Enačbe pri predmetu OSNOVE ELEKTROTEHNIKE II – VSŠ (Dejan Križaj)

(Na izpitu je dovoljeno imeti te formule in na istem listu dorisane slike z oznakami, če je potrebno. Dodatne formule niso dovoljene)

2. SILA NA (TOKO)VODNIK V MAGNETNEM POLJU

$\mu_0 = 4\pi 10^{-7}\,\frac{\mathrm{N}}{\mathrm{A}^2} = 4\pi 10^{-7}\,\frac{\mathrm{Vs}}{\mathrm{Am}} = 4\pi 10^{-7}\,\frac{\mathrm{H}}{\mathrm{m}}$

$F = \frac{\mu_0 I_1 I_2 l}{2\pi r}$ med ravnima vodnikoma

$\mathrm{d}\vec{F} = I\mathrm{d}\vec{l}\times\vec{B}$ sila na tokovni element

3. BIOT-SAVARTOV ZAKON

$\mathrm{d}\vec{B} = \frac{\mu_0}{4\pi}\frac{I\mathrm{d}\vec{l}\times\vec{r}}{r^3}$

$\vec{B} = \vec{e}_\varphi \frac{\mu_0 I}{2\pi R}$ Tokovna premica

$\vec{B} = \vec{e}_\varphi \frac{\mu_0 I}{4\pi R}\left(\cos\theta_1 - \cos\theta_2\right)$ daljica

$B = \frac{\mu_0 I}{4\pi R}\beta$ Tokovna zanka (obroč)

$\vec{B} = \vec{e}_z \frac{\mu_0 I R^2}{2\left(z^2+R^2\right)^{3/2}}$ tokovna zanka

$\vec{B} = \vec{e}_z \frac{\mu_0 NI}{2l}\left(\cos\beta_1 + \cos\beta_2\right)$ solenoid

4. AMPEROV ZAKON

$\oint_L \vec{B}\cdot\mathrm{d}\vec{l} = \mu_0 I_{\text{objeti}}$

$B = \frac{\mu_0 NI}{l}$ Polje dolge tuljave - solenoida

$B = \frac{\mu_0 NI}{2\pi r}$ Polje toroida

$B = \frac{\mu_0 K}{2}$ Polje tokovne obloge

5. MAGNETNI PRETOK – FLUKS

$\Phi = \int_A \vec{B}\cdot\mathrm{d}\vec{A};\ \Phi \approx BA\cos\alpha$

$\oint_A \vec{B}\cdot\mathrm{d}\vec{A} = 0$ ¨Brezizvornost B polja

6. DELO MAGNETNIH SIL

$A = \int_S \vec{F}\cdot\mathrm{d}\vec{s}$

$A = I\left(\Phi_{\text{končni}} - \Phi_{\text{začetni}}\right)$

7. NAVOR NA (TOKO)VODNIK

$\vec{T} = \vec{r}\times\vec{F}\quad \vec{T} = \vec{m}\times\vec{B}$

$\vec{m} = \vec{e}_n IA$ magnetni dipolni moment

8. GIBANJE NABOJEV

$\vec{F} = Q\vec{E} + Q\vec{v}\times\vec{B}$ Lorentzova sila

$R = \frac{mv}{QB}$ radij kroženja

9. MAGNETNE LASTNOSTI SNOVI

$\vec{H} = \frac{\vec{B}}{\mu_0} - \vec{M}$ Magnetna poljska jakost

$\oint_L \vec{H}\cdot\mathrm{d}\vec{l} = NI$ razširjen Amperov zakon

$\vec{M} = \chi_m \vec{H}$ vektor magnetizacije

$\vec{B} = \mu_0(\vec{H} + \chi_m\vec{H}) = \mu_0(1+\chi_m)\vec{H} = \mu_0\mu_r\vec{H}$

$\Theta = \oint_L \vec{H}\cdot\mathrm{d}\vec{l}$ Magnetna napetost

$V_m(T_1) = \int_{T_1}^{T_2(V_m=0)} \vec{H}\cdot\mathrm{d}\vec{l}$ Magnetni potencial.

