STUDIJSKI PROGRAM ENERGETIKA, ELEKTRONIKA I TELEKOMUNIKACIJE

K TET Katedra za teorijsku elektrotehniku www.ktet.ftn.uns.ac.rs	Osnovi elektrotehnike 2 (I kolokvijum)	**K1** **30.09.2018.**

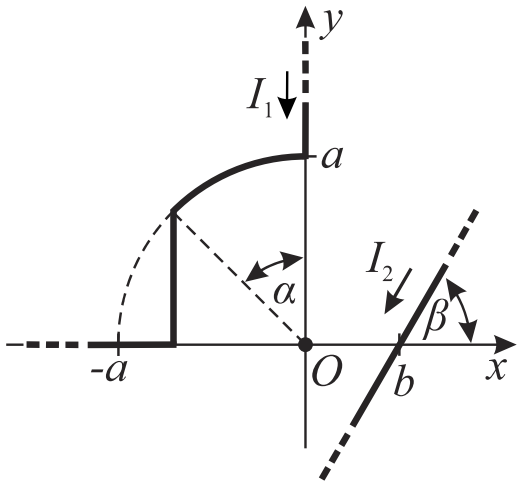
ZADACI

Zadatak 1. Veoma dugačka žičana kontura sa vremenski konstantnom strujom jačine I_1, savijena je kao što je prikazano na slici 1. Kontura se nalazi u x-y ravni Dekartovog pravouglog koordinatnog sistema i sastoji se od tri pravolinijska segmenta i jednog lučnog segmenta, poluprečnika a. Sredina je vazduh.

a) Odrediti, u opštim brojevima, izraz za vektor magnetske indukcije koji stvara kontura sa strujom jačine I_1 u tački O (koordinatni početak).

b) Odrediti ugao β koji beskonačno dugačak žičani provodnik, sa vremenski konstantnom strujom I_2, zaklapa sa x osom, tako da ukupni vektor magnetske indukcije u tački O bude jednak nuli.

Brojne vrednosti su: $I_1 = 2{,}5 \cdot I_2$, $a = 1\ cm$, $b = a/2$, $\alpha = 45°$, $\mu_0 = 4\pi \cdot 10^{-7} H/m$.



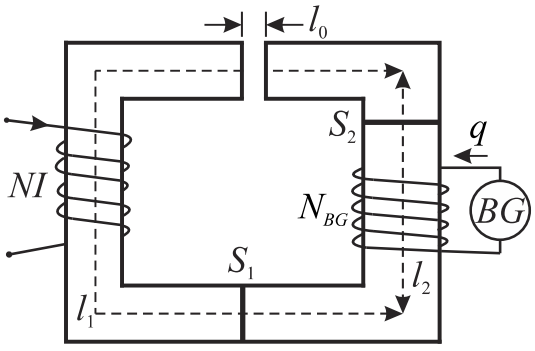
Slika 1.

Zadatak 2. Na slici 2a je prikazano tanko magnetsko kolo, načinjeno od feromagnetskog materijala čija je idealizovana magnetska karakteristika data na slici 2b. Na jezgro je ravnomerno i gusto namotan pobudni namotaj sa $N = 150$ zavojaka u kojima je uspostavljena struja jačine I. Odrediti:

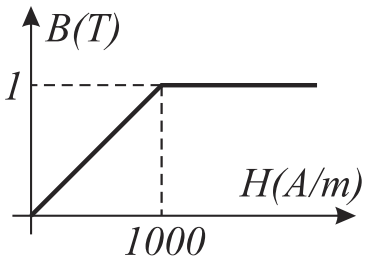
a) Jačinu struje, I, tako da intenzitet vektora magnetske indukcije u procepu magnetskog kola ima vrednost $B_0 = 0{,}81\ T$. Rasipanja zanemariti.

b) Proteklu količinu naelektrisanja q, u naznačenom referentnom smeru, kroz namotaj balističkog galvanometra otpornosti $R_{BG} = 20\ \Omega$, sa $N_{BG} = 5$ zavojaka, kada se intenzitet struje smanji dva puta u odnosu na prvobitnu vrednost određenu pod a), $I_1 = I/2$.

