STUDIJSKI PROGRAM MEHATRONIKA		
K TET Katedra za teorijsku elektrotehniku www.ktet.ftn.uns.ac.rs	Osnovi elektrotehnike 2 (I kolokvijum)	K1 28.08.2017.

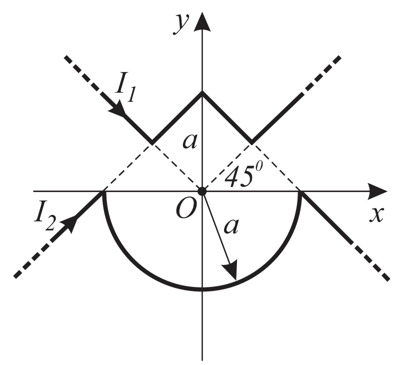
ZADACI

Zadatak 1. Dva veoma dugačka žičana provodnika sa vremenski konstantnim strujama jačine I_1 i I_2, savijena su kao što je prikazano na slici 1. Provodnici se nalaze u x-y ravni Dekartovog pravouglog koordinatnog sistema.

a) Odrediti u opštim brojevima izraz za vektor magnetske indukcije u koordinatnom početku koji stvara kontura sa strujom jačine I_1.

b) Odrediti jačinu struje u drugom provodniku, I_2, tako, da ukupan vektor magnetske indukcije u koordinatnom početku bude jednak 0.

Sredina je vazduh.
Brojne vrednosti su: $I_1 = 1$ A, $a = 2$ cm, $\mu_0 = 4\pi\cdot 10^{-7}$H/m.



Slika 1.

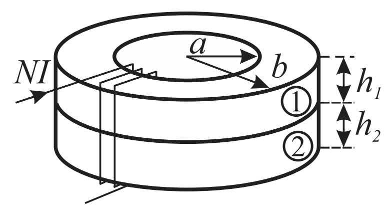
Zadatak 2. Na slici 2 je prikazano debelo torusno jezgro, načinjeno od dva različita materijala i njihove krive prvobitnog magnetisanja. Na jezgro je ravnomerno namotano $N = 180$ zavojaka u kojima se uspostavila struja jačine I. Odrediti:

a) jačinu struje, I, pri kojoj će jedna četvrtina dela jezgra načinjenog od materijala 2 biti u linearnom režimu,

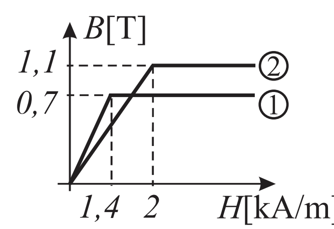
b) režim rada u materijalu 1 pri struji određenoj pod a),

c) fluks vektora magnetske indukcije kroz poprečni presek jezgra, pri struji određenoj pod a),

d) energiju utrošenu na uspostavljanje magnetskog polja u jezgru, pri izračunatoj jačini struje.



Slika 2a.



Slika 2b.

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.

STUDIJSKI PROGRAM MEHATRONIKA

K TET Katedra za teorijsku elektrotehniku www.ktet.ftn.uns.ac.rs	# Osnovi elektrotehnike 2 (II kolokvijum)	**K2** **28.08.2017.**

ZADACI

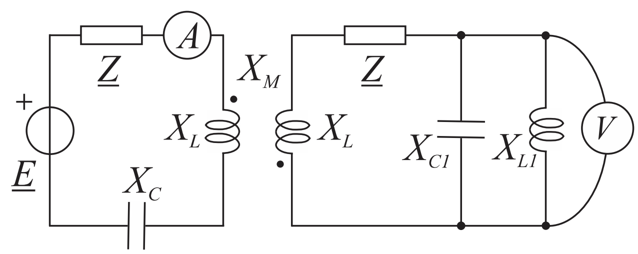
Zadatak 1. U mreži prostoperiodične struje prikazanoj na slici 1, odrediti:

a) Pokazivanje idealnog ampermetra i voltmetra.

b) Aktivnu snagu kondenzatora X_{C1} i reaktivnu snagu kalema X_{L1}.

c) Trenutnu vrednost jačine struje $i_{C1}(t)$ koja teče u grani sa kalemom X_{C1}.

