STUDIJSKI PROGRAM ZA PRIMENJENO SOFTVERSKO INŽENJERSTVO

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

Osnovi elektrotehnike (I kolokvijum)

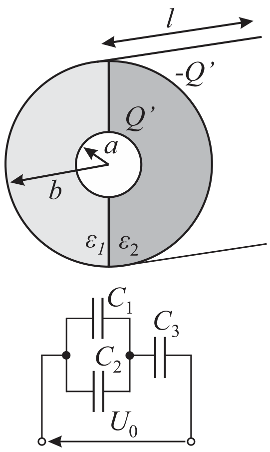
K1

07.10.2017.

ZADACI

Zadatak 1. Na slici 1 je prikazan koaksijalni kabl, poluprečnika unutrašnje elektrode $a = 5\ mm$ i spoljašnje $b = 2{,}7a$, dužine $l = 1\ m$. Kabl je naelektrisan podužnim naelektrisanjem Q' i ispunjen je sa dva dielektrika, čije su permitivnosti $\varepsilon_1 = 3\varepsilon_0$ i $\varepsilon_2 = 4\varepsilon_0$.

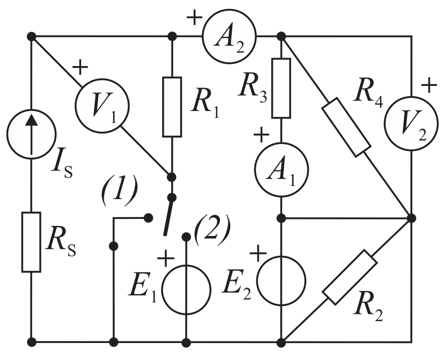
a) Izvesti izraz za podužnu kapacitivnost ovog kabla.
b) Odrediti maksimalni napon na koji sme da se priključi kabl, ako su električne čvrstine dielektrika $E_{č1} = 35\ kV/cm$ i $E_{č2} = 50\ kV/cm$.
c) Za grupu kondenzatora sa slike, izračunati energiju sadržanu u kondenzatoru C_2, ako je grupa kondenzatora priključena na napon $U_0 = 10\ kV$. Kapacitivnosti pojedinih kondenzatora su: $C_1 = 10\ nF$, $C_2 = 20\ nF$, $C_3 = 30\ nF$.



Slika 1.

Zadatak 2. U električnom kolu prikazanom na slici 2, odrediti promenu pokazivanja idealnih mernih instrumenata pri prebacivanju prekidača iz položaja *(1)* u položaj *(2)*.

Brojni podaci su: $E_1 = 10\ V$, $E_2 = 5\ V$, $R_1 = 16\ \Omega$, $R_2 = 20\ \Omega$, $R_3 = 40\ \Omega$, $R_4 = 60\ \Omega$, $I_S = 1\ A$, $R_S = 5\ \Omega$.



Slika 2.

PRAVILA POLAGANJA

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

STUDIJSKI PROGRAM ZA PRIMENJENO SOFTVERSKO INŽENJERSTVO

K TET Katedra za teorijsku elektrotehniku www.ktet.ftn.uns.ac.rs	Osnovi elektrotehnike (II kolokvijum)	**K2** **07.10.2017.**

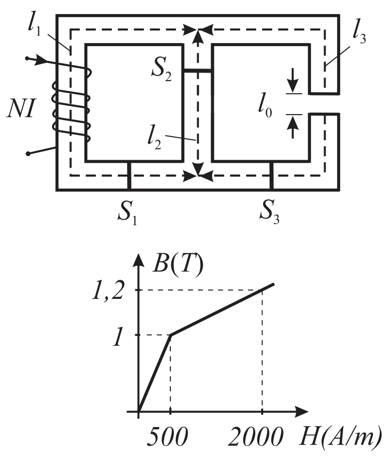
ZADACI

Zadatak 1. Tanko magnetsko kolo i idealizovana kriva prvobitnog magnetisanja feromagnetskog materijala od koga je kolo načinjeno su dati na slici 1. Na jezgro je ravnomerno i gusto namotano N = 500 zavojaka u kojima se uspostavila struja jačine I. Odrediti:

a) jačinu struje pri kojoj će intenzitet vektora jačine magnetskog polja u procepu biti jednak 398 *kA/m*, i
b) magnetski fluks u grani sa procepom.

