2. MI Tehnika visokog napona 4. srpnja 2011.

grupa A

① $R = 200\ M\Omega$ VN otpornik } naponsko djelilo
$R = 273\ M\Omega$ NN otpornik
iskrište zaštita osobja i ampermetra
$R = 0.5\ M\Omega$ prigušni otpornik
(μA) mikroampermetar za mjerenje struje

$r_1 = 18\ mm$
$r_2 = 72\ mm$
$\delta = 0.986$
$k_1 = 30\ kV/cm$
$k_2 = 0.3\ \sqrt{cm}$
$U', I = ??$

$$\eta = \frac{\ln\frac{r_2}{r_1}}{\frac{r_2}{r_1} - 1} = \frac{\ln\frac{72}{18}}{\frac{72}{18} - 1} = 0.46 < 0.8$$

$$U' = E' s \eta = \delta k_1 \left(1 + \frac{0.3}{\sqrt{\delta r_1}}\right)(r_2 - r_1)\eta =$$

$$= 0.986 \cdot 30 \left(1 + \frac{0.3}{\sqrt{0.986 \cdot 1.8}}\right) \cdot 5.4 \cdot 0.46 = 90.02\ kV$$

$$I = \frac{U}{R} = \frac{90 \cdot 10^3}{200 \cdot 10^6} = 450\ \mu A$$

② $C_t = 80\ pF$
$T_1 = 1.2\ \mu s$
$T_2 = 50\ \mu s$
$C_u' = 0.6\ \mu F$
$d_1 = 2.96$
$k_2 = 0.73$
$R_i, R_p, \eta = ?$

$$C_u = \frac{C_u'}{4} = 0.15 \cdot 10^{-6}\ F$$

$$T_1 = k_1 R_p \frac{C_u C_t}{C_u + C_t} \Rightarrow R_p = \frac{T_1 (C_u + C_t)}{k_1 C_u C_t} = \frac{1.2 \cdot 10^{-6} \cdot (0.15 \cdot 10^{-6} + 80 \cdot 10^{-12})}{2.96 \cdot 0.15 \cdot 10^{-6} \cdot 80 \cdot 10^{-12}} = 5070\ \Omega$$

$$T_2 = k_2 R_i (C_u + C_t) \Rightarrow R_i = \frac{T_2}{k_2 (C_u + C_t)} = \frac{50 \cdot 10^{-6}}{0.73 \cdot (0.15 \cdot 10^{-6} + 80 \cdot 10^{-12})} = 456.4\ \Omega$$

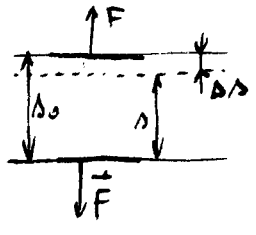
$$\eta = \frac{C_u}{C_u + C_t} = \frac{0.15 \cdot 10^{-6}}{0.15 \cdot 10^{-6} + 80 \cdot 10^{-12}} = 0.999$$

③ $s_\delta = 15\ \mu m$
$E_M = 12\ kV/cm$
$\varepsilon_r = 2.5$

$$W = \frac{CU^2}{2} = \frac{QU}{2};\quad U = \int_l \vec{E}\, d\vec{l},\quad Q = \iint_A \vec{D}\, d\vec{A},\quad \vec{D} = \varepsilon_0 \varepsilon_r \vec{E}$$

$$W_e = \iint_{Al} \frac{\vec{D}\vec{E}\, d\vec{A}\, d\vec{l}}{2} = \frac{\varepsilon_0 \varepsilon_r}{2} \int_V E^2 dV$$

$$dW_e = d\vec{F}\, d\vec{l} = \frac{\varepsilon_0 \varepsilon_r}{2} E^2 d\vec{A}\, d\vec{l} \Rightarrow F = \frac{\varepsilon_0 \varepsilon_r}{2} \left(\frac{U}{s}\right)^2 \cdot A$$



$$\sigma_M = \frac{F}{A} = \varepsilon_M \log\frac{s_0}{s_0 - \Delta s};\quad s = s_0 - \Delta s$$

$$\sigma_M = \frac{\varepsilon_0 \varepsilon_r}{2} \left(\frac{U}{s_0}\right)^2 \cdot \left(\frac{s_0}{s}\right)^2 = \varepsilon_M \log\frac{s_0}{s} \Rightarrow E_M^2 = \left(\frac{U}{s_0}\right)^2 = \frac{-2\varepsilon_M}{\varepsilon_0 \varepsilon_r} \left(\frac{s}{s_0}\right)^2 \log\frac{s}{s_0}$$

