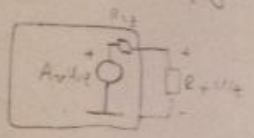
M1 (2012/2013) ELEKTRONIKA 1

PITANJA

1. A_V => opterećeno pojačalo $A_V = 100$



$$A_V = \frac{U_{iz}}{U_{ul}} = \frac{A_V U_{ul} \frac{R_T}{R_T + R_{iz}}}{U_{ul}}$$

$$A_V = A_V \frac{R_{iz} + R_T}{R_T}$$

$$A_V = A_V \left(1 + \frac{R_{iz}}{R_T}\right) = 200$$

TOČAN ODGOVOR: d) IDEALNO POJAČALO ($R_{iz} = 0$)

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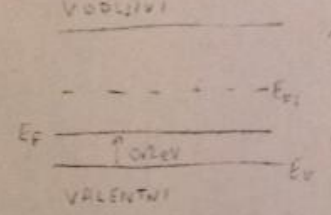
2. p-tip => dopirano akceptorima



$E_G = 1,12\,eV$

$T = 400K$ E_F ostaje isti

$T \uparrow \rightarrow E_F \rightarrow E_{Fi}$ moramo dopirati akceptorima da bi ga opet vratili na $E_F = 0.2\,eV$

TOČAN ODGOVOR: a)

③ $N_A = 1000 N_D$

$N_A >> N_D$ → $d_{Bn} >> d_{Bp}$

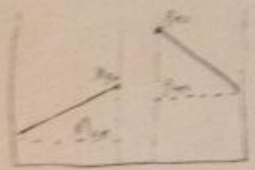
većinski nosioci $p_{0p} >> n_{0n}$

manjinski nosioci $n_{0p} = \frac{n_i^2}{p_{0p}} << p_{0n} = \frac{n_i^2}{n_{0n}}$

$I_{Dp} \sim \frac{p_{0n}}{w_n}$

$I_{Dn} \sim \frac{n_{0p}}{w_p}$

$\Big\}$ $I_{Dp} >> I_{Dn}$



TOČAN ODGOVOR: ⓐ

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④

$\lambda = 690\,nm = 0.69\,\mu m$

$\lambda = \frac{1.24}{E_G} \Rightarrow E_G = \frac{1.24}{\lambda} = \frac{1.24}{0.69} = \underline{1.8\,eV}$

rekombinacija → Propusna polarizacija

TOČAN ODGOVOR: D

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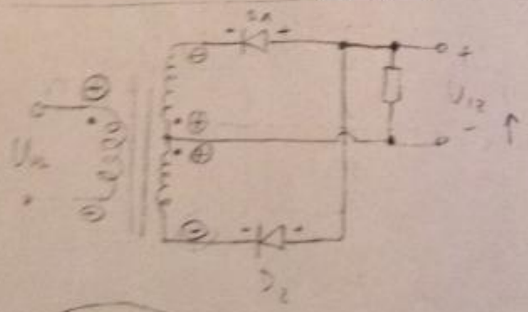
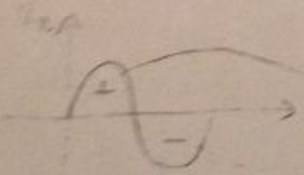
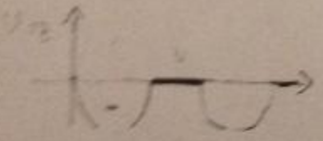
⑤





→ D_1, D_2 → prop. pol.

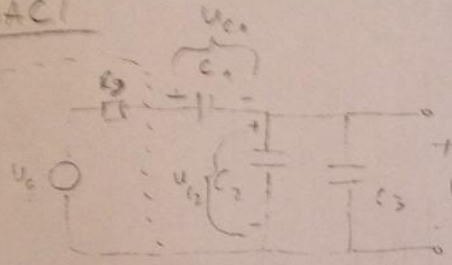
→ D_1, D_2 → zaporna pol.



