ZADATAK 1

$T = 300\,K$

$n = 10^{15}\ cm^{-3}$

$p = ?$

$T = 550\,K$

$n, p = ?$

IZVOD:

$np = n_i^2$

$n + N_A = p + N_D$

$p = n - N_D$

$n(n - N_D) = n_i^2$

$n^2 - N_D n - n_i^2 = 0$

$n_{1,2} = \frac{N_D \pm \sqrt{N_D^2 + 4n_i^2}}{2}$

$n = \frac{N_D + \sqrt{N_D^2 + 4n_i^2}}{2}$

$n = 1,9 \cdot 10^{15}\ cm^{-3}$

$n_i = C_1 T^{\frac{3}{2}} \exp\left(-\frac{E_{g0}}{2kT}\right)$

$n_i = 1,44 \cdot 10^{10}\ cm^{-3}$

$np = n_i^2 \Rightarrow p = 209675\ cm^{-3}$

$n \gg n_i$

$N_D = 10^{15}$

$n_{i4} = 1,32 \cdot 10^{15}\ cm^{-3}$

$N_D = 10^{15}$

$np = n_i^2$

$p = 3,12 \cdot 10^{14}\ cm^{-3}$

ZADATAK 2.

$N_A = 1,5 \cdot 10^{15}\ cm^{-3}$

$N_D = 10^{15}\ cm^{-3}$

$T_1 = 300\,K$

$T_2 = 473\,K$

nakon pivog:

$n_i = 1,44 \cdot 10^{10}\ cm^{-3}$

$N_A \gg n_i \Rightarrow p = 1,5 \cdot 10^{15}$

$n = 138240$

$n_i = 1,35 \cdot 10^{14}\ cm^{-3}$

$N_A \gg n_i$

$p = N_A = 1,5 \cdot 10^{15}\ cm^{-3}$

$n = 1,21 \cdot 10^{13}\ cm^{-3}$

nakon drugog

$N_{Aneto} = N_A - N_D = 5 \cdot 10^{14}\ cm^{-3}$

$N_{Aneto} \gg n_i$

$p = N_{Aneto} = 5 \cdot 10^{14}\ cm^{-3}$

$n = 414720\ cm^{-3}$

$p = \frac{N_{Aneto} + \sqrt{N_{Aneto}^2 + 4n_i^2}}{2}$

$p = 5,34 \cdot 10^{14}\ cm^{-3}$

$n = 3,41 \cdot 10^{13}\ cm^{-3}$

$n_i = 4.96 \cdot 10^{11}\ cm^{-3}$

$n = 2.46 \cdot 10^{17}\ cm^{-3}$

$N_D = 2.46 \cdot 10^{17}\ cm^{-3}$

$n_i = 1.71 \cdot 10^{14}$

$N_D \geq n_i$

$n = 2.46 \cdot 10^{17}\ cm^{-3}$

$p = 1.19 \cdot 10^{11}$

ZADATAK 4.

$N_A = 1,5 \cdot 10^{15}\ cm^{-3}$

$N_D = 2 \cdot 10^{15}\ cm^{-3}$

$n_i = 1.44 \cdot 10^{10}\ cm^{-3}$

$T = 300\ K$

nakon prvog

$N_A >> n_i$

$p = N_A = 1,5 \cdot 10^{15}\ cm^{-3}$

$N_V = 3,67 \cdot 10^{19}$

$p_0 = N_V \exp\left(\frac{E_V - E_F}{E_T}\right)$

$\ln \frac{p_0}{N_V} = \frac{E_V - E_F}{E_T}$

$E_V - E_F = -0,261$

$E_F = E_V + 0,261 eV$

nakon drugog

$N_{Dneto} = N_D - N_A$

$N_{Dneto} = 5 \cdot 10^{14}$

$N_{Dneto} >> n_i$

$n = 5 \cdot 10^{14}$

$N_C = 3,67 \cdot 10^{19}$

$n_0 = N_c \exp\left(\frac{E_F - E_C}{E_T}\right)$

$E_F - E_C = -0.289$

$E_F = E_C - 0,289$

$E_F - E_C = -0,2$

$$n_0 = N_C \exp\left(\frac{E_F - E_C}{E_T}\right)$$

$$n_0 = 3,67 \cdot 10^{19} \exp\left(\frac{-0,2}{E_T}\right)$$

$n_0 = 1.6 \cdot 10^{16}\ cm^{-3}$ n-tip

$n \gg n_i \quad N_D = n = 1.6 \cdot 10^{16}\ cm^{-3}$

a) prema dnu vodljivog

$E_F - E_C = -0,1$

$n_0 = 7,68 \cdot 10^{17}\ cm^{-3}$

$N_{D2} = n - N_{D1} = 7.52 \cdot 10^{17}$

b) prema vrhu valentnog

$E_F - E_C = -0,3$

$n_{02} = 3,36 \cdot 10^{14}\ cm^{-3}$

$n_0 \gg n_i$

$n_{01} - n_{02} = N_{A0}$

$N_A = 1,566 \cdot 10^{16}\ cm^{-3}$

ZADATAK 6.

$T = 300\ K$
$n = 10^{15}\ cm^{-3}$
$\sigma = ?$ $T = 300\ K$ $T = 530\ K$

$\mu_n = 900\ cm^2/Vs$
$\mu_p = 350\ cm^2/Vs$

$\mu_{n2} = 0,8 \cdot 900 = 720\ cm^2/Vs$
$\mu_{p2} = 0,8 \cdot 350 = 280\ cm^2/Vs$

$n_i = 1.44 \cdot 10^{10}\ cm^{-3}$

$p = 207360$
$N_D = n$

$\sigma = q(\mu_n \cdot n + \mu_p \cdot p)$

$\sigma = 0.144\ S/cm$

$n_i = 7,74 \cdot 10^{14}\ cm^{-3}$

$N_D = 10^{15}\ cm^{-3}$

$n = \frac{N_D + \sqrt{N_D^2 + 4n_i^2}}{2}$

$n = 1,42 \cdot 10^{15}\ cm^{-3}$

$p = 4.2 \cdot 10^{14}\ cm^{-3}$

$\sigma = q(\mu_n \cdot n + \mu_p \cdot p)$

$\sigma = 0,182\ S/cm$

$N_{K2} = 2 \cdot 10^{15}\ cm^{-3}$

$T = 300\ K$

$\mu_n = 900\ cm^2/Vs$

$\mu_p = 350\ cm^2/Vs$

a) $N_{K1} = N_{D1}$

$N_{K2} = N_{D2}$

$$\sigma = q \cdot \underbrace{(N_{D1} + N_{D2})}_{\approx n} \cdot \mu_n$$

$\sigma = 0{,}504\ S/cm$

b) $N_{K1} = N_D$

$N_{K2} = N_A$

$N_{Aneto} = 3 \cdot 10^{14}$

$N_{Aneto} \approx p$

$n = \frac{n_i^2}{p} = 414720$

$\sigma = q \cdot p \cdot \mu_p$

$\sigma = 0{,}028\ S/cm$

ZADATAK 8.

