{U_f}{5} = 44$

$I_2 = \frac{220\angle -120}{5 - j5} = 22\sqrt{2}\angle -75°$

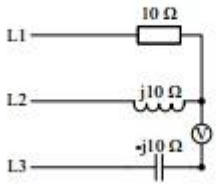
$I_3 = \frac{220\angle -240}{5 + j5} = 22\sqrt{2}\angle 75°$

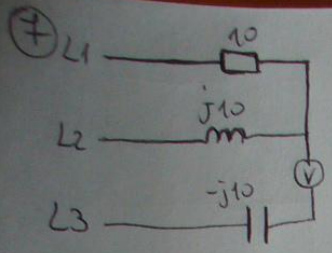
PAZI!!!
Kutevi trofaznog sustava

$I_A = 44 + 22\sqrt{2}\angle -75° + 22\sqrt{2}\angle 75° = 60,105\ A$

7. Na simetrični trofazni izvor linijskog napona U_L=400 V priključen je spoj prema slici. Odredite pokazivanje voltmetra.
3 boda

A) U = 102,8 V
B) U = 115,3 V
C) U = 127,1 V
D) U = 146,4 V
E) U = 191,5 V

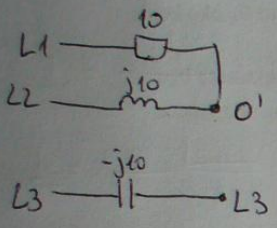




$U_L = 400\ V$

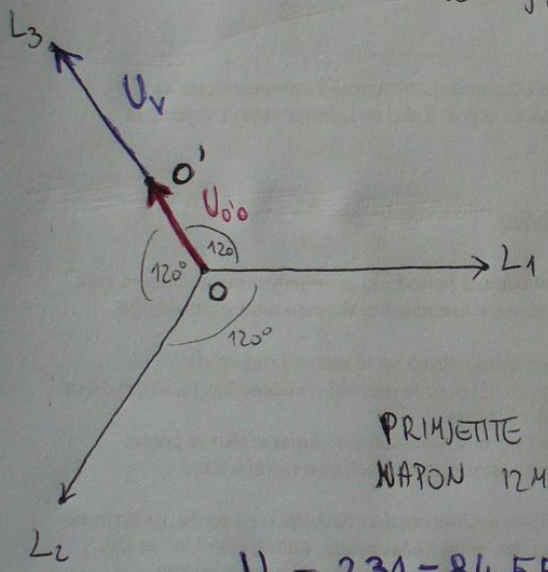
$U_f = 230,94\ V = 231\ V$

VOLTMETAR IMA BESKONAČNI OTPOR PA JE DONJA GRANA ODSPOJENA.



MORAMO NAĆI POLOŽAJ O' PO MILLMANU

$$U_{O'O} = \frac{\frac{231}{10} + \frac{231\angle -120}{j10}}{\frac{1}{10} + \frac{1}{j10}} = 84,55\angle 120°$$



$L_3 = 231\angle 120°$

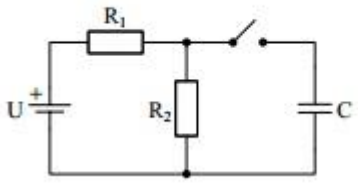
PRIMJETITE DA VOLTMETAR ZAPRAVO MJERI NAPON IZMEĐU TOČAKA O' i L3.

$U_V = 231 - 84,55 = 146,45$

VOLTMETAR NE POKAZUJE KUTOVE

8. Kondenzator je prazan. U trenutku $t_0=0$ zatvara se sklopka. Odredite napon na kondenzatoru u
2 boda trenutku $t=50\mu s$. Zadano je $R_1=2\ k\Omega$, $R_2=2\ k\Omega$, $C=20$ nF, $U=100$ V.

A) $U=23{,}3$ V
B) $U=38{,}5$ V
C) $U=60{,}2$ V
D) $U=12{,}7$ V
E) $U=45{,}9$ V



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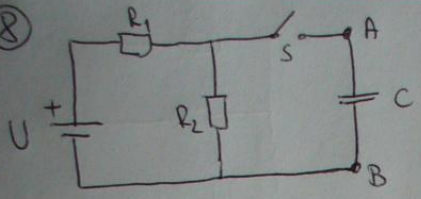
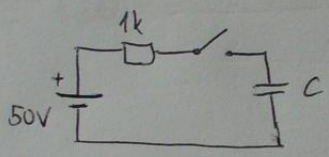


$t_0=0$
$t=50\,\mu s$
$R_1=2\,k\Omega$
$R_2=2\,k\Omega$
$C=20\,nF$
$U=100\,V$

PRVO ćemo ostatak može zamjeniti theveninovim nadomjeskim izvorom

$R_{ab}=R_T=1\,k\Omega$
$U_{ab}=U_T=50\,V$



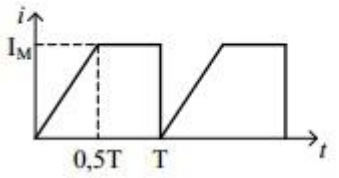
I SADA PO FORMULI $U_c(t)=U\left(1-e^{-\frac{t}{\tau}}\right)$

$\tau=RC=2\cdot10^{-5}\,s$ $\qquad \frac{t}{\tau}=\frac{5}{2}$

$U_c=50\left(1-e^{-\frac{5}{2}}\right)=45{,}896\ V$

9. Ako je srednja vrijednost struje valnog oblika prema slici I_{SR}=2 A, odredite njezinu efektivnu vrijednost.
2 boda

A) I_{ef} = 1,55 A
B) I_{ef} = 1,76 A
C) I_{ef} = 1,92 A
D) I_{ef} = 2,18 A
E) I_{ef} = 2,35 A



