

## 5. Auditorne uprave

Zadatok 1.)

$$N_D = 10^{16} \text{ cm}^{-3}$$

$$N_A = 5 \times 10^{13} \text{ cm}^{-3}$$

$$\mu_n = 500 \text{ cm}^2/\text{Vs}$$

$$\mu_p = 400 \text{ cm}^2/\text{Vs}$$

$$J_n = 0.5 \text{ A}$$

$$J_p = 1 \text{ A}$$

$$S = 0.25 \text{ mm}^2 = 2.5 \times 10^{-3} \text{ cm}^2$$

$$T = 300 \text{ K}$$

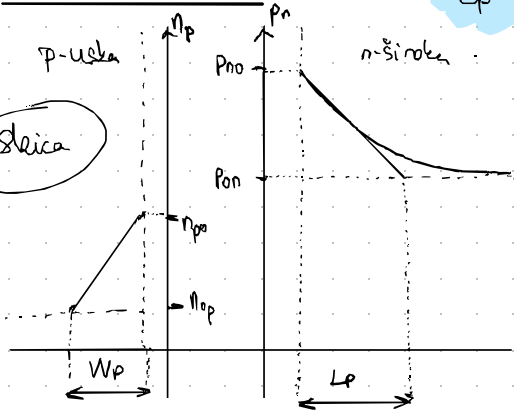
$$L_p \ll W_n \text{ (fizička širina)}$$

$$L_n \gg W_p \text{ (koristimo magju)}$$

$$U = 0.6 \text{ V}$$

$$m = 1$$

$$I_s = ? \quad I_D = ?$$



Einstein

$$D_n = U_T \cdot \mu_n = \frac{300 \text{ K}}{11600} \cdot 500 = 12.93 \text{ cm}^2/\text{s}$$

$$D_p = \mu_p U_T = 10.35 \text{ cm}^2/\text{s}$$

Difuzijska dužina

$$L_p = \sqrt{D_p J_p} \Rightarrow L_p = 3.22 \times 10^{-3} \text{ cm}$$

$$n_{op} = \frac{n_i^2}{N_A} = \frac{(1.45 \times 10^{10})^2}{5 \times 10^{17}} \text{ cm}^{-3} = 4.205 \times 10^2$$

$$p_{on} = \frac{n_i^2}{N_D} = \frac{(1.45 \times 10^{10})^2}{10^{16}} \text{ cm}^{-3} = 2.1 \times 10^4$$

$$I_s = qS \left( D_n \frac{n_{op}}{W_p} + D_p \frac{p_{on}}{L_p} \right)$$

$$I_s = 4.881 \times 10^{-14} \text{ A} \Rightarrow \boxed{48.81 \text{ fA}}$$

sinija kroz diodu:  $I_0 = I_s \left[ \exp\left(\frac{U}{mU_T}\right) - 1 \right] = 48.81 \cdot 10^{-14} \cdot \left[ \exp\left(\frac{0.6}{11600}\right) - 1 \right]$

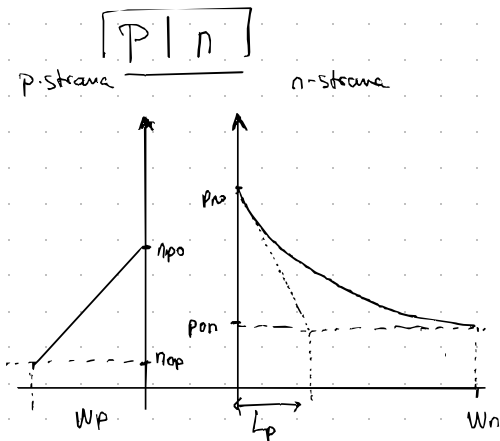
$$I_0 = 5.1801 \times 10^{-4} \text{ A} \Rightarrow \boxed{I_0 = 0.58 \text{ mA}}$$

Boltzmannove formule:

$$n_{po} = n_{op} \exp\left(\frac{U}{U_T}\right) = 5 \times 10^{12} \text{ cm}^{-3}$$

$$p_{no} = p_{on} \exp\left(\frac{U}{U_T}\right) = 2.15 \times 10^{14} \text{ cm}^{-3}$$

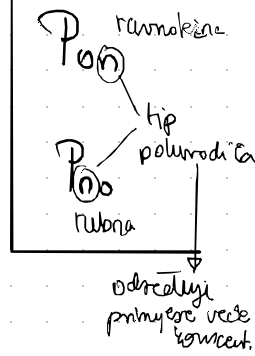
$$n_{po} < p_{no}$$



→ uska  
⇒ linearni p

→ široka  
→ exp. pad

Sjeti se



## Zadatak 2.)

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

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

$$\mu_n = 1300 \text{ cm}^2/\text{Vs}$$

$$\mu_p = 300 \text{ cm}^2/\text{Vs}$$

p-široka ( $W_p \gg L_n$ )

$$\tau_n = 1 \mu\text{s}$$

n-uska ( $W_n \ll L_p$ )