MEJNI POGOJI MAGNETNEGA POLJA

$B_{n2} = B_{n1}$ in $H_{t2} = H_{t1}$

11. ANALIZA MAGNETNIH STRUKTUR

$\sum_{i=1}^{N} H_i\cdot l_i = \Theta$ ali $\sum_{i=1}^{N}\Phi_i\frac{l_i}{\mu_i A_i} = \Theta$

$\Theta = \sum_i \pm N_i I_i$

$\sum_{i=1}^{N}\Phi_i = 0 \qquad \Phi = BA = \mu HA$

12. INDUCIRANA NAPETOST

$\vec{E}_i = \frac{\vec{F}_m}{Q} = \vec{v}\times\vec{B}$ inducirano polje

$u_i = \int_0^l \left(\vec{v}\times\vec{B}\right)\cdot\mathrm{d}\vec{l}$ Gibalna ui

$u_i(t) = \oint_L \vec{E}_i\cdot\mathrm{d}\vec{l} = -\frac{\mathrm{d}}{\mathrm{d}t}\int_A \vec{B}\cdot\mathrm{d}\vec{A}$

$= -\frac{\mathrm{d}\Phi}{\mathrm{d}t}$ Transformatorska ui

$\oint_L \vec{E}\cdot\mathrm{d}\vec{l} = -\int_A \frac{\partial}{\partial t}\vec{B}\cdot\mathrm{d}\vec{A} + \oint_L\left(\vec{v}\times\vec{B}\right)\cdot\mathrm{d}\vec{l}$

$\Psi = \sum_i N_i\Phi_i$ Magnetni sklep

$\Psi = Li$

$M_{21} = \frac{\Psi_{21}}{I_1} = \frac{N_2\Phi_{21}}{I_1}$ medsebojna ind.

$M = k\sqrt{L_1 L_2}$ faktor sklopa

$u_L = -u_i = L\frac{\mathrm{d}i}{\mathrm{d}t}$ u tuljave

$u_1 = R_1 i_1 + L_1\frac{\mathrm{d}i_1}{\mathrm{d}t} \pm M\frac{\mathrm{d}i_2}{\mathrm{d}t}$

13. ENERGIJA MAGNETNEGA POLJA

$W(t) = \frac{1}{2}Li^2(t)$

$W = \frac{1}{2}L_1 i_1^2 + \frac{1}{2}L_2 i_2^2 \pm M i_1 i_2$ dve tuljavi

$w_{\text{mag}}(t) = \int_0^{B(t)} \vec{H}\cdot\mathrm{d}\vec{B}$ gostota energije

$w = \frac{B^2}{2\mu} = \frac{\mu H^2}{2}$ in $W = \frac{B^2}{2\mu}V$ linearne strukture

$p_{\text{hist}} = fw_{\text{BH zanke}}$ Histerezne izgube

$L_{dvovoda} = \frac{\mu_0 l}{\pi}\left(\frac{1}{4} + \ln\frac{d}{R}\right)$ dvovod

$F_\delta = \left|-\frac{\partial W_\delta}{\partial x}\right| = \frac{B_\delta^2 A}{2\mu_0}$ Magnetna sila

$F_x = \frac{\partial W_m}{\partial x} = \frac{1}{2}\frac{\partial}{\partial x}(Li^2) = \frac{i^2}{2}\frac{\partial L}{\partial x}$

Enačbe pri predmetu OSNOVE ELEKTROTEHNIKE II – VSŠ (Dejan Križaj)

(Na izpitu je dovoljeno imeti te formule in na istem listu dorisane slike z oznakami, če je potrebno. Dodatne formule niso dovoljene)

IZMENIČNA VEZJA

8. PREHODNI POJAVI

$u(t) = R \cdot i(t) \quad \Leftrightarrow \quad i(t) = G \cdot u(t)$

$u(t) = \frac{1}{C}\int_0^t i(t)\mathrm{d}t + u_{C0} \quad \Leftrightarrow \quad i(t) = C\frac{\mathrm{d}u(t)}{\mathrm{d}t}$

