STUDIJSKI PROGRAM MERENJE I REGULACIJA		
K TET Katedra za teorijsku elektrotehniku www.ktet.ftn.uns.ac.rs	Osnovi elektrotehnike 2 (I kolokvijum)	**K1** **14.09.2019.**

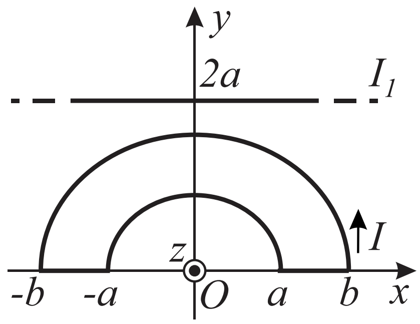
ZADACI

Zadatak 1. Tanak žičani provodnik, sa vremenski konstantnom strujom jačine I, savijen je tako da oblikuje konturu, prikazanu na slici 1. Provodnik se sastoji od dva pravolinijska i dva lučna segmenta, pri čemu cela kontura leži u x-y ravni Dekartovog pravouglog koordinatnog sistema. Paralelno sa x osom, na rastojanju $2a$ postavljen je veoma dugačak provodnik, sa strujom nepoznatog intenziteta I_1. Sredina je vazduh.

a) Odrediti intenzitet vektora magnetske indukcije u koordinatnom početku, u tački O, koji potiče od žičane konture.

b) Odrediti intenzitet i smer struje I_1, tako, da ukupan vektor magnetske indukcije u koordinatnom početku bude jednak nuli.

Brojne vrednosti: $I = 2$ A, $a = 3$ cm, $b = 4$ cm, $\mu_0 = 4\pi\cdot10^{-7}$ H/m.



Slika 1.

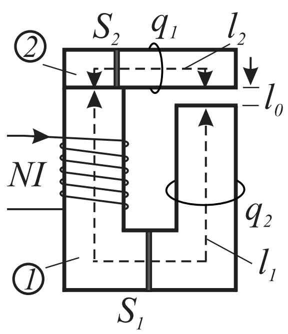
Zadatak 2. Na slici 2a je prikazano tanko magnetsko kolo načinjeno od dva različita materijala. Idealizovane krive prvobitnog magnetisanja oba materijala date su na slici 2b. Ako energija sadržana u procepu iznosi W_{m0}= 18,33 mJ, odrediti

a) Vrednost magnetske indukcije u procepu.

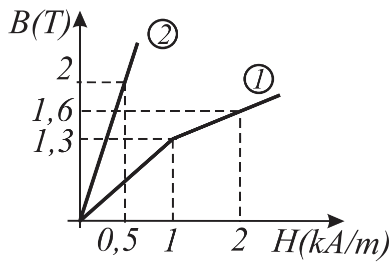
b) Broj amperzavojaka potrebnih da se postigne željena energija u procepu.

c) Smer i količinu naelektrisanja, q_1 i q_2, kroz probne zavojke otpornosti R_Z = 20 Ω, prilikom uspostavljanja polja.

Brojni podaci: S_1 =2 cm², S_2 = 1,8 cm², S_0 = 2,5 cm², ℓ_1 = 30 cm, ℓ_2 = 20 cm, ℓ_0 = 0,2 mm, $\mu_0=4\pi\cdot10^{-7}$ H/m.



Slika 2a.



Slika 2b.

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.

STUDIJSKI PROGRAM MERENJE I REGULACIJA

K TET Katedra za teorijsku elektrotehniku www.ktet.ftn.uns.ac.rs	Osnovi elektrotehnike 2 (II kolokvijum)	**K2** **14.09.2019.**