$$W_n = 0,5 \mu\text{m}$$

$$S = 0,5 \text{ mm}^2$$

Upnoppel

$$Q_n = 885 \text{ pC}$$

$$m=1 \quad T=300 \text{ K}$$

a)  $U = ?$

b)  $Q_p = ?$

c)  $I_D (\text{maksimal}) \Rightarrow$

otkud ova formule

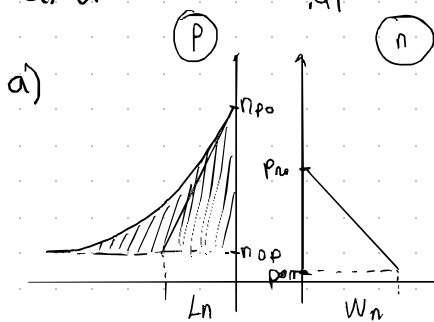
$$Q_n = q \cdot S \cdot (n_{p0} - n_{op}) \cdot L_n$$

$$L_n = \sqrt{D_n \tau_n}$$

$$D_n = u_T \cdot \mu_n$$

$$D_n = 33,62 \text{ cm}^2/\text{s}$$

$$L_n = 5,8 \times 10^{-3} \text{ cm}$$



$$n_{p0} = n_{op} \exp\left[\frac{u}{u_T}\right]$$

↓

$$Q_n = q S (n_{op} \exp\left[\frac{u}{u_T}\right] - n_{op}) \cdot L_n = q S \cdot n_{op} \left( \exp\left[\frac{u}{u_T}\right] - 1 \right) L_n$$

$$\exp\left(\frac{u}{u_T}\right) - 1 = \frac{Q_n}{q S n_{op} L_n} \rightarrow \exp\left(\frac{u}{u_T}\right) = \frac{Q_n}{q S n_{op} L_n} + 1$$

$$\frac{u}{u_T} = \ln\left(\frac{Q_n}{q S n_{op} L_n} + 1\right) \cdot u_T$$

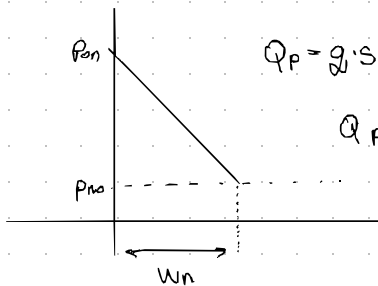
$$n_{op} = \frac{n_i^2}{N_A} = \frac{(1,45 \times 10^{10})^2}{5 \times 10^{17}}$$

$$n_{op} = 4,205 \times 10^{-4} \text{ cm}^{-3}$$

$$u = \ln\left(\frac{Q_n}{q S n_{op} L_n} + 1\right) \cdot u_T$$

$$u = 0,575 \text{ V}$$

b) nabrascani naboj ( $Q_p$ ) maksimalni šupljima na n strani



$$Q_p = q \cdot S \cdot (\text{površina naboja})$$

$$Q_p = q \cdot S \cdot \frac{1}{2} W_n \cdot (p_{n0} - p_{ni})$$

$$p_{n0} = \frac{n_i^2}{N_D} = 2,1 \times 10^3 \text{ cm}^{-3}$$

$$\Rightarrow p_{n0} = p_{ni} \exp\left(\frac{u}{u_T}\right)$$

$$p_{n0} = 9,52 \times 10^{12} \text{ cm}^{-3}$$

$$Q_p = 0,19 \text{ pC}$$

\* formula

$$Q_p = I_p \cdot \tau_p$$

$$I_{Dp} = S \cdot (-q D_p \frac{dp}{dx})$$

$$J_p = \frac{L_p}{D_p}$$

$$Q_p = -S q D_p \frac{dp}{dx} \cdot L_p$$

$$Q_p = S q \Delta p \cdot L_p \quad \text{površina} \Rightarrow \Delta p = p_{n0} - p_{ni}$$

$$Q_p = S q L_p \cdot (p_{n0} - p_{ni})$$

c) 10 (maužimėkliai) mėsaliai už tur. ornamentų požiūriu)

10 formule on se o strani na kojoj se nalaze  $\rightarrow I_D = I_{Dp} + I_{Dr}$

$= \Rightarrow I = \frac{\Phi}{\epsilon} \rightarrow$  Široka strana  $I = \frac{\Phi}{J} \rightarrow$  „životní výt.“

Silokas  
strama

(P)

n

p

(P)

uska  
strama

(w<sub>n</sub> < L<sub>p</sub>)

n su maayiriki  
nomai

p su maayiriki

P<sub>n0</sub>

P<sub>on</sub>

L<sub>n</sub>

w<sub>n</sub>

masyiriki mampi

I = t → vrijeme proleta → t =  $\frac{w^2}{2D}$

strama na kvadrat

$I_{Dn}$  (duž struja  $e^-$ )  $\rightarrow$  zemljama mas  
p Arama

$$I_{Dn} = \frac{Q_n}{T_n} = \frac{885 \times 10^{-12} \text{ As}}{10^{-6} \text{ s}} = \underline{\underline{885 \mu\text{A}}}$$

0.885mA

mayjinski men'oci

$I_{DP}$  (diš stroja šupljina)  $\rightarrow n$  stran

$$I_{Dp} = \frac{Q_p}{t_p} \quad t_p = \frac{\omega_n^2}{2D_p} \quad D_p = \mu T \mu_p$$

$$t_p = \frac{\omega_n^2}{2 \cdot U_T \cdot \mu_p}$$

$$\Rightarrow I_{Dp} = \frac{Q_p}{W_p^2} \cdot 2 U_T \mu_p$$

$$\rightarrow I_{DP} = 1.17 \text{ mA}$$

$$\rightarrow b = I_{D_0} + I_{DP} = \boxed{2,06 \text{ mA}}$$