Brojni podaci su: $\underline{E}$ = j10 V, ω=1000π rad/s,
$X_L = X_C = 4\ \Omega$, $X_{L1} = X_{C1} = 1\ \Omega$, $X_M = 2\ \Omega$,
$\underline{Z} = (5+j5)\ \Omega$.



Slika 1.

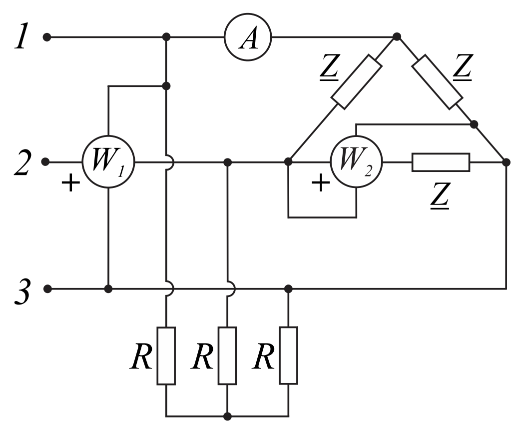
Zadatak 2. Dva trofazna prijemnika, jedan otpornosti $R = 10\ \Omega$, a drugi impedanse $\underline{Z} = (30\text{-}j30)\ \Omega$, priključena su na simetričnu trofaznu mrežu faznog napona prve faze $\underline{U}_1 = 230$ V, kao što je prikazano na slici 2. Odrediti:

a) Pokazivanje idealnog vatmetra W_1. Na fazorskom dijagramu nacrtati fazore veličina od kojih zavisi pokazivanje vatmetra.

b) Pokazivanje idealnog vatmetra W_2. Na fazorskom dijagramu nacrtati fazore veličina od kojih zavisi pokazivanje vatmetra.

c) Pokazivanje idealnog ampermetra.

d) Snagu Džulovih gubitaka trofaznog prijemnika koji se sastoji od otpornika.



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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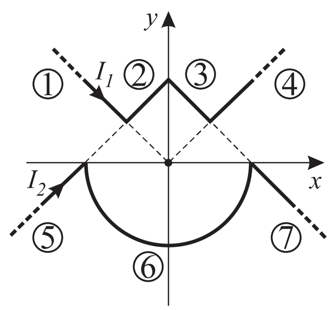
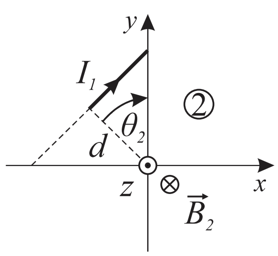
K1 Z1

a)



$$\vec{B}_1 = \vec{B}_4 = 0 \quad \rightarrow \quad \vec{dl} \times \vec{r}_0 = 0$$



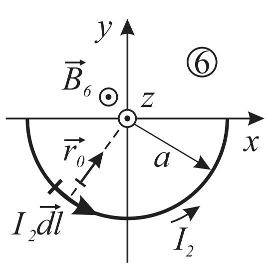
$$\theta_1 = 0, \qquad \theta_2 = \frac{\pi}{4}, \qquad d = \frac{a\sqrt{2}}{2}$$

$$B_2 = \frac{\mu_0 I_1}{4\pi d}\left(\sin\theta_2 - \sin\theta_1\right) = \frac{\mu_0 I_1}{4\pi \frac{a\sqrt{2}}{2}}\left(\frac{\sqrt{2}}{2} - 0\right)$$

$$\boxed{B_2 = \frac{\mu_0 I_1}{4\pi a}}$$

$$\boxed{\vec{B}_2 = \vec{B}_3 = \frac{\mu_0 I_1}{4\pi a}\cdot\left(-\vec{i}_z\right)}$$

b)