$R = R_\square = \frac{1}{\sigma} \cdot \frac{l}{S}$

$l = 10\ \mu m = 10^{-3}\ cm$

$S = 0{,}1\ mm^2 = 10^{-3}$

$N_A = 10^{15}\ cm^{-3}$

$N_D = 9 \cdot 10^{14}\ cm^{-3}$

$\mu_n = 900$

$\mu_p = 350\ cm^2/Vs$

$T_1 = 300\ K$

$T_2 = 450\ K$

T_1

$N_{Aneto} = 10^{14}\ cm^{-3}$

$N_A \gg n_i$

$N_A \approx p$

$n = 2 \cdot 10^6\ cm^{-3}$

$\sigma = q \cdot \mu_p \cdot p$

$= 5{,}6 \cdot 10^{-3}\ S/cm$

$R_\square = \frac{1}{\sigma} \cdot \frac{l}{S}$

$R_\square = 179\ \Omega$

T_2

$n_i = 5{,}91 \cdot 10^{13}$

$p = \frac{N_A + \sqrt{N_A^2 + 4n_i^2}}{2}$

$p = 1{,}37 \cdot 10^{14}\ cm^{-3}$

$n = 2{,}74 \cdot 10^{13}\ cm^{-3}$

$\sigma = q \cdot (\mu_p \cdot p + \mu_n \cdot n)$

$= 0{,}011$

$R_\square = 90.4\ \Omega$

driftna struja

$I_D = q \cdot p \cdot \mu_p \cdot S \cdot F = 6 \cdot S \cdot F$

$= 18,43 \text{ mA}$

ZADATAK 10

$J(x=0)$

$p_0 = 10^5 \text{ cm}^{-3}$

$p_1 = 5 \cdot 10^{17} \text{ cm}^{-3}$

$a = 10 \text{ } \mu\text{m}$

$\mu_p = 330 \text{ cm}^2/\text{Vs}$

$T = 300 \text{ K}$

$D_p = \mu_p \cdot U_T$

$= 9,32 \text{ cm}^2/\text{s}$

$p(x) = p_0 + (p_1 - p_0) \cdot e^{-\frac{x}{a}}$

$J_{Dp} = -q \cdot D_p \cdot \frac{dp(x)}{dx}$

$= -q \cdot D_p \cdot \left(-\frac{1}{a}(p_1 - p_0) \cdot e^{-\frac{x}{a}}\right)$

$= q \cdot D_p \cdot \frac{(p_1 - p_0)}{a} \cdot e^{-\frac{x}{a}}$

$p_1 \gg p_0$

$= q \cdot D_p \frac{p_1}{a} \cdot e^{-\frac{x}{a}}$

$= 7,86 \cdot 10^{-3} \text{ A/cm}^3$

$J_{Dp}(x) = J_{Dp}(0) \cdot e^{-\frac{x}{a}}$

$0,1 J_{Dp}(0) = J_{Dp}(0) \cdot e^{-\frac{x}{a}}$

$x = 2,3 \cdot 10^{-3} \text{ cm}$

VJ. 1. $T = 300 \text{ K}$

$p = 5 \cdot 10^{15} \text{ cm}^{-3}$

$n(300) = \frac{n_i(300)^2}{p}$

$n = 4147 \text{ cm}^{-3}$

$p \approx N_A = 5 \cdot 10^{15} \text{ cm}^{-3}$

$T = 550 \text{ K}$

$n_i = 1,32 \cdot 10^{15} \text{ cm}^{-3}$

$N_A = 5 \cdot 10^{15} \text{ cm}^{-3}$

$p = \frac{N_A + \sqrt{N_A^2 + 4n_i^2}}{2}$

$p = 5,33 \cdot 10^{15} \text{ cm}^{-3}$

$n = 3,27 \cdot 10^{14} \text{ cm}^{-3}$

VJ. 2. $T = 350 \text{ K}$

$p = 10^7 \text{ cm}^{-3}$

$n_i = 4,96 \cdot 10^{11} \text{ cm}^{-3}$

$n = 2,46 \cdot 10^{16} \text{ cm}^{-3}$

$N_D \approx 2,46 \cdot 10^{16} \text{ cm}^{-3}$

$T = 550$

$n_i = 1,32 \cdot 10^{15} \text{ cm}^{-3}$

$n = \frac{N_D + \sqrt{N_D^2 + 4n_i^2}}{2}$

$n = 1,36 \cdot 10^{16} \text{ cm}^{-3}$

$p = 10^{15}\ cm^{-3}$

$n_i = 3,24 \cdot 10^{14}\ cm^{-3}$

$n = 1,05 \cdot 10^{14}\ cm^{-3}$

$n + N_A = p + N_D$

$N_{A neto} = p - n$

$= 3,95 \cdot 10^{14}$

$n_i = 1,44 \cdot 10^{10}\ cm^{-3}$

$N_A \approx p \approx 8,95 \cdot 10^{14}\ cm^{-3}$

$n = 2,32 \cdot 10^{5}\ cm^{-3}$

V J. 4.

$T = 450\ K$

$n = 10^{12}\ cm^{-3}$

$n_i = 5,92 \cdot 10^{13}\ cm^{-3}$

$p = 3,5 \cdot 10^{15}$

$N_A \approx p$

$T = 300\ K$

$n_i = 1,44 \cdot 10^{10}\ cm^{-3}$

$p \approx 3,5 \cdot 10^{15}\ cm^{-3}$

$n = 5,92 \cdot 10^{4}\ cm^{-3}$

V J. 5.

$T = 450\ K$

$n = 10^{11}\ cm^{-3}$

$n_i = 5,92 \cdot 10^{13}\ cm^{-3}$

$p = 3,5 \cdot 10^{16}\ cm^{-3}$

$N_A \approx 3,5 \cdot 10^{16}\ cm^{-3}$

V J. 6.

$T = 350\ K$

$n = 10^{17}\ cm^{-3}$

$n_i = 4,96 \cdot 10^{11}\ cm^{-3}$

$p = 2,46 \cdot 10^{6}\ cm^{-3}$

$N_D \approx 10^{17}\ cm^{-3}$

V J. 7.

$T = 200\ K$

$p = 10^{13}\ cm^{-3}$

$n_i = 7,5 \cdot 10^{4}\ cm^{-3}$

$p >> n_i$

$N_A = 10^{13}\ cm^{-3}$

Vj. 8.

$N_A = 10^{\quad} cm^{-3}$

$N_D = 1{,}35 \cdot 10^{13}\ cm^{-3}$

$T = 300\ K$

$N_{Dneto} = 2{,}5 \cdot 10^{14}\ cm^{-3}$

$n_i = 1{,}44 \cdot 10^{10}\ cm^{-3}$

$n \approx N_D >> n_i$

$n = 2{,}5 \cdot 10^{14}\ cm^{-3}$

$p = 3{,}29 \cdot 10^{5}\ cm^{-3}$

$T = 473\ K$

$n_i = 1{,}35 \cdot 10^{14}\ cm^{-3}$

$n = \frac{N_{Dneto} + \sqrt{N_{Dneto}^2 + 4n_i^2}}{2}$

$n = 3{,}09 \cdot 10^{14}\ cm^{-3}$

$p = 5{,}89 \cdot 10^{13}\ cm^{-3}$

Vj. 9.

$N_A = 1{,}5 \cdot 10^{15}\ cm^{-3}$

$N_D = 10^{15}\ cm^{-3}$

$T = 300\ k$

$n_i = 1{,}44 \cdot 10^{10}\ cm^{-3}$

$N_{Aneto} = 5 \cdot 10^{14}\ cm^{-3} >> n_i$

$p = 5 \cdot 10^{14}\ cm^{-3}$

$n = 4{,}15 \cdot 10^{5}\ cm^{-3}$

$T = 450\ k$

$n_i = 5{,}92 \cdot 10^{13}\ cm^{-3}$

$p = \frac{N_{Aneto} + \sqrt{N_{Aneto}^2 + 4n_i^2}}{2}$

$p = 5{,}07 \cdot 10^{14}\ cm^{-3}$

$n = 6{,}91 \cdot 10^{13}$

Vj. 10.