ZADACI

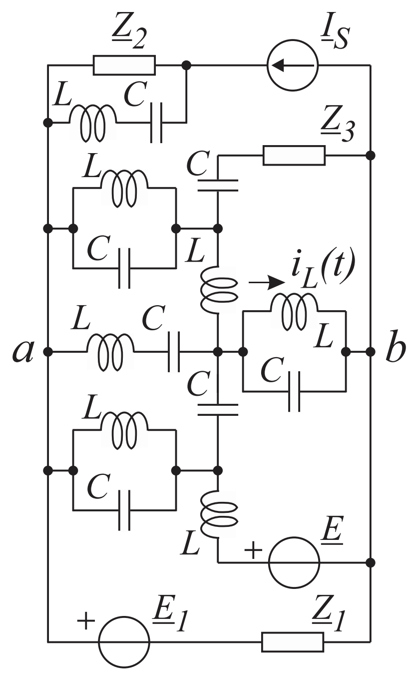
Zadatak 1. U mreži prostoperiodične struje sa slike 1, učestanost generatora ispunjava uslov $\omega^2 LC = 1$. Izračunati:

a) Kompleksne snage svih generatora.

b) Ukupnu snagu Džulovih gubitaka u kolu,

c) Vremenski oblik struje kroz kalem $i_L(t)$.

Brojni podaci su:
$\underline{E}_1 = (50+j20)$ V, $\underline{E} = 100$ V, $\underline{I}_s = 15$ mA, $X_L = 0{,}5$ kΩ, $\underline{Z}_1 = (5-j2)$ kΩ, $\underline{Z}_2 = (2+j2)$ kΩ, $\underline{Z}_3 = (8+j4)$ kΩ.



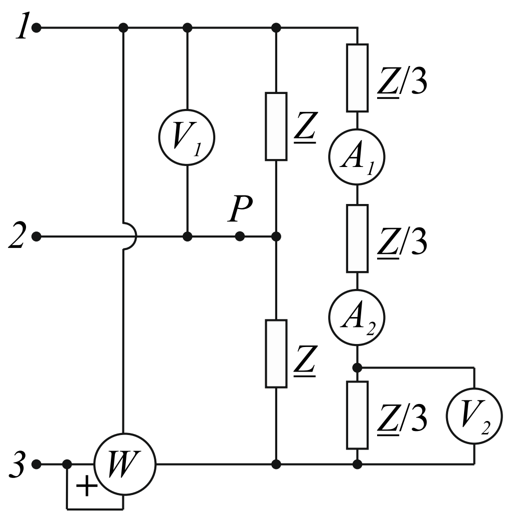
Slika 1.

Zadatak 2. Na slici 2 je prikazan simetričan trofazni prijemnik impedanse $\underline{Z} = (30+j60)$ Ω, priključen na mrežu faznog napona $U_1 = 230$ V. U tački P u jednom momentu dolazi do havarije i prekida voda.

a) Odrediti pokazivanja idealnih mernih instrumenata pre prekida,

b) Odrediti pokazivanja idealnih mernih instrumenata posle prekida,

c) Nacrtati fazorske dijagrame veličina od kojih zavise pokazivanja vatmetra pre i posle prekida.



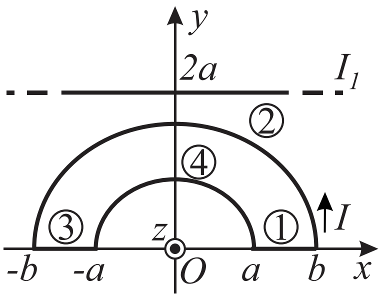
Slika 2.

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.

MiR ISPIT 14.09.2019.

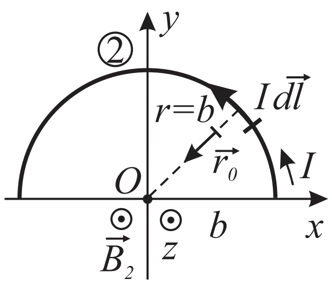
K1 Z1



a)

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

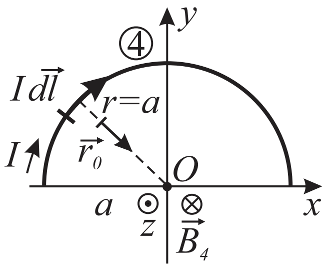
$$\boxed{\vec{B}_3 = 0} \qquad \sin\measuredangle\left(\vec{dl}, \vec{r}_0\right) = 0$$



