

REŠENJA:

1.

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

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

2. Beleške za predavanja, Povratna sprega, slajdovi 9, 10 i 11.

3. Beleške za predavanja, „9_Izlazni_pojacavacki_stepeni.pdf“, slajdovi 6-8.

4.

a)

$$B_3 = B_4 = \mu_n C_{ox} \left(\frac{W}{L} \right)_3 = 2 \frac{\text{mA}}{\text{V}^2}$$

$$\left. \begin{aligned} I_R &= \frac{V_{DD} - V_{GS3} - V_{GS4}}{R_R} \\ V_{GS3} = V_{GS4} &= V_T + \sqrt{\frac{2I_R}{B_3}} \end{aligned} \right\} \Rightarrow I_R = \frac{V_{DD} - 2(V_T + \sqrt{\frac{2I_R}{B_3}})}{R_R}$$

$$I_R^2 - I_R \left(2 \left(\frac{V_{DD} - 2V_T}{R_R} \right) + \frac{8}{B_3 R_R^2} \right) + \left(\frac{V_{DD} - 2V_T}{R_R} \right)^2 = 0$$

$$I_R^2 - I_R \left(2 \left(\frac{V_{DD} - 2V_T}{R_R} \right) + \frac{8}{B_3 R_R^2} \right) + \left(\frac{V_{DD} - 2V_T}{R_R} \right)^2 = 0$$

$$I_{R1} = 6.82\text{mA}$$

$$I_{R2} = 375\mu\text{A}$$

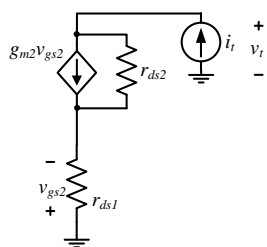
Kako prvo rešenje ne odgovara radu tranzistora u zasićenju samo drugo rešenje je validno.

b)

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

$$\left. \begin{aligned} I_{D3} = I_{D4} = I_R \\ I_{D1} = I_{D2} = I_0 \end{aligned} \right\} \Rightarrow I_0 = 2I_R = 750\mu\text{A}$$

c) $g_{m1} = g_{m2} = \sqrt{2I_0 B_1} = 2.45\text{mS}$



$$r_{ds1} = r_{ds2} = \frac{1}{\lambda I_0} = 33.3\text{k}\Omega$$

$$\left. \begin{aligned} v_{gs2} &= -i_t r_{ds1} \\ v_t &= r_{ds1} i_t + r_{ds2} (i_t - g_{m2} v_{gs2}) \end{aligned} \right\} \Rightarrow R_0 = \frac{v_t}{i_t} = r_{ds1} + r_{ds2} (1 + g_{m2} r_{ds1}) = 2.78\text{M}\Omega$$

5. a)

Jednosmerni režim:

$$V_B = \frac{V_{CC}}{2} = V_A = 2.5\text{V}$$

$$V_C = V_A + \frac{V_A - V_G}{R} 2R = 3V_A - 2V_G = -0.5\text{V}$$

$$V_I = 0$$

Naizmenični režim:

$$v_b = v_a = 0$$

$$v_c = -2v_g = v_i$$

Ukupan signal:

$$v_A(t) = V_A + v_a(t) = 2.5\text{V}$$

$$v_B(t) = V_B + v_b(t) = 2.5\text{V}$$

$$v_C(t) = V_C + v_c(t) = -(0.5\text{V} + 0.4 \sin 2\pi ft)\text{V}$$

$$v_I(t) = V_I + v_i(t) = -0.4 \sin 2\pi ft\text{V}$$

b) $-5\text{V} \leq v_C(t) \leq 5\text{V}$ da operacioni pojačavač ne bi ušao u zasićenje

$$v_{g \max} = \frac{V_C - v_{c \min}}{2} = 2.25\text{V}$$

$$v_{g \min} = \frac{V_C - v_{c \max}}{2} = -2.75\text{V}$$

$$V_m = \min\{v_{g \max}, -v_{g \min}\} = 2.25\text{V}$$