$T = 300\ K$

$n = 5 \cdot 10^{7}\ cm^{-3}$

$n_i = 1{,}44\ 10^{10}\ cm^{-3}$

$p = 4{,}15 \cdot 10^{14}\ cm^{-3}$

$N_{A1} \approx 4{,}15 \cdot 10^{14}\ cm^{-3}$

$T = 450\ K$

$n_i = 5{,}92 \cdot 10^{13}$

$n = 5 \cdot 10^{7}\ cm^{-3}$

$p = 7 \cdot 10^{19}$

$N_{A2} \approx 7 \cdot 10^{19}$

$N_{AU} = N_{A2} - N_{A1} \approx N_{A2}$

$= 7 \cdot 10^{19}\ cm^{-3}$

Vj. 11.

$T = 300\ K$

$p = 10^{15}\ cm^{-3}$

$n_i = 1{,}44 \cdot 10^{10}\ cm^{-3}$

$n = 207360$

$N_A \approx 10^{15}$

$T = 550$

$n_i = 1{,}32 \cdot 10^{15}\ cm^{-3}$

$p = 10^{15}$

$n = 1{,}74 \cdot 10^{15}$

$n + N_A = p + N_D$

$N_D = 1{,}74 \cdot 10^{15}\ cm^{-3}$

$E_F - E_C = -0.18\,eV$

$N_C = C T^{\frac{3}{2}} = 3,67 \cdot 10^{19}$

$n = N_C \exp\left(\frac{E_F - E_C}{E_T}\right)$

$n = 3,49 \cdot 10^{16}\ cm^{-3}$

$p = 5941$

$N_D = 3,49 \cdot 10^{16}\ cm^{-3}$

$0,18 + E_V = E_F$

$E_V - E_F = -0,18$

$p = 3,49 \cdot 10^{16}\ cm^{-3}$

$N_A = 3,49 \cdot 10^{16}\ cm^{-3}$

$N_{DA} = N_A + N_D$
$= 6,98 \cdot 10^{16}\ cm^{-3}$

VI. 13. $T = 300\ K$

$n = 10^{15}\ cm^{-3}$

$n >> n$

$N_D = 10^{15}$

$N_n = 450\ cm^2/Vs$

$N_p = 220\ cm^2/Vs$

$n_i = 1,44 \cdot 10^{10}\ cm^{-3}$

$T = 523\ K$

$n_i = 7,31 \cdot 10^{14}\ cm^{-3}$

$n = \frac{N_D + \sqrt{N_D^2 + 4 n_i^4}}{2}$

$n = 1,39 \cdot 10^{15}\ cm^{-3}$

$p = 3,84 \cdot 10^{14}$

$\sigma = q(N_n \cdot n + N_p \cdot p)$

$= 0,114\ S/cm$

VI. 14 $T = 300\ K$

$n = 10^4\ cm^{-3}$

$n_i = 1,44 \cdot 10^{10}\ cm^{-3}$

$p = 2,07 \cdot 10^{16}\ cm^{-3}$

$N_A = 2,07 \cdot 10^{16}\ cm^{-3}$

$T = 400\ K$

$N_n = 800\ cm^2/Vs$

$N_p = 320\ cm^2/Vs$

$n_i = 7,23 \cdot 10^{18}\ cm^{-3}$

$p = N_A = 2,07 \cdot 10^{16}$

$n = 2,52 \cdot 10^{2}$

$\sigma = q \cdot N_p \cdot p$

$\sigma = 1,06\ S/cm$

$n = 10 \cdot p$

$n_i = 6{,}75 \cdot 10^{14}\ cm^{-3}$

$n \cdot p = n_i^2$

$10\ p^2 = n_i^2$

$p = 2{,}13 \cdot 10^{14}$

$n = 2{,}13 \cdot 10^{15}$

$p + N_D = n + N_A$

$N_D - N_A = 1{,}917 \cdot 10^{15}\ cm^{-3} = N_{Dnetto}$

$\mu_n = 900\ cm^2/Vs$

$\mu_p = 350\ cm^2/Vs$

$n = 1{,}917 \cdot 10^{15}$

$\sigma = q \cdot n \cdot \mu_n$

$\sigma = 0{,}276\ S/cm$

VL. 16.

$T = 400K$

$p = n \cdot 10^5$

$n_i = 7{,}23 \cdot 10^{10}\ cm^{-3}$

$n^2 \cdot 10^5 = n_i^2$

$n = 2{,}28 \cdot 10^{10}\ cm^{-3}$

$p = 2{,}28 \cdot 10^{15}\ cm^{-3} \gg n$

$N_A = 2{,}28 \cdot 10^{15}\ cm^{-3}$

$T = 300K$

$\mu_n = 900\ cm^2/Vs$

$\mu_p = 350\ cm^2/Vs$

$p = 2{,}28 \cdot 10^{15}\ cm^{-3}$

$\sigma = q \cdot p \cdot \mu_p$

$= 0{,}128\ S/cm$

$\rho = ?$

$\rho = \frac{1}{\sigma} = 7{,}83\ \Omega cm$

VL. 17

$T = 550$

$\sigma = 0{,}28\ S/cm$

$\sigma = q \cdot (\mu_n \cdot n + \mu_p \cdot p)$

$n_i = 1{,}32 \cdot 10^{15}\ cm^{-3}$

$\frac{\sigma}{q} = \mu_n \cdot n + \mu_p \cdot \frac{n_i^2}{n} \mid \cdot n$

$\frac{\sigma}{q} \cdot n = \mu_n \cdot n^2 + \mu_p \cdot n_i^2$

$900\ n^2 - 1.75 \cdot 10^{18} n + 6{,}0934 \cdot 10^{32} = 0$

$\rightarrow n_1 = 1{,}49 \cdot 10^{15}\ cm^{-3}$

$n_2 = 4{,}55 \cdot 10^{14}\ cm^{-3}$

$\rightarrow p_1 = 1{,}17 \cdot 10^{15}\ cm^{-3}$

$p_2 = 3{,}33 \cdot 10^{15}\ cm^{-3}$

$N_{D_2} = N_D - N_{Anetto} = 1{,}62 \cdot 10^{15}$

$N_1 = 3{,}4 \cdot 10^{14}$

$T = 300K$

$\sigma = 0{,}28\ S/cm$

$n_i = 1.44 \cdot 10^{10}\ cm^{-3}$

$900 n^2 - 1.75 \cdot 10^{13} n + 725 \cdot 10^{22} = 0$

$n_1 = 1{,}94 \cdot 10^{13}$

$n_2 = 4{,}1428 \cdot 57$

$N_D = 1{,}94 \cdot 10^{15}\ cm^{-3}$

$\mu_n = 900\ cm^2/Vs$

$\mu_p = 350\ cm^2/Vs$

$N_A = 10^{15}\ cm^{-3}$

$N_D = 1.1 \cdot 10^{15}\ cm^{-3}$

$N_{D neto} = 10^{14}\ cm^{-3}$

$T_1 = 300$ $\quad T_2 = 450\ K$

$\mu_p = 330\ cm^2/Vs$ $\quad \mu_p = 297.5\ cm^2/Vs$

$\mu_n = 900\ cm^2/Vs$ $\quad \mu_n = 765\ cm^2/Vs$

$n_i = 1,44 \cdot 10^{10}\ cm^{-3}$ $\quad n_i = 3,92 \cdot 10^{13}\ cm^{-3}$

$n = N_{D neto}$ $\quad n = \dfrac{N_{neto} + \sqrt{N_{Dneto}^2 + 4n_i^2}}{2}$

$\sigma = q \cdot n \cdot \mu_n$ $\quad n = 1,27 \cdot 10^{14}\ cm^{-3}$