Rasipanja magnetskog fluksa zanemariti.

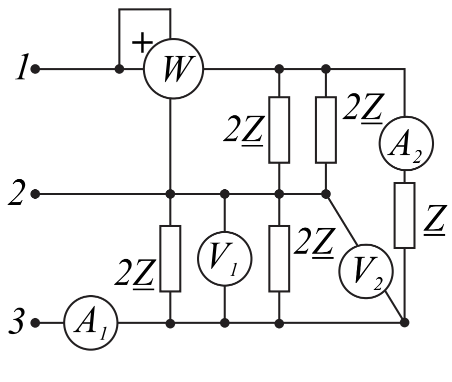
Brojni podaci su: l_1 = 30 *cm*, l_2 = 12 *cm*, l_3 = 29,9 *cm*, l_0= 1 *mm*, S_1 = S_2 = 1 cm^2, S_3 = 1,5 cm^2



Slika 1.

Zadatak 2. Na slici 2 je prikazan simetričan trofazni prijemnik, impedanse potrošača $\underline{Z}$ = (25−j10) *Ω*, priključen na mrežu faznog napona prve faze $\underline{U}_1$ = 230 *V*.

a) Odrediti pokazivanja idealnih mernih instrumenata.
b) Skicirati fazorski dijagram faznih napona mreže i svih fazora veličina od kojih zavisi pokazivanje instrumenata.
c) Odrediti ukupnu aktivnu i reaktivnu snagu trofaznog prijemnika.



Slika 2.

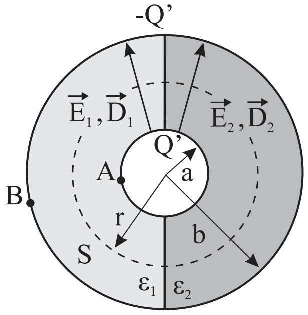
PRAVILA POLAGANJA

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

PSI ISPIT 07.10.2017.

K1 Z1

a)



Granični uslov:

$$E_{t1} = E_{t2} \qquad E_1 = E_2 = E$$

$$D_{n1} \neq D_{n2}$$

$$D_1 = \varepsilon_1 \cdot E$$

$$D_2 = \varepsilon_2 \cdot E$$

$$\oint_S \vec{D} \cdot \vec{ds} = Q_{slobodno\ u\ S}$$

$$\cancel{\int_{S_{B1}} \vec{D} \cdot \vec{ds}}^{\,0} + \cancel{\int_{S_{B2}} \vec{D} \cdot \vec{ds}}^{\,0} + \int_{S_{OM}} \vec{D} \cdot \vec{ds} = Q_{slobodno\ u\ S}$$

$$\sphericalangle(\vec{D}, \vec{n}_{B1}) = 90° \qquad \sphericalangle(\vec{D}, \vec{n}_{B2}) = 90° \qquad \sphericalangle(\vec{D}, \vec{n}_{OM}) = 0°$$

$$\int_{S_{OM1}} D_1 \cdot ds + \int_{S_{OM2}} D_2 \cdot ds = Q' \cdot l$$

$$D_1 \cdot r\pi l + D_2 \cdot r\pi l = Q' \cdot l$$

$$\varepsilon_1 \cdot E \cdot r\pi l + \varepsilon_2 \cdot E \cdot r\pi l = Q' \cdot l$$

$$\boxed{E = \frac{Q'}{\varepsilon_1 \cdot r\pi + \varepsilon_2 \cdot r\pi}}, \qquad a < r < b$$

$$U_{AB} = \int_A^B \vec{E} \cdot \vec{dl} = \int_a^b E \cdot dr = \int_a^b \frac{Q'}{(\varepsilon_1 + \varepsilon_2) \cdot r\pi} \cdot dr = \frac{Q'}{(\varepsilon_1 + \varepsilon_2) \cdot \pi} \cdot \ln \frac{b}{a}$$

$$C' = \frac{Q'}{U_{AB}} \qquad \boxed{C' = \frac{(\varepsilon_1 + \varepsilon_2) \cdot \pi}{\ln \frac{b}{a}}} \qquad \boxed{C' = 194{,}52\ \frac{pF}{m}}$$