$Q(t) = Cu(t)$

$u(t) = L\frac{\mathrm{d}i(t)}{\mathrm{d}t} \quad \Leftrightarrow \quad i(t) = \frac{1}{L}\int_0^t u(t)\mathrm{d}t + i_{L0}$

$u_C(0^+) = u_C(0^-)$ in $i_L(0^+) = i_L(0^-)$

$\tau = RC$ in $\tau = \frac{L}{R}$

9. OSNOVNI POJMI PRI OBRAVNAVI PERIODIČNIH SIGNALOV

$f = \frac{1}{T}$, $\omega = 2\pi f = \frac{2\pi}{T}$

$I_{sr} = \frac{1}{T}\int_0^T i(t)\mathrm{d}t$

$I_{ef} = \sqrt{\frac{1}{T}\int_0^T i^2(t)\cdot dt}$

$I_r = \frac{1}{T}\int_0^T |i(t)|\mathrm{d}t$

faktor oblike $= FF = \frac{I_{ef}}{I_r}$

temenski faktor $= \frac{I_m}{I_{ef}}$

10. R, L, C pri $i = I_m \sin(\omega t)$

$u(t) = Ri(t) \;\; p = \frac{I_m^2 R}{2}\left(1 - \cos\left(2\omega t\right)\right)$

$P = \frac{I_m^2 R}{2} = I_{ef}^2 R$

$u_L = L\frac{\mathrm{d}i}{\mathrm{d}t} = LI_m\omega\sin\left(\omega t + \frac{\pi}{2}\right) = U_m\sin\left(\omega t + \frac{\pi}{2}\right)$

$p_L = iu = \frac{I_m U_m}{2}\sin(2\omega t) \;\; W_{L,\max} = \frac{LI_m^2}{2}$

$u_C = \frac{I_m}{\omega C}\sin\left(\omega t - \frac{\pi}{2}\right) = U_m\sin\left(\omega t - \frac{\pi}{2}\right)$

$p = iu = -\frac{I_m U_m}{2}\sin(2\omega t) \;\; W_{C,\max} = \frac{CU_m^2}{2}$

11. IZMENIČNI SIGNALI – MOČ

$P = \frac{1}{T}\int_0^T p(t)\mathrm{d}t$

$P = \frac{U_m I_m}{2}\cos(\varphi)$ DELOVNA MOČ

$Q = \frac{I_m U_m}{2}\sin(\varphi)$ JALOVA MOČ

$S = \frac{I_m U_m}{2}$ NAVIDEZNA MOČ

$S^2 = P^2 + Q^2$

12. OBRAVNAVA IZMENIČNIH SIGNALOV S KOMPLEKSNIM RAČUNOM

$e^{\mathrm{j}\alpha} = \cos(\alpha) + \mathrm{j}\sin(\alpha)$ EULERJEV OBRAZEC

$i(t) = I\cos(\omega t + \varphi) = \mathrm{Re}\left\{\underline{I}e^{\mathrm{j}\omega t}\right\}$ za

$\underline{I} = Ie^{\mathrm{j}\varphi}$

$\underline{U} = R\underline{I}$ ali $\underline{I} = G\underline{U}$

$\underline{U} = \frac{\underline{I}}{\mathrm{j}\omega C} = -\mathrm{j}\frac{\underline{I}}{\omega C} = \mathrm{j}X_C\underline{I}$ ali

$\underline{I} = \mathrm{j}\omega C\underline{U} = \mathrm{j}B_C\underline{U}$

$\underline{U} = \mathrm{j}\omega L\underline{I} = \mathrm{j}X_L\underline{I}$ ali

$\underline{I} = \frac{\underline{U}}{\mathrm{j}\omega L} = \mathrm{j}B_L\underline{U}$

13. MOČ S KOMPLEKSNIM RAČUNOM

$\underline{S} = S\left(\cos(\varphi) + \mathrm{j}\sin(\varphi)\right) = P + \mathrm{j}Q = Se^{\mathrm{j}\varphi}$