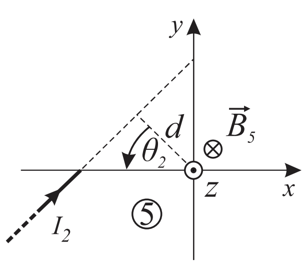


$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\vec{dl}\times\vec{r}_0}{r^2}$$

$$dB_6 = \frac{\mu_0}{4\pi}\frac{I_2 dl}{a^2}$$

$$B_6 = \frac{\mu_0 I_2}{4\pi a^2}\int_0^{a\pi} dl = \frac{\mu_0 I_2}{4\cancel{\pi} a^{\cancel{2}}}\cdot \cancel{a}\,\cancel{\pi}$$

$$\boxed{B_6 = \frac{\mu_0 I_2}{4a}} \qquad \boxed{\vec{B}_6 = \frac{\mu_0 I_2}{4a}\cdot(\vec{i}_z)}$$



$$\theta_1 = -\frac{\pi}{2}, \qquad \theta_2 = -\frac{\pi}{4}, \qquad d = \frac{a\sqrt{2}}{2}$$

$$B_5 = \frac{\mu_0 I_2}{4\pi d}\left(-\sin\frac{\pi}{4} - \left(-\sin\frac{\pi}{2}\right)\right) = \frac{\mu_0 I_2}{4\pi d}\left(1 - \frac{\sqrt{2}}{2}\right)$$

$$\boxed{B_5 = \frac{\mu_0 I_2\sqrt{2}}{4\pi a}\left(1 - \frac{\sqrt{2}}{2}\right)}$$

$$\boxed{\vec{B}_5 = \vec{B}_7 = \frac{\mu_0 I_2\sqrt{2}}{4\pi a}\left(1 - \frac{\sqrt{2}}{2}\right)\cdot\left(-\vec{i}_z\right)}$$

c)

$$\vec{B}_0=\sum_{i=1}^{7}\vec{B}_i=\left(0-B_2-B_3+0-B_5+B_6-B_7\right)\cdot\left(\vec{i}_z\right)$$

Po uslovu zadatka:

$$-B_2-B_3-B_5+B_6-B_7=0$$

$$B_6=B_2+B_3+B_5+B_7=2B_2+2B_5$$

$$\frac{\cancel{\mu_0}\,I_2}{\cancel{4}\,\cancel{a}}=2\frac{\cancel{\mu_0}\,I_1}{\cancel{4}\pi\cancel{a}}+2\frac{\cancel{\mu_0}\,I_2\sqrt{2}}{\cancel{4}\pi\cancel{a}}\left(1-\frac{\sqrt{2}}{2}\right)$$

$$I_2=\frac{2I_1}{\pi}+\frac{2I_2\sqrt{2}}{\pi}\left(1-\frac{\sqrt{2}}{2}\right)$$

$$I_2\left(1-\frac{2\sqrt{2}}{\pi}\left(1-\frac{\sqrt{2}}{2}\right)\right)=\frac{2I_1}{\pi}$$

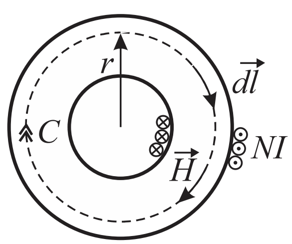
$$I_2\left(1-\frac{2\sqrt{2}}{\pi}+\frac{2}{\pi}\right)=\frac{2I_1}{\pi}\quad /\cdot\pi$$

$$I_2\left(\pi-2\sqrt{2}+2\right)=2I_1$$

$$I_2=\frac{2I_1}{\pi-2\sqrt{2}+2}=\boxed{0,865A}$$

K1 Z2

a)



Granični uslov: $H_{1t}=H_{2t}=H$

$$\oint_c \vec{H}\cdot\vec{dl}=NI$$

$$H\cdot 2r\pi=NI$$

$$H=\frac{NI}{2r\pi},\qquad a<r<b$$

$$H(r_c)=\frac{NI}{2r_c\pi}=H_{c2}$$

$$r_c=a+\frac{3}{4}(b-a)=3cm+\frac{3}{4}(5cm-3cm)=4,5cm$$

$$I=\frac{2r_c\pi H_{c2}}{N}=\frac{2\cdot 4,5\cdot 10^{-2}\cdot\pi\cdot 2\cdot 10^{3}}{180}=\boxed{3,14A}$$