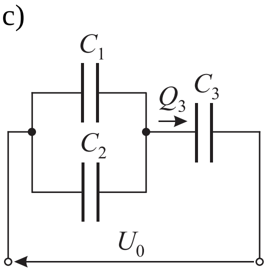
b)

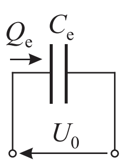
$$E_{\max 1} = E_{\max 2} = E_{\max (r=a)} = \frac{Q_{\max}'}{(\varepsilon_1 + \varepsilon_2) \cdot a\pi} = \min\{E_{\check{c}1}, E_{\check{c}2}\} = E_{\check{c}1} = 35\ \frac{kV}{cm}$$

$$\frac{C' \cdot U_{\max}}{(\varepsilon_1 + \varepsilon_2) \cdot a\pi} = E_{\check{c}1}$$

$$U_{\max} = \frac{E_{\check{c}1} \cdot (\varepsilon_1 + \varepsilon_2) \cdot a\pi}{C'} = \frac{E_{\check{c}1} \cdot (\varepsilon_1 + \varepsilon_2) \cdot a\pi}{\frac{(\varepsilon_1 + \varepsilon_2) \cdot \pi}{\ln \frac{b}{a}}} = E_{\check{c}1} \cdot a \cdot \ln \frac{b}{a} \qquad \boxed{U_{\max} = 17{,}5\ kV}$$

c)





$$C_{12} = C_1 + C_2 = 30\ nF$$

$$Q_{12} = Q_3 = Qe \qquad C_{12} = \frac{Q_{12}}{U_{12}}$$

$$U_{12} = \frac{Q_{12}}{C_{12}} = 3kV \qquad C_2 = \frac{Q_2}{U_2}$$

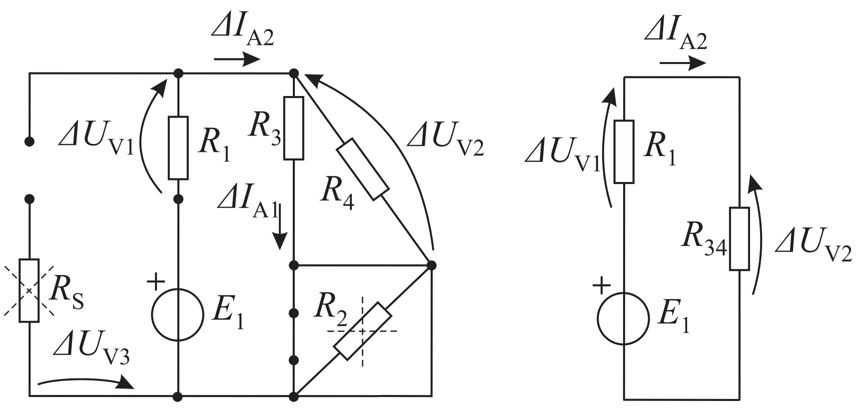
$$Q_2 = C_2 U_2 = 60\mu C$$

$$W_{C3} = \frac{1}{2} \cdot \frac{Q_2^2}{C_2} = \qquad \boxed{W_{C2} = 90\ mJ}$$