$\sigma = 0,0144\ S/cm$ $\quad p = 2,75 \cdot 10^{13}$

$\sigma = 0,0169\ S/cm$

VJ. 19

$N_{x1} = 5 \cdot 10^{16}\ cm^{-3}$

$N_{x2} = 10^{17}$

$\sigma = ?$ $\quad \varrho = ?$

$\mu_n = 900\ cm^2/Vs$

$\mu_p = 350\ cm^2/Vs$

a) najveći $\Rightarrow$ σ_{min} $\quad n_i = 1,44\ 10^{10}\ cm^{-3}$

$N_{x1} = N_{D1}$ $\quad N_{A neto} = 5 \cdot 10^{16}$

$N_{x2} = N_A$ $\quad p = 5 \cdot 10^{16}$

$\sigma = 2,8\ S/cm$

$\varrho = 0,357\ \Omega cm$

b) najmanji $\Rightarrow \sigma_{max}$

$N_{x1} = N_{D1}$ $\quad N_D = 1,5 \cdot 10^{17}\ cm^{-3}$

$N_{x2} = N_{D2}$

$\sigma = 21,6\ S/cm$

$\varrho = 0,0463\ \Omega cm$

VJ 20.

$l = 10\ \mu m = 10^{-3}\ cm$

$S = 1\ \mu m^2 = 10^{-8}\ cm^2$

$\sigma = 100\ S/cm$

$U = 1,8\ V$

$R = \dfrac{U}{I}$

$I = \dfrac{U}{R} = 1,8 \cdot 10^{-3}\ A$

$R = \varrho \cdot \dfrac{l}{S} = \dfrac{1}{\sigma} \cdot \dfrac{l}{S}$

$R = 1000\ \Omega$

ZADATAK 1.

$T = 300K$
$d_B = ?$
$U = 0V$
$N_A = 10^{17}\ cm^{-3}$
$N_D = 10^{16}\ cm^{-3}$
$C_B = ?$
$S = 5\ \mu m^2$

$n_i = 1{,}44 \cdot 10^{10}\ cm^{-3}$

$p_{op} \approx N_A = 10^{17}\ cm^{-3}$ $\quad n_{on} = N_D = 10^{16}\ cm^{-3}$

$$U_k = U_T \cdot \ln\left(\frac{n_{on} \cdot p_{op}}{n_i^2}\right) = 0{,}755\ V$$

$$d_D = \sqrt{\frac{2 \cdot \varepsilon_0 \cdot \varepsilon_r}{e} \cdot \left(\frac{1}{N_A} + \frac{1}{N_D}\right)(U_k - U)} = 0{,}328\ \mu m$$

$$C_B = \varepsilon_0 \cdot \varepsilon_r \cdot \frac{S}{d_B} = 1{,}58\ fF$$

ZADATAK 2.

$N_D = 10^{17}\ cm^{-3}$
$N_A = 10^{15}\ cm^{-3}$
$\mu_n = 900\ cm^2/Vs$
$\mu_p = 300\ cm^2/Vs$
$\tau_n = 1\ \mu s$
$\tau_p = 0{,}5\ \mu s$
$S = 1\ mm^2$
$T = 300\ K$
$I_s = ?$
$W_n \gg L_p$
$W_p \gg L_n$

$$I_s = e \cdot S\left(D_n \frac{n_{op}}{L_n} + D_p \frac{p_{on}}{L_p}\right)$$

$$n_{op} = \frac{n_i^2}{N_A} = 207360\ cm^{-3}$$

$$p_{on} = \frac{n_i^2}{N_D} = 2073.6\ cm^{-3}$$

$D_n = \mu_n \cdot U_T = 23{,}28\ cm^2/s$

$D_p = \mu_p \cdot U_T = 7{,}76\ cm^2/s$

$L_n = \sqrt{D_n \tau_n} = 48{,}25\ \mu m$

$L_p = \sqrt{D_p \tau_p} = 19{,}7\ \mu m$

$I_s = 1{,}63 \cdot 10^{-12}\ A$

$$I = I_s\left(\exp\left(\frac{U}{m U_T}\right) - 1\right)$$

$I = 0{,}41\ mA$

$N_D = 10^{15}\ cm^{-3}$
$N_A = 10^{17}\ cm^{-3}$

$\mu_n = 700\ cm^2/Vs$
$\mu_p = 350\ cm^2/Vs$

$\tau_n = 0{,}5\ \mu s$
$\tau_p = 1\ \mu s$
$S = 1\ mm^2$

$T = 300\ K$
$U = 0{,}3\ V$
$m = 1$

$L_p \gg W_n = 1\ \mu m$

$L_n \gg W_p = 2\ \mu m$

$$I_S = q \cdot S \cdot \left(D_n \frac{n_{op}}{W_p} + D_p \frac{p_{on}}{W_n} \right)$$

$n_{op} = 2073{,}6\ cm^{-3}$
$p_{on} = 207360\ cm^{-3}$

$D_n = 18{,}1\ cm^2/s$
$D_p = 9{,}05\ cm^2/s$

$I_S = 3{,}03 \cdot 10^{-11}\ A$

$$I = I_S \left(\exp \frac{U}{m U_T} - 1 \right)$$

$= 7{,}55 \cdot 10^{-3}\ A$

ZADATAK 4.

$N_D = 10^{17}\ cm^{-3}$
$N_A = 10^{15}\ cm^{-3}$

$\mu_n = 900\ cm^2/Vs$
$\mu_p = 300\ cm^2/Vs$

$\tau_n = 1\ \mu s$
$\tau_p = 0{,}5\ \mu s$

$S = 1\ mm^2$
$T = 300\ K$
$I_S = ?$
$U = 0{,}4\ V$
$m = 1$

$L_p \gg W_n = 1\ \mu m$
$L_n \ll W_p$

$L_n = \sqrt{D_n \cdot \tau_n} = 4{,}82 \cdot 10^{-3}\ cm$

$n_{op} = 207360\ cm^{-3}$
$p_{on} = 2073.6\ cm^{-3}$

$D_n = 23.28\ cm^2/s$
$D_p = 7{,}76\ cm^2/s$

$$I_S = q \cdot S \left(D_n \frac{n_{op}}{L_n} + D_p \frac{p_{on}}{W_n} \right)$$

$= 1{,}86 \cdot 10^{-16}\ A$

$$I = I_S \cdot \left(\exp \left(\frac{U}{m U_T} \right) - 1 \right)$$

$= 4{,}63 \cdot 10^{-4}\ A$

ZADATAK 5.

$N_D = 10^{15}\ cm^{-3}$
$N_A = 10^{17}\ cm^{-3}$

$\mu_n = 700\ cm^2/Vs$
$\mu_p = 350\ cm^2/Vs$

$\tau_n = 0{,}5\ \mu s$
$\tau_p = 1\ \mu s$

$S = 1\ mm^2$
$T = 300\ K$
$I_S = ?$
$U = 0{,}5\ V$

$$I = I_S\left(\exp\frac{U}{m U_T} - 1\right)$$

$= 3{,}98 \cdot 10^{-4}\ A$

$L_p << W_n$

$L_n >> W_p = 1\ \mu m$

$$I_S = q \cdot S\left(D_n \frac{n_{op}}{W_p} + D_p \frac{p_{on}}{L_p}\right)$$

$$n_{op} = \frac{n_i^2}{N_A} = 2073\ cm^{-3}$$

$$p_{on} = \frac{n_i^2}{N_D} = 207360\ cm^{-3}$$

$D_n = 18{,}1\ cm^2/s$

$D_p = 9{,}05\ cm^2/s$

$L_p = \sqrt{D_p \cdot \tau_p} = 3 \cdot 10^{-3}\ cm$

$I_S = 1{,}6 \cdot 10^{-12}\ A$

ZADATAK 6.

