REŠENJA:

1.

$$I_{C4} = I_4 = I_3 = \frac{V_{CC} - V_{EE} - V_{BE}}{R_1} = 1\text{mA};\ I_1 = I_2 = 0{,}5\text{mA};\ g_{m1} = g_{m2} = \frac{I_1}{V_T} = 20\text{mS}$$

$$A_d = \frac{v_i}{v_{u1} - v_{u2}} = \frac{g_{m2} R_2}{2};\ A_s \cong -\frac{R_2}{2r_{ce4}};\ \rho = \left|\frac{A_d}{A_s}\right| \cong g_{m2} r_{ce4} = 1000$$

2. Beleške za predavanja, Operacioni pojačavač, slajd 17.

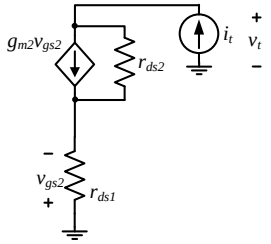
3. Beleške za predavanja, „9_Izlazni_pojacavacki_stepeni.pdf“, slajdovi 10-11 (+ 6-8).

4. a)

$$\left.\begin{array}{l} V_{GS1} = V_{GS3} \\ 2B_1 = B_3 \end{array}\right\} \Rightarrow I_{D3} = 2I_{D1}$$

$$\left.\begin{array}{l} I_{D3} = I_{D4} = I_R \\ I_{D1} = I_{D2} = I_0 \end{array}\right\} \Rightarrow I_0 = I_R / 2 = 50\mu A$$

b) $g_{m1} = g_{m2} = \sqrt{2I_0 B}_1 = 447.21\mu\text{S}$



$$r_{ds1} = r_{ds2} = \frac{1}{\lambda I_0} = 500\text{k}\Omega$$

$$\left.\begin{array}{l} v_{gs2} = -i_t r_{ds1} \\ v_t = r_{ds1} i_t + r_{ds2}(i_t - g_{m2} v_{gs2}) \end{array}\right\} \Rightarrow R_0 = \frac{v_t}{i_t} = r_{ds1} + r_{ds2}(1 + g_{m2} r_{ds1}) = 112.8\text{M}\Omega$$

c)

$$\left.\begin{array}{l} v_{DG2} > -V_T \\ v_{DG2} = v_{D2} - (v_{GS3} + v_{GS4}) \end{array}\right\} \Rightarrow v_{D2} > 2V_{GS3} - V_T \Rightarrow V_{DD} - I_0 R_P > 2V_{GS3} - V_T$$

$$R_P < \frac{V_{DD} - 2V_{GS3} + V_T}{I_0},\ V_{GS3} = V_T + \sqrt{\frac{2I_R}{B_3}} = 0.92V$$

$$R_{P\max} = 37.2\text{k}\Omega$$

5.

a) ,b)

$$v_{IOP} = \frac{v_1}{2} - R_X \frac{v_1}{2R} = \frac{v_1}{2}\left(1 - \frac{R_X}{R}\right)$$

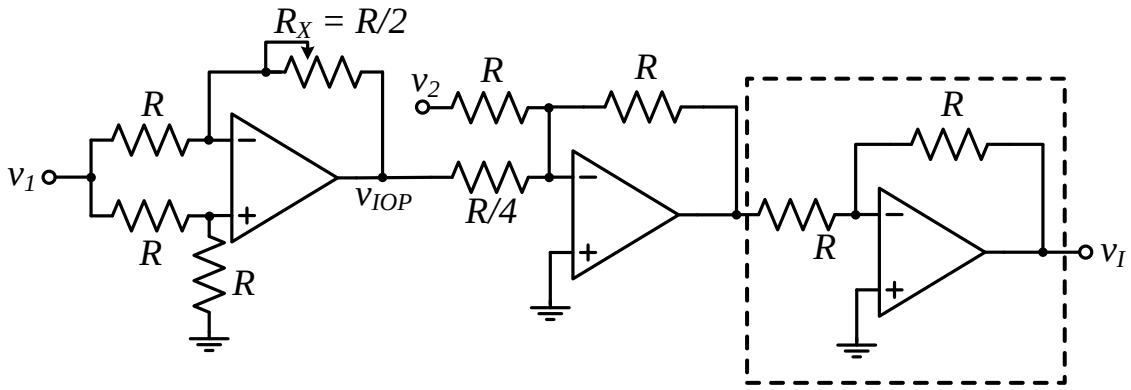
$$v_I = -4v_{IOP} - v_2 = -2\left(1 - \frac{R_X}{R}\right)v_1 - v_2$$

Za $v_I = -v_2 - v_1$ potrebno je da bude ispunjeno $2\left(1 - \frac{R_X}{R}\right) = 1 \Rightarrow R_X = \frac{R}{2}$

Za $v_I = -v_2 + v_1$ potrebno je da bude ispunjeno $2\left(1 - \frac{R_X}{R}\right) = -1 \Rightarrow R_X = \frac{3R}{2}$

c) Kritičan je izlaz drugog operacionog pojačavača (pri vrednostima $R_X = 0$ i $R_X = 2R$) koji ulazi u zasićenje pri $V_m = \frac{10}{3}\text{V}$.

d)


$R_X = R/2$
v_1
v_2
R
R
R
R
R
R
R/4
v_{IOP}
v_I