K1 Z2

$$U_{V1}^{(2)} = U_{V1}^{(1)} + \Delta U_{V1} \qquad \Rightarrow \qquad \Delta U_{V1} = U_{V1}^{(2)} - U_{V1}^{(1)}$$

$$\underset{(2)}{\boxed{\begin{matrix} Svi \\ generatori \end{matrix}}} = \underset{(1)}{\boxed{\begin{matrix} Svi \\ sem\ E_1 \end{matrix}}} + \boxed{\begin{matrix} Samo \\ E_1 \end{matrix}}$$



$$R_{34} = R_3 \,||\, R_4 = \frac{R_3\, R_4}{R_3 + R_4} = \frac{40 \cdot 60}{40 + 60} = 24\,\Omega$$

$$-E_1 + R_1\, \Delta I_{A2} + R_{34}\, \Delta I_{A2} = 0$$

$$\Delta I_{A2} = \frac{E_1}{R_1 + R_{34}} = \frac{10}{16 + 24} \qquad \boxed{\Delta I_{A2} = 0,25\ A}$$

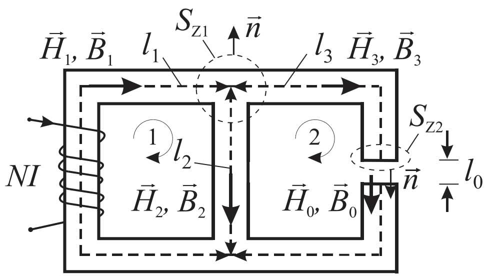
$$\Delta U_{V1} = -R_1\, \Delta I_{A2} = -16 \cdot 0,25 \qquad \boxed{\Delta U_{V1} = -4\,V}$$

$$\Delta U_{V2} = R_{34}\, \Delta I_{A2} = 24 \cdot 0,25 \qquad \boxed{\Delta U_{V2} = 6\,V}$$

$$\Delta I_{A1} = \frac{\Delta U_{V2}}{R_3} = \frac{6}{40} \qquad \boxed{\Delta I_{A1} = 0{,}15\ A}$$

K2 Z1

a)



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

$$\boxed{\begin{aligned}&(1)\quad H_1 \cdot l_1 + H_2 \cdot l_2 = NI \\ &(2)\quad H_3 \cdot l_3 + H_0 \cdot l_0 - H_2 \cdot l_2 = 0\end{aligned}}$$

$$\oint_{S_{Z1}} \vec{B} \cdot \vec{ds} = 0$$

$$\Phi_1 = \Phi_2 + \Phi_3$$

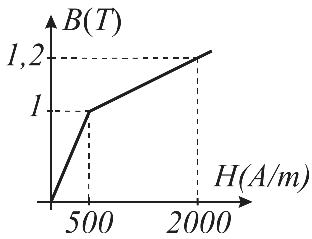
$$\boxed{(3)\quad B_1 \cdot S_1 = B_2 \cdot S_2 + B_3 \cdot S_3}$$

$$\oint_{S_{Z2}} \vec{B} \cdot \vec{ds} = 0$$

$$\Phi_3 = \Phi_0$$

$$B_3 \cdot S_3 = B_0 \cdot S_0, \qquad (S_3 = S_0)$$

$$\boxed{(4)\quad B_3 = B_0}$$



$H_0 = 398\, kA/m \qquad \Rightarrow \qquad B_0 = \mu_0 \cdot H_0 = 0{,}5\, T$

Iz (4) sledi $B_3 = B_0 = 0{,}5\, T$

Sa krive magnetisanja sledi $H_3 = \dfrac{B_3}{\mu} = \dfrac{0{,}5}{\frac{1}{500}} = 250\; A/m$

Iz (2) sledi $H_2 = H_3 \cdot \dfrac{l_3}{l_2} + H_0 \cdot \dfrac{l_0}{l_2} = 250 \cdot \dfrac{0{,}299}{0{,}12} + 398 \cdot 10^3 \cdot \dfrac{0{,}001}{0{,}12} = 3939{,}58\; A/m > 500\; A/m$

Jednačina za drugi deo krive magnetisanja: $B - B_{c1} = \dfrac{B_{c2} - B_{c1}}{H_{c2} - H_{c1}}(H - H_{c1})$

$$B - 1 = \frac{1{,}2 - 1}{2000 - 500}(H - 500),$$

$$B = \frac{0{,}2}{1500} H + 0{,}93$$

Sledi da je $B_2 = \dfrac{0{,}2}{1500} H_2 + 0{,}93 = 1{,}455\, T$

Iz (3) sledi $B_1 = \dfrac{S_2}{S_1} B_2 + \dfrac{S_3}{S_1} B_3 = B_2 + \dfrac{S_3}{S_1} B_3 = 2{,}205\, T$