$N_D = 10^{17}\ cm^{-3}$
$N_A = 5 \cdot 10^{19}\ cm^{-3}$

$\mu_n = 350\ cm^2/Vs$
$\mu_p = 300\ cm^2/Vs$

$\tau_n = 1{,}2\ \mu s$
$\tau_p = 9{,}2\ \mu s$

$S = 1\ mm^2$

$T = 300\ K$

$r = ?,\ U = 0{,}5\ V \rightarrow$ nacrtati
$U = 50\ mV$

$L_p >> W_n = 1\ \mu m$

$L_n >> W_p = 2\ \mu m$

$$I_S = q \cdot S\left(D_n \frac{n_{op}}{W_p} + D_p \frac{p_{on}}{W_n}\right)$$

$n_{op} = 41473\ cm^{-3}$
$p_{on} = 2073\ cm^{-3}$

$I_S = 7{,}65 \cdot 10^{-12}\ A$

$$I = I_S\left(\exp\frac{U}{U_T} - 1\right)$$

$D_n = 21{,}93\ cm^2/s$
$D_p = 7{,}76\ cm^2/s$

$I_1^{0,5} = 1{,}9 \cdot 10^{-3}\ A$

$I_2 = 4{,}52 \cdot 10^{-11}\ A$

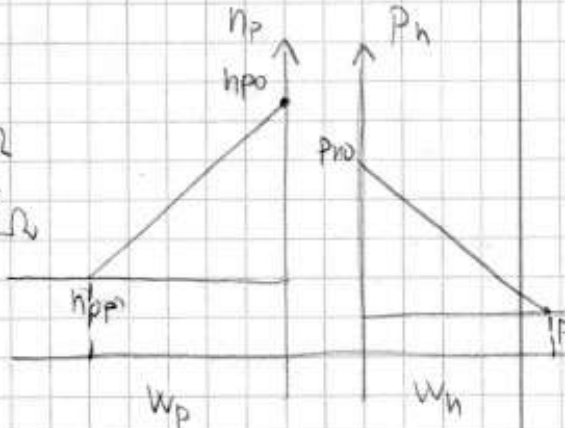
$$r_d = \frac{U_T}{I + I_S}$$

$r_{d1} = 13{,}61\ \Omega$

$r_{d2} = 489 \cdot 10^6\ \Omega$

$n_{po} = 1{,}03 \cdot 10^{13}\ cm^{-3}$

$p_{no} = 5{,}16 \cdot 10^{11}\ cm^{-3}$



ZADATAK 7.

$T = 300\,K$

$I_S = 1 \cdot 10^{-12}\,A$

$R_S = 10\,\Omega$

$I = 1\,mA$

$U = ?$

$U = U_D + I \cdot R_S$

$I = I_S\left(e^{\frac{U_D}{U_T}} - 1\right)$

$\frac{I}{I_S} + 1 = e^{\frac{U_D}{U_T}}$

$U_D = U_T \cdot \ln\left(\frac{I}{I_S} + 1\right)$

$= 0,536\,V$

$U = 0,546\,V$

ZADATAK 8.

$I_S = 1\,pA = 10^{-12}\,A$

$i_D = 1,5\,[mA] + 0,25\sin(\omega t)\,[mA]$

$U_T = 25\,mV$

$U = U_D + I \cdot R_S = 0,545\,V$

$I \cdot R_S = 1,5\cdot 10^{-3} \cdot 10$

$= 0,015$

$U_D = U_T \ln\left(\frac{I}{I_S} + 1\right)$

$= 0,53\,V$

$u_d = i_d r_d + i_d R_S = i_d(r_d + R_S)$

$= 6,67\,mV$

$u_D = 0,545\,[V] + 6,67\sin\omega t\,[mV]$

ZADATAK 9.

$U = 60\,mV$

$U_1, U_2 = ?$

$I_S = 10\,pA$

$U_T = 25\,mV$

$m = 1$

$U = U_1 + U_2$

$U_1 = U - U_2$

$I_{D1} = I_S\left(\exp\left(\frac{U_1}{U_T}\right) - 1\right)$

$I_{D2} = I_S\left(\exp\left(\frac{U_2}{U_T}\right) - 1\right)$

$I_{D3} = I_S\left(\exp\left(\frac{-U_2}{U_T}\right) - 1\right)$

$I_{D1} + I_{D3} = I_{D2}$

$\exp\frac{U_1}{U_T} + \exp\frac{-U_2}{U_2} - 1 = \exp\frac{U_2}{U_T}$

$U_2 = 27,47\,mV$

$U_1 = 32,53\,mV$

$\frac{12,02}{x} - 1 = x \;/\cdot x$

$12,02 - x = x^2$

$x_1 = 3$

$x_2 \not= 4$

$\exp\frac{U}{U_T} = \exp\frac{U_2}{U_1} + \exp\frac{-U_2}{U_2} - 1 = \exp\frac{U_2}{U_T}$

$\frac{\exp\frac{U}{U_T} + 1}{\exp\frac{U_2}{U_T} = x} - 1 = \exp\frac{U_2}{U_T}$

Vj. 1.

$d_B = ?$
$T = 300\ K$
$U = 0\ V$
$S = 25\ \mu m^2$
$C_B = ?$

$N_A = 5 \cdot 10^{17}\ cm^{-3}$
$N_D = 10^{16}\ cm^{-3}$
$n_i = 1{,}44\ 10^{10}\ cm^{-3}$
$U_K = 0{,}797\ V$
$d_B = 3{,}24 \cdot 10^{-5}\ cm$

$C_B = \varepsilon \frac{S}{d_B}$
$= 7.98 \cdot 10^{-15}\ F$

Vj. 2

$T = 300\ K$
$U = -3$
$S = 50\ \mu m^2$
$d_B, C_B = ?$

$\varepsilon = \varepsilon_{Si} \cdot \varepsilon_0$

$N_A = 5 \cdot 10^{16}\ cm^{-3}$
$N_D = 10^{15}\ cm^{-3}$

$U_K = U_T \ln\left(\frac{N_A \cdot N_D}{n_i^2}\right)$
$= 0{,}68\ V$

$d_B = \sqrt{\frac{2 \cdot \varepsilon_{Si} \varepsilon_0}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right)(U_K - U)}$

$d_B = 2{,}2 \cdot 10^{-4}\ cm$

$C_B = \varepsilon \cdot \frac{S}{d_B} = 2{,}35 \cdot 10^{-15}\ F$

Vj. 3.

$T = 300\ K$
$U = 0{,}3\ V$
$S = 50\ \mu m^2$
$d_B, C_B = ?$

$N_A = 5 \cdot 10^{16}\ cm^{-3}$
$N_D = 10^{15}\ cm^{-3}$

$U_K = U_T \ln\left(\frac{N_A N_D}{n_i^2}\right)$
$= 0{,}68\ V$

$d_B = 7{,}08 \cdot 10^{-5}\ cm$

$C_B = \varepsilon \cdot \frac{S}{d_B} = 7{,}3 \cdot 10^{-15}\ F$

Vj. 4.