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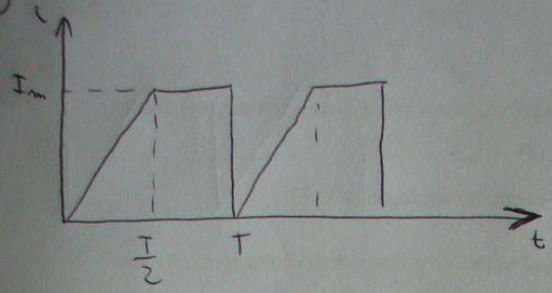


$I_{SR} = 2\ A$

$I_{ef} = ?$

PRVO MORAMO IZRAČUNATI I_m PREKO I_{SR}

OD 0 DO $\frac{T}{2}$

$$I_{SR1} = \frac{1}{T}\int_0^{T/2} \frac{2I_m}{T}\,t\,dt = \frac{1}{T}\,\frac{I_m}{T}\,t^2\Big|_0^{T/2} = \frac{I_m}{T^2}\,\frac{T^2}{4} = \frac{I_m}{4}$$

OD $\frac{T}{2}$ DO T

$$I_{SR2} = \frac{I_m}{2}$$

SLIJEDI:

$$I_{SR} = I_{SR1} + I_{SR2}$$

$$2 = \frac{3}{4} I_m \Rightarrow I_m = \frac{8}{3}$$

SADA TRAŽIMO EFEKTIVNE VRIJEDNOSTI

$$I_{ef_1} = \frac{I_m}{\sqrt{3}}\sqrt{\frac{T_i}{T}} \Rightarrow$$ ZA PILASTI OBLIK UVIJEK IDE $\frac{I_m}{\sqrt{3}}$

T_i → KOLIKO DUGO JE PILASTI OBLIK

T → PERIOD

$$I_{ef_1} = \frac{\frac{8}{3}}{\sqrt{3}}\sqrt{\frac{T/2}{T}} = \frac{8}{3\sqrt{6}}$$

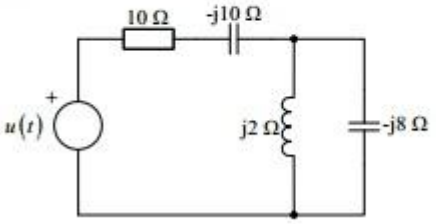
$$I_{ef_2} = I_m\sqrt{\frac{T_i}{T}} = \frac{8}{3\sqrt{2}}$$ ⇒ ZA PRAVOKUTNI OBLIK

$$I_{ef} = \sqrt{I_{ef_1}^2 + I_{ef_2}^2} = 2{,}177\ A$$

10. U spoju prema slici napon izvora je složenog valnog oblika danog izrazom $u(t)=100+\sqrt{2}\sin(\omega t)+2\sqrt{2}\sin(2\omega t)$ V. Odredite efektivnu vrijednost struje kroz otpornik. Sve reaktancije su dane za kružnu frekvenciju ω.

2 boda

A) I_{ef} = 38,1 mA
B) I_{ef} = 59,2 mA
C) I_{ef} = 80,6 mA
D) I_{ef} = 97,0 mA
E) I_{ef} = 105,5 mA



(10)

$u(t) = 100 + \sqrt{2}\sin(\omega t) + 2\sqrt{2}\sin(2\omega t)$

$I_{ef} = ?$

$X_{C_1} = \frac{1}{\omega C_1} = 10\ \Omega$ $\quad R = 10\ \Omega$

$X_{C_2} = \frac{1}{\omega C_2} = 8\ \Omega$

$\omega L = 2\ \Omega = X_L$

i) harmonik

$U = 100$

$I_{ef_1} = 0$

NAPOMENA: kod istosmjerne struje
kapaciteti se brišu
induktiviteti se kratko spajaju

ii) harmonik

$U = \sqrt{2}\sin(\omega t)$

$U_{ef} = 1$

$\underline{Z} = 10 - \frac{22}{3}j$

$I_{ef_2} = \frac{U_{ef}}{Z} = 0{,}08064\ A$

iii) harmonik

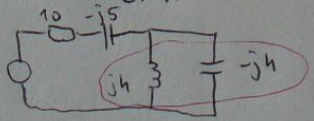
$U = 2\sqrt{2}\sin(2\omega t)$ → PAZI!!! TREBA IZRAČUNATI REAKTANCIJE

$X'_{C_1} = \frac{1}{2\omega C_1} \Rightarrow \frac{1}{2}\frac{1}{\omega C_1} = X'_{C_1} \Rightarrow X'_{C_1} = \frac{1}{2}X_{C_1} = 5\ \Omega$

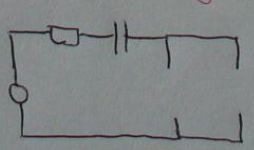
$X'_{C_2} = \frac{1}{2}\frac{1}{\omega C_2} = \frac{1}{2}X_{C_2} = 4\ \Omega$

$X'_L = 2\omega L = 2X_L = 4\ \Omega$

NOVA SHEMA



PARALELNA REZONANCIJA



NEMA ZATVORENOG STRUJNOG KRUGA

$I_{ef_3} = 0$

$I_{ef_{uk}} = I_{ef_1} + I_{ef_2} + I_{ef_3}$

$I_{ef} = 0 + 0{,}08064 + 0$

$I_{ef} = 0{,}08064\ A$