← TOČAN ODGOVOR

TOČAN ODGOVOR: c)

ZADAC 1

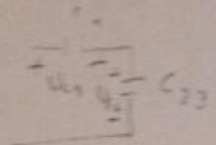


$C_1 = C$

$C_2 = \frac{3}{4} C$

$C_3 = \frac{1}{4} C$

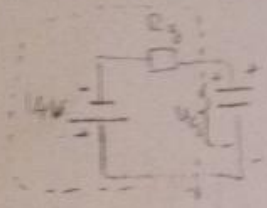
U_{C1} → početni napon za paralelu



$C_{23} = C_2 + C_3 = C$

$C_{123} = \frac{C}{2}$

$U_{C0} = U_1 + U_{C2}$



$U_{C0} = 2V$

$U_{C0} = 2V$

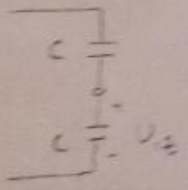
$U_{C\infty} = -4V$

$\tau = R_1 \cdot \frac{C}{2} = 1ms$

$$U_c(t) = U_{C0} + (U_{C\infty} - U_{C0})\left(1 - \exp\frac{-t}{\tau}\right)$$

$$= 2 + [-4 - 2]\left(1 - \exp\frac{-t}{\tau}\right)$$

$$= -4 + 6 \exp\frac{-t}{\tau}$$



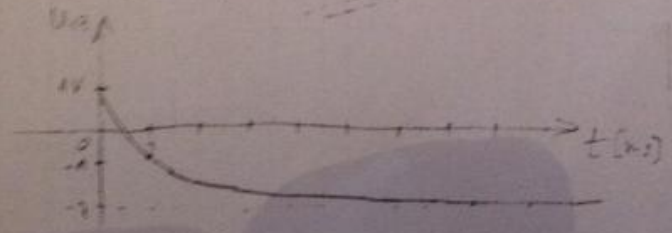
$$U_{12} = \frac{\frac{1}{C}}{\frac{1}{C} + \frac{1}{C}} U_c = \frac{1}{2} U_c$$

$$U_{12}(t) = \frac{1}{2} U_c(t) = -2 + 3 \exp\frac{-t}{\tau}$$

$U_2(0) = 1V$

$U_{12}(1ms) = -2 + 3 \exp\frac{-1}{1} = -0.896V$

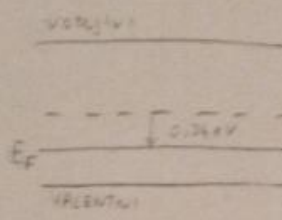
$U_{12}(\infty) = -2V$



2) $E_F = E_{F_i} - 0{,}34\,eV$

$T = 300\,K \rightarrow n_i = 1{,}45 \cdot 10^{10}\,cm^{-3}$

$U_n = 1400\ \frac{cm^2}{Vs}$ $\mu_p = 420\ \frac{cm^2}{Vs}$



$E_F < E_{F_i}$ (p-tip)

dopiran akceptorima

$p_0 = n_i \exp\frac{E_{F_i} - E_F}{kT} = 1{,}45 \cdot 10^{10} \cdot \exp\frac{0{,}34 \cdot 1600}{300}$

$p_0 = 7{,}43 \cdot 10^{15}\,cm^{-3}$ VEĆINSKI

MANJINSKI $\Rightarrow n_0 = \frac{n_i^2}{p_0} = \frac{(1{,}45 \cdot 10^{10})^2}{7{,}43 \cdot 10^{15}} = 2{,}83 \cdot 10^{5}\,cm^{-3}$

$p_0 >> n_i \Rightarrow p_0 \approx N_A = 7{,}43 \cdot 10^{15}\,cm^{-3}$

$p_0 >> n_0 \Rightarrow \sigma \doteq \sigma_p = q\,\mu_p\,p_0 = 0{,}5\ \frac{S}{cm}$

(uključena područja)

$n_i(500K) = C_1 T^{\frac{3}{2}} \exp\left(\frac{-E_{gi}}{2kT}\right) = 3{,}24 \cdot 10^{17}\,cm^{-3}$

$N_A = 7{,}43 \cdot 10^{15}\,cm^{-3} >> n_i$ (i dalje je bar 10 puta veće)