$T = 350\ K$
$U = 0\ V$
$S = 100\ \mu m^2$
$d_B, C_B = ?$

$n_i = 4{,}96 \cdot 10^{11}\ cm^{-3}$

$N_A = 5 \cdot 10^{17}\ cm^{-3}$
$N_D = 5 \cdot 10^{15}\ cm^{-3}$
$U_K = 0{,}695$

$d_B = 4{,}26 \cdot 10^{-5}$

$C_B = 2{,}4 \cdot 10^{-14}\ F$

Vj. 5

$T = 350\ K$
$U = -2\ V$
$S = 100\ \mu m^2$

$d_B, C_B = ?$

$n_i = 4{,}96 \cdot 10^{11}\ cm^{-3}$

$N_A = 5 \cdot 10^{17}$
$N_D = 5\ 10^{15}\ cm^{-3}$

$U_K = 0{,}596$

$d_B = 3{,}24 \cdot 10^{-5}\ cm^{-3}$

$C_B = 1{,}26 \cdot 10^{-14}\ F$

$N_D = 5 \cdot 10^{17}\ cm^{-3}$
$N_A = 10^{16}\ cm^{-3}$

$\mu_n = 800\ cm^2/Vs$
$\mu_p = 280\ cm^2/Vs$

$\tau_n = 0{,}8\ \mu s$
$\tau_p = 0{,}6\ \mu s$

$S = 1\ mm^2$
$T = 300\ K$
$I_s = ?$
$U = 0{,}6\ V$
$I_D = ?$

$w_n >> L_p \qquad w_p >> L_n$

$n_{op} = 2736\ cm^{-3}$
$p_{on} = 414{,}72\ cm^{-3}$

$D_n = 20{,}69\ cm^2/s$
$D_p = 7{,}24\ cm^2/s$

$L_n = 4 \cdot 10^{-3}\ cm$
$L_p = 1{,}9 \cdot 10^{-3}\ cm$

$$I_S = q \cdot S \left(D_n \frac{n_{op}}{L_n} + D_p \frac{p_{on}}{L_p} \right)$$

$I_S = 1{,}74 \cdot 10^{-13}\ A$

$$I = I_S \left(\exp \frac{U}{U_T} - 1 \right)$$

$I = 2{,}07 \cdot 10^{-3}\ A$

Vs. 7

$N_D = 5 \cdot 10^{17}\ cm^{-3}$
$N_A = 10^{16}\ cm^{-3}$

$\mu_n = 800\ cm^2/Vs$
$\mu_p = 230\ cm^2/Vs$

$\tau_n = 0{,}8\ \mu s$
$\tau_p = 0{,}5\ \mu s$

$S = 1\ mm^2$
$T = 360\ K$

$U = 0{,}6\ V$

$n_i = 4{,}96 \cdot 10^{11}\ cm^{-3}$

$w_n >> L_p \qquad w_p >> L_p$

$n_{op} = 2{,}46 \cdot 10^2\ cm^{-3}$
$p_{on} = 492032$

$D_n = 24{,}14\ cm^2/s$
$D_p = 3{,}45\ cm^2/s$

$L_n = 4{,}39 \cdot 10^{-3}\ cm$
$L_p = 2{,}06 \cdot 10^{-3}\ cm$

$$I_S = q \cdot S \left(D_n \frac{n_{op}}{L_n} + D_p \frac{p_{on}}{L_p} \right)$$

$= 2{,}19 \cdot 10^{10}\ A$

$I = 0{,}095\ A$

$N_D = 5 \cdot 10^{15}\ cm^{-3}$
$N_A = 10^{17}\ cm^{-3}$

$\mu_n = 700\ cm^2/Vs$
$\mu_p = 320\ cm^2/Vs$

$\tau_n = 0{,}5\ \mu s$
$\tau_p = 0{,}8\ \mu s$

$S = 0{,}1\ mm^2$
$T = 300\ K$

$U = 0{,}5\ V$

$L_p >> W_n = 1{,}5\ \mu m$ $\quad L_n >> W_p = 2\ \mu m$

$n_{op} = 2073\ cm^{-3}$
$p_{on} = 41472\ cm^{-3}$

$D_n = 18{,}1\ cm^2/s$
$D_p = 8{,}28\ cm^2/s$

$$I_S = q \cdot S \cdot \left(D_n \frac{n_{op}}{W_p} + D_p \frac{p_{on}}{W_n} \right)$$
$$= 3{,}96 \cdot 10^{-13}\ A$$

$$I = 9{,}87 \cdot 10^{-5}\ A$$

VJ. 9.

$N_D = 5 \cdot 10^{15}\ cm^{-3}$
$N_A = 10^{17}\ cm^{-3}$

$\mu_n = 600\ cm^2/Vs$
$\mu_p = 300\ cm^2/Vs$

$\tau_n = 0{,}5\ \mu s$
$\tau_p = 0{,}8\ \mu s$

$S = 0{,}1\ mm^2$
$T = 350\ K$
$U = 0{,}5\ V$
$n_i = 4{,}96 \cdot 10^{11}\ cm^{-3}$

$L_p >> W_n = 1{,}5\ \mu m$ $\quad L_n >> W_p = 2\ \mu m$

$n_{op} = 2460160\ cm^{-3}$
$p_{on} = 49203200\ cm^{-3}$

$D_n = 13{,}1\ cm^2/s$
$D_p = 9{,}05\ cm^2/s$

$$I_S = q \cdot S \left(D_n \frac{n_{op}}{W_p} + D_p \frac{p_{on}}{W_n} \right)$$
$$I_S = 5{,}1 \cdot 10^{-10}\ A$$

$$I = 8{,}03 \cdot 10^{-3}\ A$$

VJ. 10.

$N_D = 5 \cdot 10^{17}\ cm^{-3}$
$N_A = 10^{16}\ cm^{-3}$

$\mu_n = 300\ cm^2$
$\mu_p = 280\ cm^2/Vs$

$\tau_n = 0{,}8\ \mu s$

$\tau_p = 0{,}4\ \mu s$

$S = 0{,}1\ mm^2$
$T = 300\ K$
$U = 0{,}5\ V$

$L_p >> W_n = 2\ \mu m$ $\quad L_n << W_p$

$n_{op} = 20736\ cm^{-3}$
$p_{on} = 414\ cm^{-3}$

$D_n = 20{,}69\ cm^2/Vs$
$D_p = 7{,}24\ cm^2/Vs$

$L_n = 4{,}07 \cdot 10^{-3}\ cm.$

$$I_S = q \cdot S \cdot \left(D_n \frac{n_{op}}{L_n} + D_p \frac{p_{on}}{W_n} \right)$$
$$= 1{,}93 \cdot 10^{-14}\ A$$

$$I = 4{,}79 \cdot 10^{-6}\ A$$

VS. 11.

$N_D = 10^{16}\ cm^{-3}$
$N_A = 5 \cdot 10^{17}\ cm^{-3}$
$\mu_n = 500\ cm^2/Vs$
$\mu_p = 350\ cm^2/Vs$

$\tau_n = 0,4\ \mu s$
$\tau_p = 0,3\ \mu s$

$S = 0,1\ mm^2$
$I_S = ?$
$T = 300\ K$
$U = 0,5\ V$

$L_p >> W_n = 2\ \mu m$ $\quad L_n << W_p$

$n_{op} = 414$
$P_{on} = 20736$
$D_n = 12,93$
$D_p = 9,05$

$L_n = 2,27 \cdot 10^{-3}\ cm$

$$I_S = q \cdot S \cdot \left(D_n \frac{n_{op}}{L_n} + D_p \frac{P_{on}}{W_n} \right)$$

$I_S = 1,49 \cdot 10^{-13}\ A$

$$I = I_S \left(exp^{\frac{U}{U_T}} - 1 \right)$$

$I = 3,73 \cdot 10^{-5}\ A$

VS. 12.