Sa krive magnetisanja sledi $B_1 = \dfrac{0{,}2}{1500} H_1 + 0{,}93 \qquad \Rightarrow \qquad H_1 = \dfrac{B_1 - 0{,}93}{\frac{0{,}2}{1500}} = 9562{,}5\, \dfrac{A}{m}$

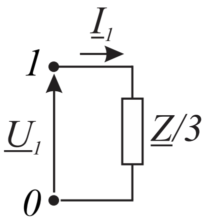
Iz (1) sledi $I = \dfrac{H_1 \cdot l_1 + H_2 \cdot l_2}{N} \qquad \boxed{I = 6{,}68\; A}$

b)

$\Phi_3 = \displaystyle\int_{S_3} \vec{B}_3 \cdot d\vec{S} = B_3 \cdot S_3 = 0{,}5 \cdot 1{,}5 \cdot 10^{-4} = 75\; \mu Wb \qquad \boxed{\Phi_3 = 75\; \mu Wb}$

K2 Z2

a)



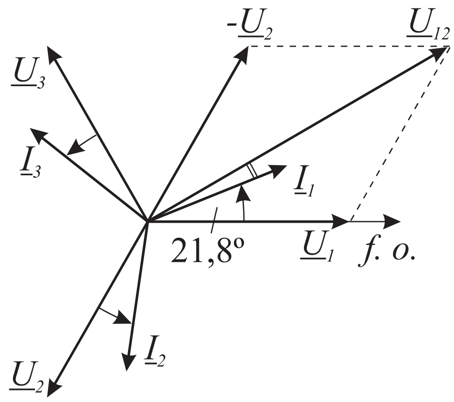
$$\underline{Z} = (25 - j10)\,\Omega = 26{,}93\, e^{-j21{,}8^\circ}\ \Omega$$

$$\underline{I}_1 = \frac{\underline{U}_1}{\frac{\underline{Z}}{3}} = \frac{U_1\, e^{j0^\circ}}{\frac{1}{3} Z\, e^{j\varphi}} = \frac{230}{\frac{1}{3}\cdot 26{,}93\, e^{-j21{,}8^\circ}} = 25{,}62\, e^{j21{,}8^\circ}\ A$$

$$\underline{I}_2 = 25{,}62\, e^{-j98{,}2^\circ}\ A$$

$$\underline{I}_3 = 25{,}62\, e^{-j218{,}2^\circ}\ A$$

b)



$$I_{A1} = |\underline{I}_3| = \boxed{25{,}62\ A}$$

$$I_{A2} = |\underline{I}_{13}| = \frac{|\underline{I}_1|}{\sqrt{3}} = \boxed{14{,}79\ A}$$

$$U_{V1} = U_{V2} = |\underline{U}_{23}| = \sqrt{3}\,|\underline{U}_1| = \sqrt{3}\cdot 230 = \boxed{398{,}37\, V}$$

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

$$P_W = \sqrt{3} U_1\, I_1 \cos(30^\circ - 21{,}8^\circ) = \sqrt{3}\cdot 230\cdot 25{,}62\cdot \cos 8{,}2^\circ$$

$$\boxed{P_W = 10101{,}9\, W}$$

c)

$$\underline{S} = 3\,\underline{U}_1\ \underline{I}_1^{\,*} = 3\cdot 230\, e^{j0}\cdot 25{,}62\, e^{-j21{,}8^\circ} = 17677{,}8\, e^{-j21{,}8^\circ}\ VA$$

$$\underline{S} = 17677{,}8\cdot\cos(-21{,}8^\circ) + j17677{,}8\cdot\sin(-21{,}8^\circ) = (16413{,}6 - j6564{,}9)\, VA$$

$$\boxed{P = 16413{,}6\, W} \qquad \boxed{Q = -6564{,}9\, VAr}$$