EKSTRINSIČNI: $p_0 \doteq N_A = 7{,}43 \cdot 10^{15}\,cm^{-3}$

$n \uparrow T \uparrow q \Rightarrow \mu \downarrow$ $\mu_p(500K) = 0{,}45\,\mu_p(300K)$

$\sigma = \sigma_p = q\,\mu_p\,p_0 = 0{,}45\,\sigma(300K)$

$\sigma = 0{,}225\ \frac{S}{cm}$

(3) n strana ⇒ $N_D = 2 \cdot 10^{15}\ cm^{-3}$, $\mu_p = 320\ \frac{cm^2}{Vs}$, $\tau_p = 0{,}8\ \mu s$

$W_n = 0{,}5\ \mu m = 0{,}5 \cdot 10^{-4}\ cm$

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p strana ⇒ $N_A = 8 \cdot 10^{17}\ cm^{-3}$, $\mu_n = 700\ \frac{cm^2}{Vs}$, $\tau_n = 0{,}5\ \mu s$

$W_p = 100\ \mu m = 100 \cdot 10^{-4}\ cm$

$n_{on} \doteq N_D = 2 \cdot 10^{15}\ cm^{-3}$ $\qquad p_{on} = \frac{n_i^2}{n_{on}} = 1{,}05 \cdot 10^5\ cm^{-3}$

$p_{op} \approx N_A = 8 \cdot 10^{17}\ cm^{-3}$ $\qquad n_{op} = \frac{n_i^2}{p_{op}} = 2{,}63 \cdot 10^2\ cm^{-3}$

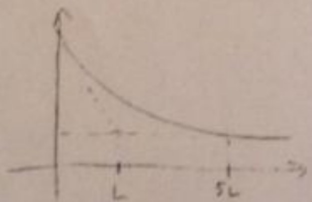
p strana $\quad L_n = \sqrt{D_n \cdot \tau_n} = \sqrt{\mu_n \frac{T}{11600} \tau_n} = 30{,}09\ \mu m$

$W_p = 100\ \mu m >> L_n$ (široka)

↳ (evo i zašto) ⇒

(to ne moramo znati)

$-\frac{x}{L}$	0	-1	-2	-3	-4	-5
$\exp -\frac{x}{L}$	1	0,368	0,135	0,05	0,018	0,0067



široka strana

$W > \frac{3L}{5L}$

n strana $\quad L_p = 25{,}73\ \mu m >> W_n = 0{,}5\ \mu m$ (uska)

$$I_s = I_{sn} + I_{sp} = qS \left[D_n \frac{n_{op}}{L_n} + D_p \frac{p_{on}}{W_n} \right]$$

→ (4) str.

(4.) $U_{DS} > 0$, $I_D > 0$ } **NMOS**

$U_{GSA} = -U_{GSB} \rightarrow$ $U_{GSA} > 0$, $U_{GSB} < 0$ } osiromašeni

uz oba predznaka U_{GS} rade pa radi i za $U_{GS} = 0$ $I_D > 0$

B: $I_{DB} = 1\,mA$ zasićenje

$$I_{DS} = \frac{K}{2}\left(U_{GSB} - U_{GSO}\right)^2 \quad (1)$$

A: Granica Triodnog i zasićenja

$$U_{DS} = U_{GSA} - U_{GSO} = 3V$$

$$U_{GSO} = U_{GSA} - 3 \quad (2)$$

$$U_{GSA} = -U_{GSB} \quad (3)$$

(2),(3) $\longrightarrow$ (1)

$$I_{DB} = \frac{K}{2}\left(-U_{GSA} - U_{GSA} + 3\right)^2$$

$$\frac{2 I_{DB}}{K} = \left(3 - 2U_{GSA}\right)^2$$

$$3 - 2U_{GSA} = \pm\sqrt{\frac{2 I_{DB}}{K}}$$

$1 \Rightarrow U_{GSA_1} = 1V$

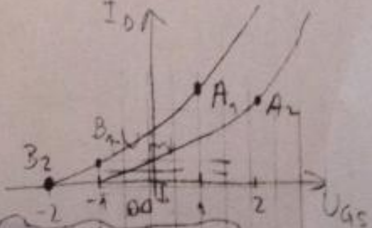
$-1 \Rightarrow U_{GSA_2} = 2V$

1) $U_{GSA_1} = 1V$

$U_{GSO_1} = U_{GSA_1} - 3 = -2V$

$U_{GSB_1} = -1V$

2) $U_{GSA_2} = 2V$, $U_{GSO_2} = -1V$, $U_{GSB_2} = -2V$ } NE MOŽE



1) MOŽE ✓

(4) str.