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

$$B_2 = \int dB_2 = \frac{\mu_0 I}{4\pi b^2}\int_0^{\frac{1}{2}2b\pi} dl = \frac{\mu_0 I}{4\pi b^2} b\pi = \frac{\mu_0 I}{4b}$$

$$\boxed{\vec{B}_2 = \frac{\mu_0 I}{4b}\cdot\vec{i}_z}$$



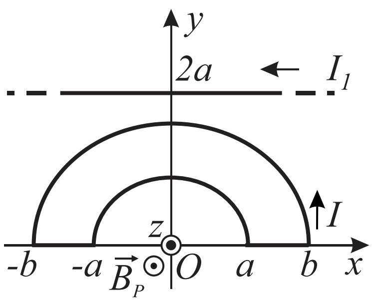
$$\vec{dB}_4 = \frac{\mu_0}{4\pi}\frac{I\,\vec{dl}\times\vec{r}_0}{r^2} \qquad dB_4 = \frac{\mu_0}{4\pi}\frac{I\,dl}{a^2} \qquad \measuredangle\left(\vec{dl}, \vec{r}_0\right) = \frac{\pi}{2}$$

$$B_4 = \int dB_4 = \frac{\mu_0 I}{4\pi a^2}\int_0^{\frac{1}{2}2a\pi} dl = \frac{\mu_0 I}{4\pi a^2} a\pi = \frac{\mu_0 I}{4a}$$

$$\boxed{\vec{B}_4 = \frac{\mu_0 I}{4a}\cdot\left(-\vec{i}_z\right)}$$

$$\boxed{\begin{aligned}&\vec{B}_K = \vec{B}_1 + \vec{B}_2 + \vec{B}_3 + \vec{B}_4 = \left(\frac{\mu_0 I}{4b} - \frac{\mu_0 I}{4a}\right)\cdot\vec{i}_z = \frac{\mu_0 I}{4}\left(\frac{1}{b} - \frac{1}{a}\right)\cdot\vec{i}_z\\ &\vec{B}_K = 0{,}52\ \mu\mathrm{T}\cdot\left(-\vec{i}_z\right)\end{aligned}}$$

b)



$$\left|\vec{B}_P\right| = \frac{\mu_0 I_1}{2\pi(2a)} = \frac{\mu_0 I_1}{4\pi a}$$

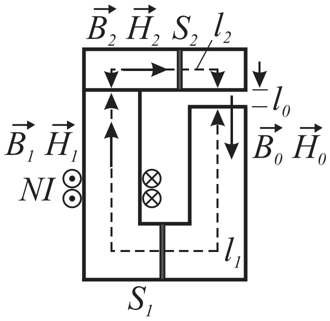
$$\vec{B}_O = \vec{B}_K + \vec{B}_P = 0 \quad \Rightarrow \quad \vec{B}_P = \frac{\mu_0 I_1}{4\pi a}\cdot\vec{i}_z$$

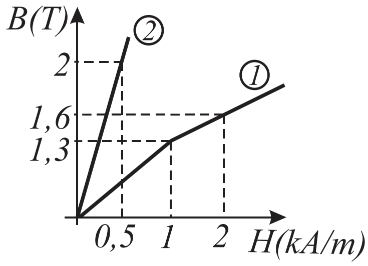
$$\frac{\mu_0 I_1}{4\pi a} = \frac{\mu_0 I}{4}\left(\frac{1}{a} - \frac{1}{b}\right)$$

$$\frac{\cancel{\mu_0} I_1}{\cancel{4}\pi\cancel{a}} = \frac{\cancel{\mu_0} I}{\cancel{4}}\frac{b-a}{\cancel{a}b}$$

$$\boxed{I_1 = \frac{I\cdot\pi(b-a)}{b} = 1{,}57\ \mathrm{A}}$$

K1 Z2





a)