Dimenzije jezgra su: $l_1 = 105\ mm$, $l_2 = 30\ mm$, $l_0 = 1\ mm$, $S_1 = 1\ cm^2$, $S_2 = 1{,}5\ cm^2$.



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 ENERGETIKA, ELEKTRONIKA I TELEKOMUNIKACIJE

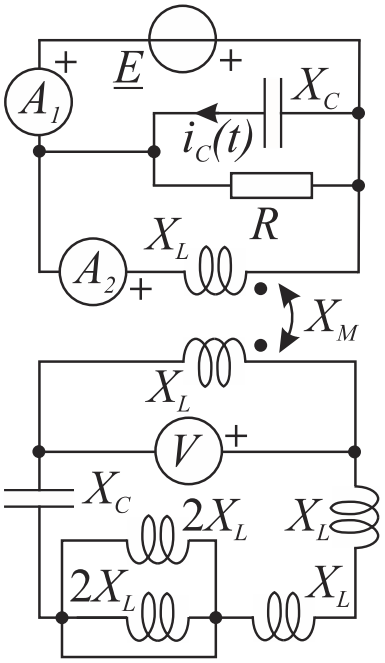
K TET Katedra za teorijsku elektrotehniku www.ktet.ftn.uns.ac.rs	Osnovi elektrotehnike 2 (II kolokvijum)	**K2** **30.09.2018.**

ZADACI

Zadatak 1. U mreži prostoperiodičnih struja, prikazanoj na slici 1, odrediti:

a) pokazivanja idealnih mernih instrumenata,
b) aktivnu snagu koja se razvija na naponskom generatoru *ems* $\underline{E}$, i
c) napisati izraz za trenutnu vrednost jačine struje u grani sa kondenzatorom, $i_C(t)$.

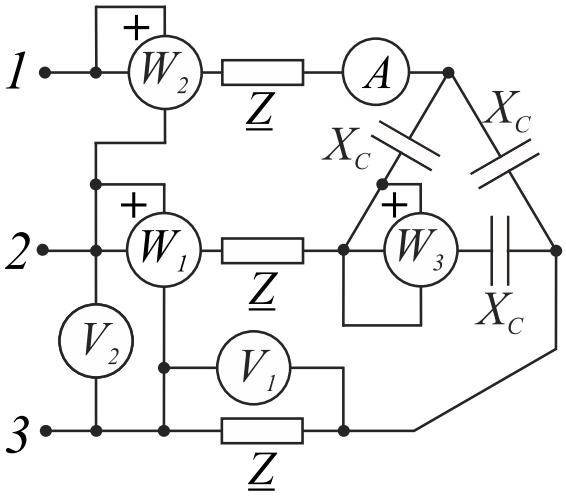
Brojni podaci su: $\underline{E} = j10\ V$, $R = X_L = X_C = 2{,}5 \cdot X_M = 10\ \Omega$, $\omega = 1000\ rad/s$.



Slika 1.

Zadatak 2. Trofazni prijemnik reaktanse $X_C = 30\ \Omega$, priključen je na simetričnu trofaznu mrežu faznog napona prve faze $\underline{U}_1 = 230\ V$, preko trofaznog voda impedanse $\underline{Z} = (5 + j15)\ \Omega$, kao što je prikazano na slici 2. Odrediti:

a) Pokazivanje idealnih mernih instrumenata.
b) Skicirati fazorski dijagram svih veličina od kojih zavisi pokazivanje mernih instrumenata.



Slika 2.