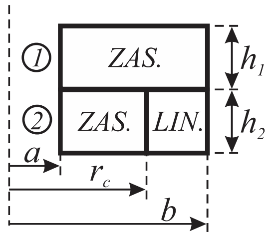
b)

$$H_1(a)=\frac{NI}{2a\pi}=3000\,{}^{A}\!/_{m}>H_{c1}$$

$$H_1(\mathrm{b})=\frac{NI}{2b\pi}=1800\,{}^{A}\!/_{m}>H_{c1}$$

Materijal 1 je u zasićenju.

c)



$$\Phi = \Phi_1 + \Phi_2 = \Phi_{1Z} + \Phi_{2Z} + \Phi_{2L}$$

$$\Phi = B_{c1}(b-a)h_1 + B_{c2}(r_c - a)h_2 + \int_{r_c}^{b} \mu_2 \frac{NI}{2\pi r} dr \cdot h_2$$

$$\Phi = B_{c1}(b-a)h_1 + B_{c2}(r_c - a)h_2 + \frac{1,1}{2000}\frac{NI}{2\pi} h_2 \ln\frac{b}{r_c}$$

$$\Phi = 280\mu Wb + 330\mu Wb + 104,3\mu Wb = \boxed{714,3\mu Wb}$$

d)

$$W_m = W_{m1} + W_{m2} = W_{m1Z} + W_{m2Z} + W_{m2L}$$

$$W_m = \frac{1}{2}B_{c1}H_{c1}(b^2 - a^2)\pi h_1 + \frac{1}{2}B_{c2}H_{c2}(r_c^{\,2} - a^2)\pi h_2 + \int_{r_c}^{b} \frac{1}{2}\mu_2 \left(\frac{NI}{2\pi r}\right)^2 2r\pi \cdot dr \cdot h_2$$

$$W_m = \frac{1}{2}B_{c1}H_{c1}(b^2 - a^2)\pi h_1 + \frac{1}{2}B_{c2}H_{c2}(r_c^{\,2} - a^2)\pi h_2 + \frac{1}{2}\cdot\frac{1,1}{2000}\frac{(NI)^2}{2\pi} h_2 \ln\frac{b}{r_c}$$

$$W_m = 49,2mJ + 77,75mJ + 29,49mJ = \boxed{156,44mJ}$$

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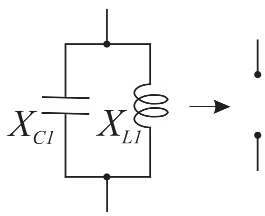
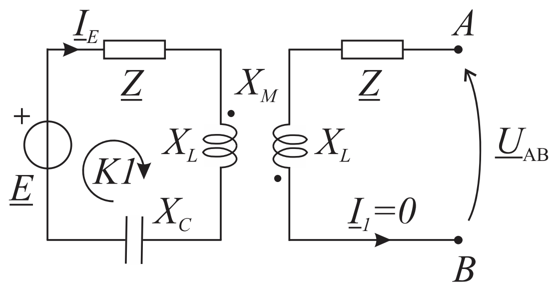
K2 Z1

a)





$$K1:\quad -\underline{E}+\underline{Z}\,\underline{I}_E+\left(jX_L\,\underline{I}_E-\underbrace{jX_M\,\underline{I}_1}_{0}\right)-jX_C\,\underline{I}_E=0$$

$$-j10+(5+j5)\underline{I}_E+\cancel{j4\underline{I}_E}-\cancel{j4\underline{I}_E}=0$$

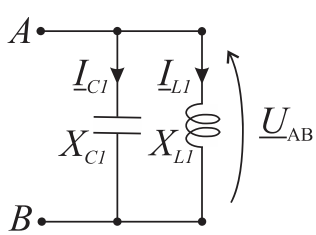
$$\underline{I}_E=\frac{j10}{5+j5}=\frac{j2}{1+j}\cdot\frac{1-j}{1-j}=\frac{j\cancel{2}(1-j)}{\cancel{2}}=(1+j)A=\sqrt{2}e^{j45^0}A$$

$$\boxed{I_A=\sqrt{2}A}$$

$$\underline{U}_{AB}=\underbrace{\underline{Z}\,\underline{I}_1}_{0}+\left(\underbrace{jX_L\,\underline{I}_1}_{0}-jX_M\,\underline{I}_E\right)=-j2(1+j)=2(1-j)=2\sqrt{2}e^{-j45^0}V$$