$N_D = 5 \cdot 10^{15}\ cm^{-3}$
$N_A = 5 \cdot 10^{17}\ cm^{-3}$

$\mu_n = 500\ cm^2/Vs$
$\mu_p = 300\ cm^2/Vs$

$\tau_n = 0,5\ \mu s$
$\tau_p = 1\ \mu s$

$U = 0,5\ V$

$L_p << W_n$ $\quad L_n >> W_p : 1 \mu m$

$n_{op} = 414\ cm^{-3}$
$P_{on} = 41472\ cm^{-3}$

$D_n = 12,93\ cm^2/s$
$D_p = 1,76\ cm^2/s$

$L_p = 2,29 \cdot 10^{-3}\ cm$

$$I_S = q \cdot S \cdot \left(D_n \frac{n_{op}}{W_p} + D_p \frac{P_{on}}{L_p} \right)$$

$= 2,14 \cdot 10^{-14}\ A$

$$I = I_S \cdot \left(e^{\frac{U}{U_T}} - 1 \right)$$

$I = 5,32 \cdot 10^{-6}\ A$

VS 13

$N_D = 5 \cdot 10^{15}\ cm^{-3}$
$N_A = 5 \cdot 10^{17}\ cm^{-3}$

$\mu_n = 400\ cm^2/Vs$
$\mu_p = 250\ cm^2/Vs$

$\tau_n = 0,5\ \mu s$
$\tau_p = 1\ \mu s$

$S = 0,1\ mm^2$
$T = 350\ K$

$n_i = 4,96\ 10^{11}\ cm^{-3}$

$L_p << W_n$ $\quad L_n >> W_p$

$n_{op} = 492032\ cm^{-3}$
$P_{on} = 4,92 \cdot 10^7\ cm^{-3}$

$D_n = 12,06\ cm^2/s$
$D_p = 7,54\ cm^2/s$

$L_p = 2,74 \cdot 10^{-3}\ cm$

$$I_S = q \cdot S \left(D_n \frac{n_{op}}{W_p} + D_p \frac{P_{on}}{L_p} \right)$$

$= 3,12 \cdot 10^{-11}\ A$

VJ 14

$I_S = 10 \cdot 10^{-12}\ A$

$R_i = 15\ \Omega$

$T = 300\ K$

$I = 10\ mA$

$U = ?$

$I = I_S\left(e^{\frac{U}{U_T}} - 1\right)$

$\frac{I}{I_S} + 1 = e^{\frac{U}{U_T}}$

$U_T \ln\left(\frac{I}{I_S} + 1\right) = U$

$U_D = 0{,}536\ V$

$U' = R \cdot I$

$U' = 0{,}15\ V$

$U = U_D + U'$

$= 0{,}686\ V$

VJ 15

$I_S = 10^{-9}$

$T = 350\ K$

$R_i = 15\ \Omega$

$I = 10\ mA$

$U_D = U_T \ln\left(\frac{I}{I_S} + 1\right)$

$U_D = 0{,}486$

$U = 0{,}636\ V$

$U' = R \cdot I$

$= 0{,}15\ V$

VJ 16

$I_S = 10 \cdot 10^{-12}$

$R = 15\ \Omega$

$T = 300\ K$

$U_D = U_T \ln\left(\frac{I}{I_S} + 1\right)$

$U_D = 0{,}487\ V$

$i_D = 1{,}5 + 0{,}25 \sin \omega t\ [mA]$

$U_D = (0{,}509 + 3{,}06 \cdot 10^{-3} \sin$

$U = U_D + I \cdot R_S = 0{,}5095\ V$

$r_d = \frac{U_T}{I} = 17{,}24\ \Omega$

$u_d = i_d (r_d + R_S) = 3{,}06 \cdot 10^{-3}$

VJ 17

$I_S = 10\ pA$

$R_S = 12\ \Omega$

$i_D = (2{,}5 + 0{,}35 \sin \omega t)\ [mA]$

$T = 300\ K$

$U_D = 0{,}5\ V$

$u_D = U_D + I \cdot R_S = 0{,}53\ V$

$r_d = \frac{U_T}{I} = 10{,}34\ \Omega$

$u_D = (0{,}53 + 7{,}8 \cdot 10^{-3} \sin \omega t)\ V$

$u_d = (r_d + R_S) \cdot i_d = 7{,}8 \cdot 10^{-3}$

Vd. 18.

$U = 65\ mV$

$I_{S1} = I_{S2} = 10\ pA$

$I_{S3} = 20\ pA$

$U_T = 25\ mV$

$U = U_T \ln\left(\frac{I}{I_S} + 1\right)$

$I_{S4}\left(e^{\frac{U}{U_T}} - 1\right) + I_{S3}\left(e^{\frac{U}{U_T}} - 1\right) = I_{S2}\left(e^{\frac{U_2}{U_T}} - 1\right)$

$U_1 + U_2 = U$

$U_2 = U_3$

$I_1 + I_3 = I_2$

$U = 0{,}376\ V$

ZADATAK 1.

$R_T = 100\,\Omega$
$C = 3{,}2\,mF$
$U_{pef} = 230\,V$
$\nu = 50\,Hz$
$n = 25$

$U_{sm} = \frac{\sqrt{2}\,U_{pef}}{n} = 13\,V$

$U_{1zm} = U_{sm} = 13\,V$

$\tau = R_T \cdot C = 220\,ms$

$T = \frac{1}{\nu} = 20\,ms$

$U_{1zvm} = U_{1zm}\frac{\tau}{2T} = 591\,mV$

$U_{1z} = U_{2m} - U_{1zvm} = 12{,}43\,V$

$U_{1zef} = \frac{U_{1zvm}}{\sqrt{3}} = 341\,mV$

$r = \frac{U_{1zef}}{U_{1z}} = 0{,}0275$

ZADATAK 2.

$U_{1z} = ?$
$r = ?$

$R_T = 50\,\Omega$
$C = 4{,}7\,mF$
$U_{pef} = 230\,V$
$\nu = 50\,Hz$
$n = 30$

$U_{sm} = \frac{\sqrt{2}\,U_{pef}}{n} = 10{,}84\,V$

$U_{1zm} = U_{sm} = 10{,}84\,V$

$\tau = R_T \cdot C = 235\,ms$

$T = \frac{1}{\nu} = 20\,ms$

$U_{1zvm} = U_{1zm}\frac{\tau}{4T} = 230{,}7\,mV$

$U_{1z} = U_{2m} - U_{1zvm} = 10{,}61\,V$

$U_{1zef} = \frac{U_{1zvm}}{\sqrt{3}} = 133\,mV$

$r = \frac{U_{1zef}}{U_{1z}} = 0{,}0126$

ZADATAK 3.

$r = 10^{-3}$
$R_T = 1\,k\Omega$
$U_{pm} = 250\,V$
$\nu = 50\,Hz$
$n = 10$

$U_{sm} = \frac{U_{pm}}{n} = 25\,V$

$U_{1zm} = U_{sm} = 25\,V$

$U_{1zef} = \frac{U_{1zm}\frac{T}{4CR_T}}{\sqrt{3}} = \frac{U_{1zm}}{4\sqrt{3}\,CR_T\nu}$

$r = \frac{U_{1zef}}{U_{1z}} = \frac{U_{1zm}}{4\sqrt{3}\,CR_T\nu \cdot U_{1zm}(4k-1)}$

$C = 7{,}69\,mF$

$U_{1z} = U_{1zm} - U_{2vm} = U_{1z} - U_{1zm}\frac{1}{4CR_T\nu} = U_{1zm}\frac{4Ck_T\nu - 1}{4Ck_T\nu}$

$U_{1z} = 24{,}96\,V$

$R_1 = 10\,k\Omega$

$r_d = 10\,\Omega$

$t = 0 \quad U_{c0} = 0V$

$u_c(0_+) = U_{c0} = 0V$

$u_{12}(0_+) = U_{120} = \frac{r_d}{r_d + R_g}(U_1 - U_{c0}) = 0{,}833$

$u_c(t) = U_{c0} + (U_1 + U_{c0}) \cdot \left(1 - e^{\frac{t}{\tau_1}}\right)$

$\tau_1 = C \cdot (R_g + r_d) = 6\,ms$

VJ.1.