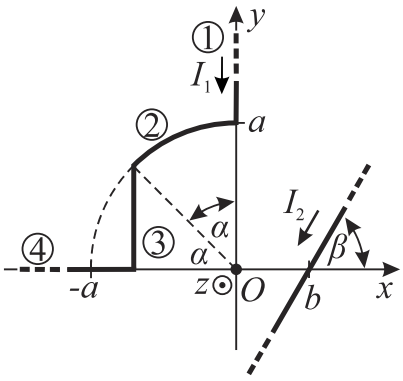
PRAVILA POLAGANJA

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.

Ispit iz OET2, 30.09.2018.

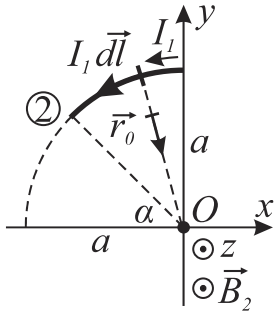
I-1

a)



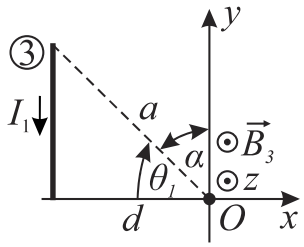
$\boxed{\vec{B}_1 = 0}$ $\boxed{\vec{B}_4 = 0}$ $\sin \sphericalangle\left(\vec{dl}, \vec{r}_0\right) = 0$

$\alpha = 45°$



$$\vec{dB}_2 = \frac{\mu_0}{4\pi}\frac{I_1 \vec{dl} \times \vec{r}_0}{r^2} \qquad dB_2 = \frac{\mu_0}{4\pi}\frac{I_1 dl}{a^2} \qquad \sphericalangle\left(\vec{dl}, \vec{r}_0\right) = \frac{\pi}{2}$$

$$B_2 = \int dB_2 = \frac{\mu_0 I_1}{4\pi a^2}\int_0^{\frac{1}{8}2a\pi} dl = \frac{\mu_0 I_1}{4\pi a^2}\frac{1}{4}a\pi = \frac{\mu_0 I_1}{16a} \qquad \boxed{\vec{B}_2 = \frac{\mu_0 I_1}{16a}\cdot\vec{i}_z}$$



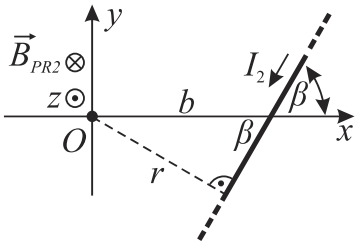
3 $\qquad d = a\sin\alpha = \frac{a\sqrt{2}}{2}, \qquad \theta_1 = -45°, \qquad \theta_2 = 0°$

$$B_3 = \frac{\mu_0 I_1}{4\pi d}\left(\sin\theta_2 - \sin\theta_1\right) = \frac{\mu_0 I_1}{4\pi\frac{a\sqrt{2}}{2}}\left[0 - \left(-\frac{\sqrt{2}}{2}\right)\right] = \frac{\mu_0 I_1}{4\pi\frac{a\sqrt{2}}{2}}\frac{\sqrt{2}}{2} = \frac{\mu_0 I_1}{4\pi a}$$

$$\boxed{\vec{B}_3 = \frac{\mu_0 I_1}{4\pi a}\cdot\vec{i}_z}$$

$$\boxed{\vec{B}_{PR1} = \vec{B}_1 + \vec{B}_2 + \vec{B}_3 + \vec{B}_4 = \left(\frac{\mu_0 I_1}{16a} + \frac{\mu_0 I_1}{4\pi a}\right)\cdot\vec{i}_z}$$

b)



$$r = b\sin\beta = \frac{a}{2}\sin\beta$$

$$B_{PR2} = \frac{\mu_0 I_2}{2\pi r} = \frac{\mu_0 I_2}{2\pi\frac{a}{2}\sin\beta} = \frac{\mu_0 I_2}{\pi a\sin\beta} \qquad \boxed{\vec{B}_{PR2} = \frac{\mu_0 I_2}{\pi a\sin\beta}\cdot\left(-\vec{i}_z\right)}$$

$$\vec{B}_{Ouk} = \vec{B}_{PR1} + \vec{B}_{PR2} = \left(\frac{\mu_0 I_1}{16a} + \frac{\mu_0 I_1}{4\pi a}\right)\cdot\vec{i}_z + \frac{\mu_0 I_2}{\pi a\sin\beta}\cdot\left(-\vec{i}_z\right) = 0$$