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

$$H_1\, l_1 + H_2\, l_2 + H_0\, l_0 = NI \qquad (1)$$

$$\Phi_1 = \Phi_2 = \Phi_0$$

$$B_1S_1 = B_2S_2 = B_0S_0 \qquad (2)$$

$$W_{m_0} = \frac{1}{2}B_0H_0V_0 = \frac{1}{2}\frac{B_0^2}{\mu_0}l_0S_0 \rightarrow B_0 = \sqrt{\frac{2\mu_0W_{m_0}}{l_0S_0}}$$

$$B_0 = 0{,}98\,\mathrm{T}$$

$$H_0 = \frac{B_0}{\mu_0} = 779{,}86\frac{\mathrm{kA}}{\mathrm{m}}$$

Iz (2) $\quad B_2S_2 = B_0S_0$

$$B_2 = B_0\frac{S_0}{S_2} = 0{,}98\cdot\frac{2{,}5}{1{,}8} = 1{,}36\,\mathrm{T}$$

$$H_2 = \frac{B_2}{\mu_2} = \frac{1{,}36}{\frac{2}{500}} = 340\ \frac{\mathrm{A}}{\mathrm{m}}$$

Iz (2) $\quad B_1S_1 = B_0S_0$

$$B_1 = B_2\frac{S_2}{S_1} = 1{,}36\cdot\frac{1{,}8}{2} = 1{,}22\,\mathrm{T}$$

$$H_1 = \frac{B_1}{\mu_1} = \frac{1{,}22}{\frac{1{,}3}{1000}} = 938{,}46\ \frac{\mathrm{A}}{\mathrm{m}}$$

Iz (1) $\quad NI = 938{,}46\cdot 0{,}3 + 340\cdot 0{,}2 + 779{,}86\cdot 0{,}2$

$$\boxed{NI = 505{,}51\,\mathrm{Azav}}$$

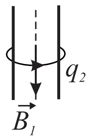
c)

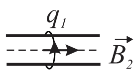
$$q_1 = -\frac{1}{Rz}\left(\Phi^{KR} - \Phi^{0}\right)$$

$$q_1 = -\frac{1}{20}B_2S_2 = -\frac{1}{20}1{,}36\cdot 1{,}8\cdot 10^{-4}$$

$$\boxed{q_1 = 12{,}24\,\mu\mathrm{C}}$$

$\boxed{q_1 = q_2}$ na osnovu uslova (2)





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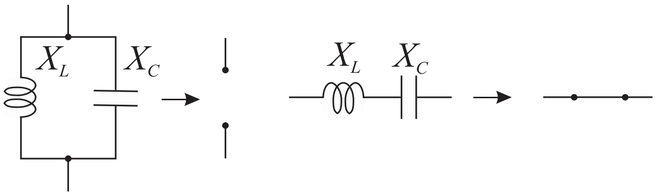
K2 Z1

a)

$$\omega^2 LC = 1 \quad \rightarrow \quad \omega L = \frac{1}{\omega C} \quad \rightarrow \quad X_L = X_C$$

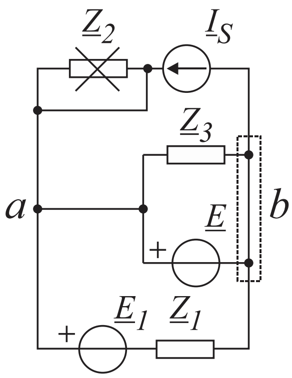


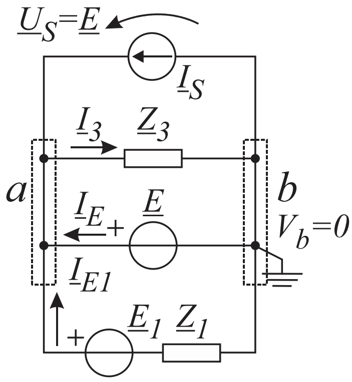
$$\underline{I}_{E1} = \frac{0 - Va + \underline{E}_1}{\underline{Z}_1} = \frac{-\underline{E} + \underline{E}_1}{\underline{Z}_1} = \frac{-100 + (50 + j20)}{(5 - j2)\cdot 10^3} = -10\,mA$$