$$\frac{\partial E_M^2}{\partial\left(\frac{s}{s_0}\right)} = 0 \Rightarrow \frac{s}{s_0} = e^{-0.5}$$

$$E_{M\,min} = \sqrt{\frac{2\varepsilon_M}{\varepsilon_0 \varepsilon_r} \frac{1}{e} \log\sqrt{e}} = 0.4 \sqrt{\frac{\varepsilon_M}{\varepsilon_0 \varepsilon_r}} = 0.4 \sqrt{\frac{12 \cdot 10^7}{8854 \cdot 10^{-12} \cdot 2.5}} = 9.31\ \frac{V}{m} 10^8$$

$$U_{M\,min} = E_{M\,min} \cdot s_0 = 13.97\ kV$$

⑤ $L_1 = 19.5\ \mu H$
$C_1 = 6\ nF$
$C_2 = 7.1\ pF$
$L_2 = ?\quad U_2/U_1 = ?$

$$L_1 C_1 = L_2 C_2 \Rightarrow$$

$$L_2 = \frac{L_1 C_1}{C_2} = 16.479\ \mu H$$

$$\frac{U_2}{U_1} = \sqrt{\frac{L_2}{L_1}} = \dots = 29$$

2 M1 Tehnika visokog napona d. Srbija 2011.
grupa B

① $r_1 = 48\ mm$
$r_2 = 72\ mm$
$\delta = 0.986$
$A = 645\ kor^{-1}\ mm^{-1}$
$B = 19\ kV\ kor^{-1}\ mm^{-1}$
$K = 13$
$T = T_0$
$U' = ?\ \ I = ?$

$$\eta = \frac{\ln \frac{r_2}{r_1}}{\frac{r_2}{r_1} - 1} = \frac{\ln \frac{72}{48}}{\frac{72}{48} - 1} = 0.81 > 0.8$$

$$\delta = \frac{p T_0}{p_0 T} = \frac{p}{p_0} \Rightarrow p = p_0 \delta = 1013 \cdot 0.986 = 998.82\ hPa$$

$$U' = \frac{B p s}{\ln \frac{A p s}{K}} = \frac{19 \cdot 0.99882 \cdot 24}{\ln \frac{645 \cdot 0.99882 \cdot 24}{13}} = 64.32\ kV$$

$$I = \frac{U}{R} = \frac{64.32 \cdot 10^3}{200 \cdot 10^6} = 321.6\ \mu A$$

② $C_t = 88\ \mu F$
$R_g = 2\ M\Omega$
$C_u' = 0.72\ \mu F$
$k_1 = 2.96$
$k_2 = 0.73$
$T_1 = 1.2\ \mu s$
$T_2 = 50\ \mu s$
$R_p, R_i, \eta = ???$

$$C_u = \frac{C_u'}{4} = \frac{0.72}{4} = 0.18\ \mu F$$

$$R_p = \frac{T_1 (C_u + C_t)}{k_1 C_u C_t} = \frac{1.2 \cdot 10^{-6} \cdot (0.18 \cdot 10^{-6} + 88 \cdot 10^{-12})}{2.96 \cdot 0.18 \cdot 10^{-6} \cdot 88 \cdot 10^{-12}} = 4609\ \Omega$$

$$R_i = \frac{T_2}{k_2 (C_u + C_t)} = \frac{50 \cdot 10^{-6}}{0.73 \cdot (0.18 \cdot 10^{-6} + 88 \cdot 10^{-12})} = 380.3\ \Omega$$

$$\eta = \frac{C_u}{C_u + C_t} = \frac{0.18 \cdot 10^{-6}}{0.18 \cdot 10^{-6} + 88 \cdot 10^{-12}} = 0.9995$$

③ $U_M = ?$
$s_0 = 12\ \mu m$
$E_M = 12\ kV/cm^2$
$\varepsilon_r = 2.8$

$$U_{M\,min} = E_{M\,min} \cdot s_0 = 0.4 \sqrt{\frac{12 \cdot 10^8}{8.854 \cdot 10^{-12} \cdot 2.8}} \cdot 12 \cdot 10^{-6} = 10.56\ kV$$

⑤ $L_1 = 19.5\ \mu H$
$C_1 = 7.2\ nF$
$C_2 = 8.52\ \mu F$
$\frac{U_2}{U_1} = ?$

$$\frac{U_2}{U_1} = \sqrt{\frac{L_2}{L_1}} = \sqrt{\frac{\frac{k_1 C_1}{C_2}}{L_1}} = 29$$

$$\frac{U_2}{U_1} = \sqrt{\frac{C_1}{C_2}}$$