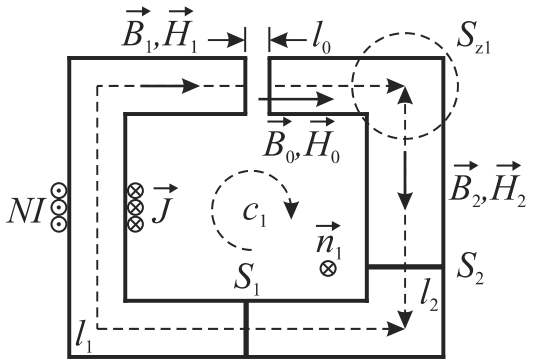
$$\frac{\mu_0 I_1}{16a} + \frac{\mu_0 I_1}{4\pi a} = \frac{\mu_0 I_2}{\pi a\sin\beta}$$

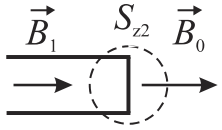
$$\sin\beta = \frac{I_2}{I_1\left(\frac{1}{16} + \frac{1}{4\pi}\right)\pi} = \frac{I_2}{2{,}5 I_2\left(\frac{\pi}{16} + \frac{1}{4}\right)} = \frac{1}{2{,}5\cdot\left(\frac{\pi}{16} + \frac{1}{4}\right)} = 0{,}896$$

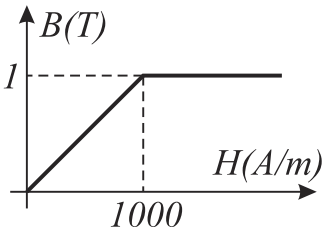
$$\boxed{\beta = 63{,}7°}$$

Ispit iz OET2, 30.09.2018.

I-2







a)

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

c_1: $\quad H_1 l_1 + H_0 l_0 + H_2 l_2 = NI \qquad (1)$

$$\oint_{S_Z} \vec{B}\cdot\vec{ds} = 0$$

S_{z1}: $\quad -B_1 S_1 + B_0 S_0 = 0 \qquad (2)$

S_{z2}: $\quad -B_1 S_1 + B_2 S_2 = 0 \qquad (3)$

$$B_0 = 0{,}81\,T \quad \Rightarrow \quad H_0 = \frac{B_0}{\mu_0} = \frac{0{,}81}{4\pi\cdot 10^{-7}} = 644{,}9\ kA/m$$

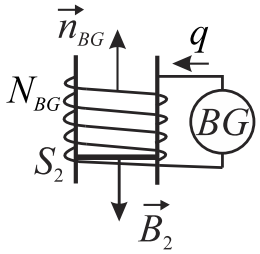
Iz (2) sledi: $B_1 = B_0 = 0{,}81\,T \quad \Rightarrow \quad H_1 = \frac{B_1}{\mu} = \frac{0{,}81}{\frac{1}{1000}} = 810\ A/m$

Iz (3) sledi: $B_2 = B_1\frac{S_1}{S_2} = 0{,}81\cdot\frac{1\cdot 10^{-4}}{1{,}5\cdot 10^{-4}} = 0{,}54\,T \quad \Rightarrow \quad H_2 = \frac{B_2}{\mu} = \frac{0{,}54}{\frac{1}{1000}} = 540\ A/m$

Iz (1) sledi: $I = \frac{H_1 l_1 + H_0 l_0 + H_2 l_2}{N} = \frac{810\cdot 0{,}105 + 644{,}9\cdot 10^3\cdot 1\cdot 10^{-3} + 540\cdot 0{,}03}{150}$