$$\underline{I}_{E1} = 10e^{-j90^\circ}\ mA$$

$$\underline{I}_3 = \frac{Va - 0}{\underline{Z}_3} = \frac{\underline{E}_3}{\underline{Z}_3} = \frac{100}{(8 + j4)\cdot 10^3} = 5(2 - j)\,mA$$

$$\underline{I}_3 = 5\sqrt{5}e^{-j26{,}56^\circ}\ mA$$





$$-\underline{I}_{E1} - \underline{I}_E + \underline{I}_3 - \underline{I}_S = 0$$

$$\underline{I}_E = -\underline{I}_{E1} + \underline{I}_3 - \underline{I}_S = -(-10) + (10 - j5) - 15$$

$$\underline{I}_E = 5(1 - j)\,mA$$

$$\underline{S}_{E1} = \underline{E}_1 \underline{I}_{E1}^* = (50 + j20)\cdot(-10)\cdot 10^{-3} = -(0{,}5 + j0{,}2)\,VA$$

$$\underline{S}_E = \underline{E}\,\underline{I}_E^* = 100 \cdot 5(1 + j)\cdot 10^{-3} = 0{,}5(1 + j)\,VA$$

$$\underline{S}_{IS} = \underline{U}_S \underline{I}_S^* = \underline{E}\,\underline{I}_S^* = 100 \cdot 15 \cdot 10^{-3} = 1{,}5\,VA$$

b)

$$\sum P_J = \mathrm{Re}\{\underline{S}_{E1} + \underline{S}_E + \underline{S}_{IS}\} = -0{,}5 + 0{,}5 + 1{,}5 = \boxed{1{,}5W}$$

ili

$$\sum P_J = \mathrm{Re}\{\underline{Z}_1 |\underline{I}_{E1}|^2 + \underline{Z}_3 |\underline{I}_3|^2\} = \boxed{1{,}5W}$$

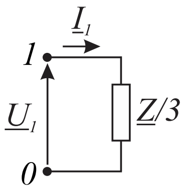
c)

$$\underline{I}_L = \frac{\underline{V}_a}{jX_L \cdot 10^3} = \frac{\underline{E}}{jX_L \cdot 10^3} = \frac{100}{500e^{j90^\circ}} = 0{,}2e^{-j90^\circ}$$

$$i_L(t) = 0{,}2\sqrt{2}\cos\left(\underbrace{\frac{1}{\sqrt{LC}}}_{\omega} t - 90^\circ\right) mA$$

K2 Z2

a)



$$\underline{Z}=(30+j60)\,\Omega=67{,}08\,e^{j63{,}43^\circ}\ \Omega$$

$$\underline{I}_1=\frac{\underline{U}_1}{\frac{\underline{Z}}{3}}=\frac{U_1\,e^{j0^\circ}}{\frac{1}{3}Z\,e^{j\varphi}}=\frac{230}{\frac{1}{3}\cdot 67{,}08\,e^{j63{,}43^\circ}}=10{,}29\,e^{-j63{,}43^\circ}\ \text{A}$$

$$\boxed{I_{A1}^{(a)}=I_{A2}^{(a)}=\left|\underline{I}_{31}\right|=\frac{\left|\underline{I}_1\right|}{\sqrt{3}}=\frac{10{,}29}{\sqrt{3}}=5{,}94\ \text{A}}$$

$$\boxed{U_{V1}^{(a)}=\left|\underline{U}_{12}\right|=\sqrt{3}\left|\underline{U}_1\right|=\sqrt{3}\cdot 230=398{,}37\ \text{V}}$$