$\underline{S} = \frac{1}{2}\underline{U}\underline{I}^* = \frac{1}{2}I^2\underline{Z} = \frac{1}{2}U^2\underline{Y}^*$

$\underline{Z}_g = \underline{Z}_b^*$ MAKSIMALNA DELOVNA MOČ

$P_{b,\max} = \frac{U_g^2}{8R_g}$ MAKSIMALNA DELOVNA MOČ

14. RESONANČNI POJAV

ZAPOREDNI NIHAJNI KROG - TOKOVNA RESONANCA

$\underline{U} = \underline{I}\left(R + \mathrm{j}\omega L + \frac{1}{\mathrm{j}\omega C}\right) = \underline{I}\underline{Z}$

$\omega_0 = \frac{1}{\sqrt{LC}} \qquad I(f = f_0) = I_0 = U/R$

$Q = \frac{\omega_0 L}{R} \qquad Q = \frac{1}{B_{\mathrm{norm}}} = \frac{f_0}{f_2 - f_1}$

15. METODE REŠEVANJA VEZIJ

$\mathrm{j}\omega M = \mathrm{j}\omega k\sqrt{L_1 L_2} = \mathrm{j}k\sqrt{X_{L1}X_{L2}}$

16. TRANSFORMATOR

$\frac{U_1}{U_2} = \frac{N_1}{N_2} = n$ NAPETOSTNA PRESTAVA

$U_{i1,ef} = N_1 2\pi f\frac{\Phi_{gl,\max}}{\sqrt{2}} = 4{,}44\,fN_1\Phi_{gl,\max}$

MAKSIMALNI FLUKS V JEDRU

$\underline{I}_{1m} = \frac{\underline{U}_1}{\mathrm{j}\omega L_1}$ MAGNETILNI TOK

$\frac{\underline{I}_1}{\underline{I}_2} = -\frac{1}{n}$ TOKOVNA PRESTAVA

$N_1\underline{I}_1 + N_2\underline{I}_2 = N_1\underline{I}_{1m}$ NAPETOSTNO RAVNOTEŽJE

$\underline{S}_1 = \underline{S}_{1m} + \underline{S}_2$ MOČ

$\underline{Z}_{vh} \approx n^2\underline{Z}_b$ VHODNA IMPEDANCA

18. TRIFAZNI SISTEMI

$u_1 = U_m\cos(\omega t + \alpha)$

$u_2 = U_m\cos\left(\omega t + \alpha - 120^{\mathrm{o}}\right)$

$u_3 = U_m\cos\left(\omega t + \alpha + 120^{\mathrm{o}}\right)$

FAZNE NAPETOSTI

$\underline{U}_1 = U_f e^{\mathrm{j}90^{\mathrm{o}}} = \mathrm{j}U_f$

$\underline{U}_2 = U_f e^{-\mathrm{j}\frac{\pi}{6}} = U_f e^{-\mathrm{j}30^0}$

$\underline{U}_3 = U_f e^{\mathrm{j}\left(\frac{\pi}{2} + \frac{2\pi}{3}\right)} = U_f e^{-\mathrm{j}150^0}$

MEDFAZNE NAPETOSTI

$\underline{U}_{12} = U_{mf} e^{\mathrm{j}120^{\mathrm{o}}}$

$\underline{U}_{23} = \underline{U}_2 - \underline{U}_3 = \sqrt{3}U_f = U_{mf}$

$\underline{U}_{31} = \underline{U}_3 - \underline{U}_1 = U_{mf} e^{-\mathrm{j}120^{\mathrm{o}}}$

POTENCIAL ZVEZDIŠČA

$\underline{V}^* = \frac{\underline{U}_1\underline{Y}_1 + \underline{U}_2\underline{Y}_2 + \underline{U}_3\underline{Y}_3}{\underline{Y}_1 + \underline{Y}_2 + \underline{Y}_3}$

$p(t) = \frac{3}{2}UI\cos(\beta)$ SIMETRIČNO BREME