$\boxed{I = 4{,}97\ A}$

b)



$I_{KR} = I_1 = I/2 = 2{,}49\ A$

Kolo ostaje u linernom režimu rada. $\quad \Rightarrow \quad B_{KR2} = \frac{B_{POČ2}}{2} = 0{,}27\,T$

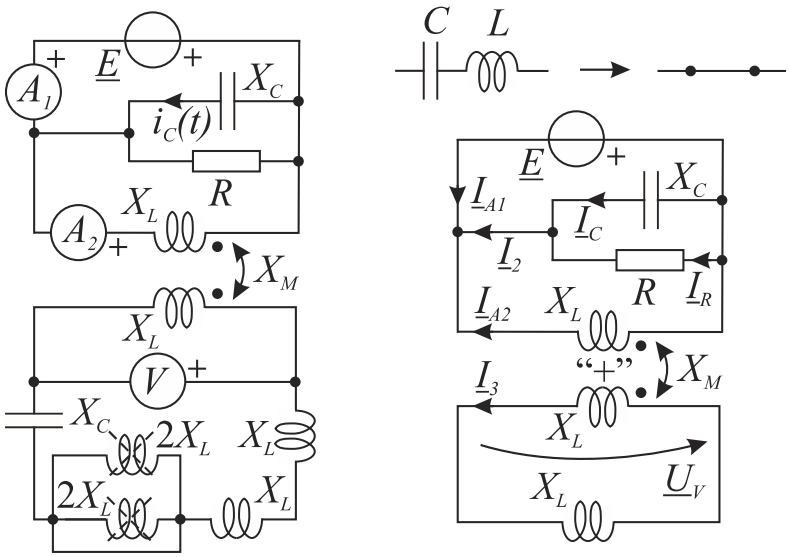
$$\Phi_2 = \int_{S_2}\vec{B}_2\cdot\vec{dS} = -\int_{S_2} B_2\,dS = -B_2\,S_2 \qquad \sphericalangle\left(\vec{B}_2,\vec{n}_{BG}\right) = 180°$$

$$q = -\frac{N_{BG}}{R_{BG}}\left(\Phi_{KR2} - \Phi_{POČ2}\right) = -\frac{N_{BG}}{R_{BG}}\left(-B_{KR2}\,S_2 - \left(-B_{POČ2}\,S_2\right)\right) = \frac{N_{BG}}{R_{BG}}\left(B_{KR2} - B_{POČ2}\right)S_2$$

$\boxed{q = -10{,}13\,\mu C}$

Ispit iz OET2, 30.09.2018.

II-1



a)

$$\underline{I}_C = \frac{\underline{E}}{-jX_C} = \frac{j10}{-j10} = -1\ A = 1\,e^{j180^\circ}\ A \qquad \underline{I}_R = \frac{\underline{E}}{R} = \frac{j10}{10} = j1\ A = 1\,e^{j90^\circ}\ A$$

$$\underline{I}_2 = \underline{I}_C + \underline{I}_R = (-1 + j1)\ A = \sqrt{2}\ e^{j135^\circ}\ A$$

(1) $\underline{E} = jX_L\,\underline{I}_{A2} + jX_M\,\underline{I}_3$

(2) $jX_L\,\underline{I}_3 + jX_L\,\underline{I}_3 + jX_M\,\underline{I}_{A2} = 0 \quad \Rightarrow \quad \underline{I}_3 = -\frac{jX_M}{2jX_L}\underline{I}_{A2} = -\frac{j4}{2\cdot j10}\underline{I}_{A2} = -\frac{1}{5}\underline{I}_{A2}$