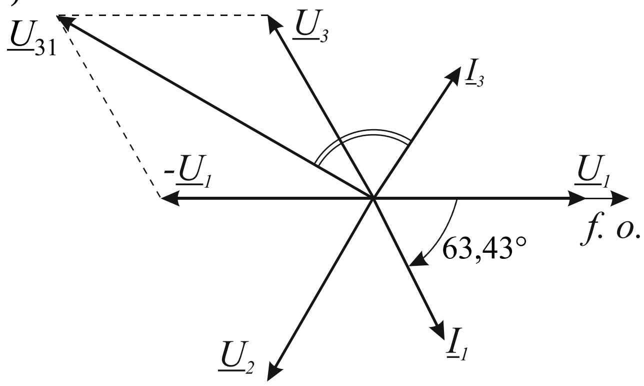
$$\boxed{U_{V2}^{(a)}=\frac{Z}{3}\cdot I_{A1}^{(a)}=\frac{67{,}08}{3}\cdot 5{,}94=132{,}82\ \text{V}}$$

$$P_W^{(a)}=\operatorname{Re}\left\{\underline{U}_{31}\,\underline{I}_3^{*}\right\}=U_{31}\,I_3\cos\sphericalangle\left(\underline{U}_{31},\underline{I}_3\right)$$

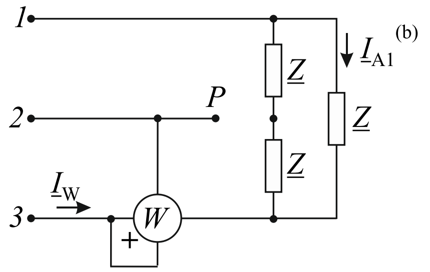
$$P_W^{(a)}=\sqrt{3}U_1\,I_1\cos\underbrace{(30^\circ+63{,}43.)}_{93{,}43^\circ}=\sqrt{3}\cdot 230\cdot 10{,}29\cdot\cos 93{,}43^\circ$$

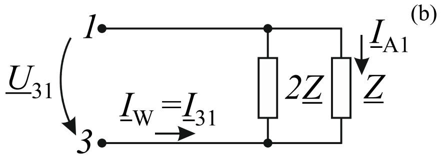
$$\boxed{P_W^{(a)}=-245{,}49\,W}$$

c)



b) Posle prekida





$$\underline{I}_{31}=\frac{\underline{U}_{31}}{\frac{2}{3}\underline{Z}}=\frac{\sqrt{3}U_1\,e^{j120^\circ}}{\frac{2}{3}\cdot 67{,}08\cdot e^{j63{,}43^\circ}}=\frac{398{,}37\cdot e^{j120^\circ}}{\frac{2}{3}\cdot 67{,}08\cdot e^{j63{,}43^\circ}}$$

$$\underline{I}_{31}=8{,}9\cdot e^{j56{,}57^\circ}\ \text{A}=\underline{I}_W$$

$$\underline{I}_{A1}^{(b)}=\frac{\underline{U}_{13}}{\underline{Z}}=\frac{\sqrt{3}U_1\,e^{-j30^\circ}}{67{,}08\cdot e^{j63{,}43^\circ}}=\frac{398{,}37\cdot e^{-j30^\circ}}{67{,}08\cdot e^{j63{,}43^\circ}}$$

$$\underline{I}_{A1}^{(b)}=5{,}93\cdot e^{-j93{,}43^\circ}\ \text{A}$$

$$\boxed{I_{A1}^{(b)}=I_{A2}^{(b)}=\left|\underline{I}_{A1}^{(b)}\right|=5{,}93\ \text{A}}$$

$$\boxed{U_{V1}^{(\text{b})}=U_{V1}^{(\text{a})}}$$

$$U_{V2}^{(\text{b})}=\frac{Z}{3}\cdot I_{A1}^{(\text{b})}=\frac{67{,}08}{3}\cdot 5{,}93$$

$$\boxed{U_{V2}^{(\text{b})}=132{,}59\ \text{V}}$$

$$P_W^{(b)}=\operatorname{Re}\left\{\underline{U}_{32}\cdot\underline{I}_W^{*}\right\}=\sqrt{3}\cdot U_1\cdot I_W\cdot\cos\sphericalangle\left(\underline{U}_{32},\underline{I}_W\right)$$

$$P_W^{(b)}=398{,}37\cdot 8{,}9\cdot\cos\left(30^\circ+3{,}43^\circ\right)$$

$$\boxed{P_W^{(b)}=-2958{,}92\ \text{W}}$$