$$I_S = q\left(S\frac{T}{11600}\left[\mu_n\frac{n_{0p}}{L_n} + \mu_p\frac{p_{on}}{W_n}\right]\right) = 13{,}32\ pA$$

$S = 0{,}5\ mm^2 = 0{,}5\cdot10^{-2}\ cm^2$

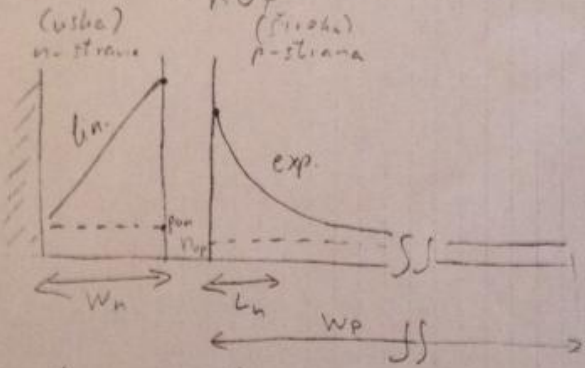
$$I_D = I_S\left[\exp\left(\frac{U_D}{mU_T}\right) - 1\right] = I_S \exp\frac{U_D}{mU_T} \ldots = 24\ mA$$

$p_{on} = 1{,}05\cdot10^{3}\ cm^{-3}$

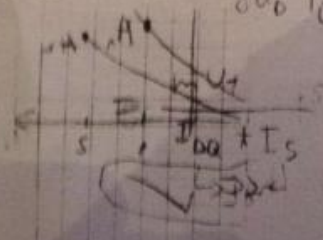
$$p_{n0} = p_{on}\exp\frac{U_D}{mU_T} \ldots = 1{,}81\cdot10^{14}\ cm^{-3}$$

$n_{op} = 2{,}63\cdot10^{2}\ cm^{-3}$

$$n_{p0} = n_{op}\exp\frac{U_D}{mU_T} \ldots = 4{,}53\cdot10^{11}\ cm^{-3}$$



$$r_d = \frac{1}{g_d} = \frac{1}{\frac{\partial i_D}{\partial u_D}\Big|_Q} = \frac{1}{I_S\exp\left(\frac{U_D}{mU_T}\right)\cdot\frac{1}{mU_T}} = \frac{mU_T}{\underbrace{I_S\exp\left(\frac{U_D}{mU_T}\right) - I_S}_{I_{DQ}} + I_S} =$$



$$\ldots = \frac{mU_T}{I_{DQ}} = 1{,}08\ \Omega$$

c) $U_{GSC} = U_{GSA} = 1V$, $I_D = 1mA$

C - tříodna področje

$$I_{DC} = K\left[(U_{GSC} - U_{GS0})U_{DSC} - \frac{U_{DSC}^2}{2}\right] \quad / \cdot \frac{2}{K}$$

$$\frac{2I_{DC}}{K} = 2(U_{GSC} - U_{GS0})U_{DSC} - U_{DSC}^2$$

$$U_{DSC}^2 - 2(U_{GSC} - U_{GS0})U_{DSC} + \frac{2 \cdot I_{DC}}{K} = 0$$

$$U_{DSC}^2 - 2(1+2)U_{DSC} + \frac{2 \cdot 1}{2} = 0$$

$$U_{DSC}^2 - 6U_{DSC} + 1 = 0$$

$$U_{DSC1,2} = \frac{6 \pm \sqrt{6^2 - 4}}{2} = \frac{6 \pm \sqrt{32}}{2} = \begin{cases} U_{DSC1} = 5,83V \text{ - NEMOGOČE} \\ U_{DSC2} = 0,17V \text{ - TRIODNO} \end{cases}$$