$$\boxed{U_V=2\sqrt{2}V}$$

b)



$$\boxed{P_{C1}=0\,W}$$

$$\underline{I}_{L1}=\frac{\underline{U}_{AB}}{jX_{L1}}=\frac{2\sqrt{2}e^{-j45^0}}{e^{j90^0}}=2\sqrt{2}e^{-j135^0}A$$

$$\underline{S}_{L1}=\underline{U}_{AB}\cdot\underline{I}_{L1}^{\,*}=2\sqrt{2}e^{-j45^0}\cdot2\sqrt{2}e^{-j135^0}=8e^{j90^0}=j8VA$$

$$\boxed{Q_{L1}=8VAr}$$

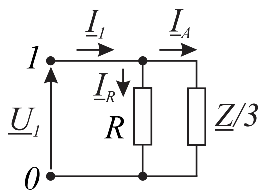
c)

$$\underline{I}_{C1}=-\underline{I}_{L1}=-2\sqrt{2}e^{-j135^0}=2\sqrt{2}e^{-j135^0}e^{j180^0}=2\sqrt{2}e^{j45^0}A$$

$$\boxed{i_{C1}(t)=4\cos(1000\pi\,t+45^0)A}$$

K2 Z2

a)

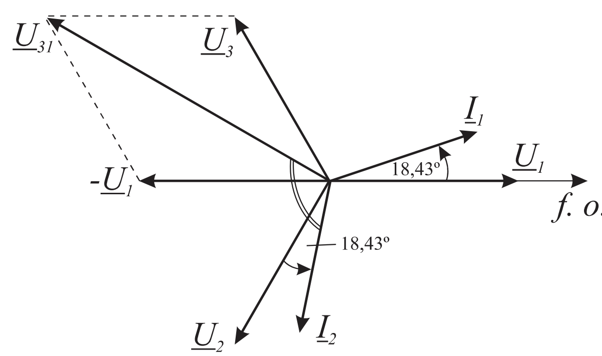


$$\underline{Z}_e = R \parallel \frac{\underline{Z}}{3} = \frac{10(10-j10)}{20-j10}\cdot\frac{2+j}{2+j} = \frac{30-j10}{5} = 6-2j = 2\sqrt{10}e^{-j18,43^0}\,\Omega$$

$$\underline{I}_1 = \frac{\underline{U}_1}{\underline{Z}_e} = \frac{230}{2\sqrt{10}e^{-j18,43^0}} = 36,37\,e^{j18,43^0}\ A$$

$$P_{W1} = \mathrm{Re}\left\{\underline{U}_{31}\,\underline{I}_2^{\,*}\right\} = U_{31}\,I_2\cos\sphericalangle\left(\underline{U}_{31},\underline{I}_2\right) = \sqrt{3}U_1\,I_1\cos\left(90^0+18,43^0\right) = \sqrt{3}\cdot 230\cdot 36,37\cdot\cos 108,43^0$$

$$\boxed{P_{W1} = -4580,6\,W}$$



b)

$$\underline{I}_{23} = \frac{\underline{U}_{23}}{\underline{Z}} = \frac{\sqrt{3}\cdot 230e^{-j90^0}}{30\sqrt{2}e^{-j45^0}} = 9,4\,e^{-j45^0}\ A$$

$$P_{W2} = \mathrm{Re}\left\{\underline{U}_{23}\,\underline{I}_{23}^{\,*}\right\} = U_{23}\,I_{23}\cos\sphericalangle\left(\underline{U}_{23},\underline{I}_{23}\right)$$

$$P_{W2} = \sqrt{3}\cdot 230\cdot 9,4\cdot\cos\left(90^0-45^0\right)$$

$$\boxed{P_{W2} = 2647,9\,W}$$

c)

$$I_A = \frac{U_1}{\frac{Z}{3}} = 16,28A = I_{23}\cdot\sqrt{3}$$

d)

$$P_R = R\cdot I_R^{\,2} = R\cdot\left(\frac{U_1}{R}\right)^2 = 5290W$$

$$P_{uk} = 3\cdot P_R = \boxed{15870W}$$