(1) $\underline{E} = jX_L\,\underline{I}_{A2} + jX_M\left(-\frac{1}{5}\underline{I}_{A2}\right)$

$$\underline{I}_{A2} = -\frac{\underline{E}}{jX_L - \frac{jX_L}{5}} = \frac{j10}{j10 - j\frac{4}{5}} = \frac{j10}{j9,2} = 1,09\ A = 1,09\,e^{j0^\circ}\ A \qquad \boxed{I_{A2} = |\underline{I}_{A2}| = 1,09\ A}$$

$$\underline{I}_{A1} = -\underline{I}_{A2} - \underline{I}_2 = -1,09 - (-1 + j1) = (-0,09 - j1)\ A = 1,004\,e^{-j95,14^\circ}\ A \qquad \boxed{I_{A1} = |\underline{I}_{A1}| = 1,004\ A}$$

$$\underline{U}_V = -jX_L\,\underline{I}_3 = -jX_L\left(-\frac{1}{5}\underline{I}_{A2}\right) = \frac{jX_L}{5}\underline{I}_{A2} = \frac{j10}{5}\cdot 1,09 = j2,18\ V = 2,18\,e^{j90^\circ}\ V \qquad \boxed{U_V = |\underline{U}_V| = 2,18\ V}$$

b)

$$\underline{S}_E = -\underline{E}\,\underline{I}_{A1}^{\,*} = -j10\cdot(-0,09 + j1) = (10 + j0,9)\ VA$$

$$P_E = \mathrm{Re}\{\underline{S}_E\} \quad \Rightarrow \quad \boxed{P_E = 10\ W}$$

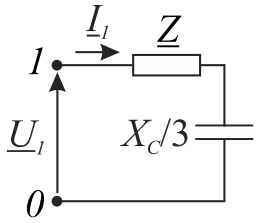
c)

$$\underline{I}_C = 1\,e^{j180^\circ}\ A \qquad \boxed{i_C(t) = \sqrt{2}\cos(1000t + 180^\circ)\ A}$$

Ispit iz OET2, 30.09.2018.

II-2

a)



$$\underline{Z}_e = \underline{Z} + \left(-j\frac{X_C}{3}\right) = 5 + j15 - j10 = (5 + j5)\,\Omega = 5\sqrt{2}\,e^{j45^\circ}\ \Omega$$

$$\underline{I}_1 = \frac{\underline{U}_1}{\underline{Z}_e} = \frac{230\,e^{j0^\circ}}{5\sqrt{2}\,e^{j45^\circ}} = 32{,}53\,e^{-j45^\circ}\ A$$

$$\boxed{I_A = |\underline{I}_1| = 32{,}53\ A}$$

$$U_{V1} = |\underline{Z}|\,|\underline{I}_3| = \sqrt{5^2 + 15^2}\cdot 32{,}53 \qquad \boxed{U_{V1} = 514{,}34\ V}$$

$$U_{V2} = |\underline{U}_{23}| = \sqrt{3}\,|\underline{U}_1| = \sqrt{3}\cdot 230 \qquad \boxed{U_{V2} = 398{,}37\ V}$$

$$P_{W1} = \mathrm{Re}\left\{\underline{U}_{23}\,\underline{I}_2^{\,*}\right\} = U_{23}\,I_2\cos\sphericalangle(\underline{U}_{23}, \underline{I}_2) = \sqrt{3}\,U_1\,I_1\cos(45^\circ + 30^\circ) = \sqrt{3}\cdot 230\cdot 32{,}53\cdot\cos 75^\circ$$

$$\boxed{P_{W1} = 3354{,}04\ W}$$

$$P_{W2} = \mathrm{Re}\left\{\underline{U}_{12}\,\underline{I}_1^{\,*}\right\} = U_{12}\,I_1\cos\sphericalangle(\underline{U}_{12}, \underline{I}_1) = \sqrt{3}\,U_1\,I_1\cos(45^\circ + 30^\circ) = \sqrt{3}\cdot 230\cdot 32{,}53\cdot\cos 75^\circ$$

$$\boxed{P_{W2} = 3354{,}04\ W}$$

$$\underline{U}_{W3} = 0\ V \quad \Rightarrow \quad \boxed{P_{W3} = 0\ W}$$

b)