$r = 10^{-3}$

$R_1 = 1k\Omega$

$U_{pm} = 250V$

$f = 50Hz$

$n = 10$

$C = ?$

$U_{sm} = \frac{U_{pm}}{n} = 25V$

$U_{12M} = U_{SM} = 25V$

$U_{12VM} = U_{12M} \cdot \frac{T}{2\pi}$

$= \frac{1}{4000\,C}$

$U_{12VEF} = \frac{1}{4000\sqrt{3}C}$

$U_{12} = U_{12M} - U_{12VM}$

$= 25 - \frac{1}{4000\,C}$

$= \frac{100000\,C - 1}{4000\,C}$

$r = \frac{U_{12VEF}}{U_{12}} = 10^{-3}$

$\frac{1}{1000} = \frac{\frac{1}{4000\sqrt{3}C}}{\frac{100000\,C - 1}{4000\,C}}$

$100000\,C - 1 = \frac{1000}{\sqrt{3}}$

$C = 5{,}78\,mF$

VJ.2,

$C, r = ?$

$U_{12} = 21V$

$R_1 = 560\,\Omega$

$U_{pef} = 150V$

$f = 50Hz$

$n = 10$

$U_{sm} = \frac{U_{pef}\sqrt{2}}{n} = 21{,}21V$

$U_{12M} = 21{,}21V$

$U_{12VM} = U_{12M} \cdot \frac{T}{2\pi}$

$= \frac{303}{800000\,C}$

$U_{12VEF} = \frac{303}{800000\sqrt{3}C}$

$= 0{,}12V$

$U_{12} = U_{12M} - U_{12VM}$

$21 = 21{,}21 - \frac{303}{800000\,C}$

$C = 1{,}8 \cdot 10^{-3}\,F$

$r = \frac{U_{12ef}}{U_{12}} = 5{,}78 \cdot 10^{-3}$

U_{12} = ?

$R_T = 220\,\Omega$
$C = 1\,mF$
$U_{pm} = 325$
$f = 50\,Hz$
$n = 20$

$U_{12M} = 16,25\,V$

$U_{12VM} = U_{12M} \frac{T}{2\tau}$

$= 0,74\,V$

$U_{12VEF} = 0,43\,V$

$= 15.51\,V$

$r = \frac{U_{12ef}}{U_{12}}$

$= 0.028$

VJ. 4

C, U_{12} = ?

$r = 10^{-3}$
$R_T = 1\,k\Omega$
$U_{pm} = 230\,V$
$f = 50\,Hz$
$n = 10$

$U_{sm} = \frac{U_{pm}}{n} = 25\,V$

$U_{12M} = 25\,V$

$U_{12VM} = U_{12M} \frac{T}{4\tau}$

$= \frac{1}{3000\,C}$

$U_{12VEF} = \frac{1}{3000\sqrt{3}\,C}$

$U_{12} = U_{12M} - U_{12VM}$

$= 25 - \frac{1}{3000\,C} = 24,96\,V$

$U_{12} = \frac{200000\,C - 1}{3000\,C}$

$r = \frac{U_{12VEF}}{U_{12}}$

$\frac{1}{1000} = \frac{3000\,C}{(200000C - 1) \cdot 3000\sqrt{3}\,C}$

$200000\,C - 1 = \frac{1000}{\sqrt{3}}$

$C = 2,89 \cdot 10^{-3}\,F$

VJ. 5

C, r = ?

$U_{12} = 21\,V$
$R_T = 560\,\Omega$
$U_{pef} = 150\,V$
$f = 50\,Hz$
$n = 10$

$U_{sm} = \frac{U_{pef}\sqrt{2}}{n} = 21,21\,V$

$U_{12M} = 21,21\,V$

$U_{12VM} = U_{12M} \frac{T}{4\tau}$

$= \frac{303}{160000\,C}$

$= 0,21\,V$

$U_{12VEF} = 0,12$

$U_{12} = U_{12M} - U_{12VM}$

$21 = 21,21 - \frac{303}{160000\,C}$

$C = 9 \cdot 10^{-3}\,F$

$r = \frac{U_{12ef}}{U_{12}}$

$r = 5,78 \cdot 10^{-3}$

VJ. 6

U_{12}, r = ?

$R_T = 220\,\Omega$
$C = 1\,mF$
$U_{pm} = 325\,V$
$f = 50\,Hz$
$n = 20$

$U_{sm} = \frac{U_{pm}}{n} = 16,25\,V$

$U_{12M} = 16,25\,V$

$U_{12VM} = U_{12M} \frac{T}{4\tau}$

$= 0,37\,V$

$U_{12VEF} = 0,21\,V$

$U_{12} = U_{12M} - U_{12VM}$

$= 15,88\,V$

$r = \frac{U_{12VEF}}{U_{12}}$

$r = 0,0132$

$r = 0{,}005$
$R_T = 330\ \Omega$
$U_{pm} = 150\ V$
$f = 50\ Hz$
$n = 15$

$U_{sm} = \frac{U_{pm}}{n} = 10\ V$

$U_{12M} = 10\ V$

$U_{12VM} = U_{12M} \cdot \frac{I}{4f}$

$= \frac{1}{6600C}$

$U_{12VEF} = \frac{1}{6600\sqrt{2}C}$

$U_{12} = U_2 - U_{12VM}$

$U_{12} = 10 - \frac{1}{6600C}$

$U_{12} = \frac{66000C - 1}{6600C} = 9{,}91\ V$

$r = \frac{U_{12VEF}}{U_{12}} = \frac{6600C}{(66000C - 1) \cdot 6600\sqrt{2}C} = \frac{1}{200}$

$66000C - 1 = \frac{200}{\sqrt{2}}$

$C = 1{,}76 \cdot 10^{-5}\ F$

VJ 8

$C, r = ?$

$U_{12} = 11\ V$
$R_T = 300\ \Omega$
$U_{pm} = 350\ V$
$f = 50\ Hz$
$n = 30$

$U_{sm} = \frac{U_{pm}}{n} = 11.67\ V = \frac{35}{3}\ V$

$U_{12M} = 11.67\ V$

$U_{12VM} = U_{12M} \frac{I}{4f}$

$= \frac{7}{36000C}$

$U_{12VEF} = \frac{7}{36000\sqrt{2}C}$

$= 9386$

$U_{12} = U_{12M} - U_{12VM}$

$11 = \frac{35}{3} - \frac{7}{36000C}$

$C = 2{,}91\ 10^{-4}\ F$

$r = \frac{U_{12VEF}}{U_{12}}$

$r = 0{,}0351$

VJ 9.

$U_{12}, r = ?$

$R_T = 500\ \Omega$
$C = 4{,}7\ mF$
$U_{pm} = 250\ V$
$f = 50\ Hz$
$n = 25$

$U_{sm} = \frac{U_{pm}}{n} = 10\ V$

$U_{12M} = 10V$

$U_{12VM} = U_{12M} \frac{I}{4f}$

$= 0{,}021$

$U_{12VEF} = 0{,}012$

$U_{12} = U_{12M} - U_{12VM}$

$= 9.979\ V$

$r = \frac{U_{12VEF}}{U_{12}}$

$r = 1{,}2 \cdot 10^{-3}$