ODEV-1 ÇÖZÜMLER

SORU-1

a) $V_{BE} = V_T \ln \frac{I_C}{I_S} = 25.10^{-3} \ln \frac{0,5.10^{-3}}{1.10^{-15}} = -673mV \Rightarrow V_{EB} = 673mV$

$-V_{BE}$

$V_E = V_{EB} + R_4 I_B$

$= +0,673V + 10k \cdot \frac{0,5mA}{200}$

$= 0,698$

$I_E = I_B + I_C$

$I_C = \frac{I_C}{\beta} + I_C \Rightarrow \frac{(1+\beta)}{\beta} I_C$

$\Rightarrow I_E = \frac{(1+\beta)}{\beta} I_C$

$V_{CC} = (R_2 + R_3) I_E + V_E$

$I_E = \frac{V_{CC} - V_E}{R_2 + R_3} = \frac{5 - (0,698)}{R_2 + R_3} \cong 0,5mA$

$\frac{4,302}{R_2 + 8,2k} = 0,5mA \Rightarrow$

$R_2 + 8,2k = 860k\Omega \Rightarrow \boxed{R_2 \cong 40k\Omega}$

b) $V_E = V_{EC} + 10k\, I_C - 10V$

$0,698 = V_{EC} + 10k \cdot 0,5mA - 10V$

$0,698 = V_{EC} + 5V - 10V$

$-5V$

$V_{EC} = 5,698 \Rightarrow \boxed{V_{CE} = -5,698V}$

c) Kolektör çıkışlı devre kazancı

$K_u = \frac{v_o}{v_i} = -\frac{R_C \| R_y}{R_e + r_e} = \frac{-R_1}{r_e + R_2} = \frac{-10.10^3}{50\Omega + 40k\Omega}$

$r_e = \frac{V_T}{I_C} = 50\Omega$

$\left(\cong -22 \right)$

d) $r_i = R_4 // r_i'$

$= R_4 // \left(h_{fe}(r_e + R_e) \right]$

$= 10 \cdot 10^3 // \left[200 \cdot (50\Omega + R_2 \; 40k\Omega) \right]$

$= 10 \cdot k // 90{,}8\,k$

$\simeq 9\,k\Omega$

Soru-2

$$I_D = \frac{\beta}{2} (V_{GS} - V_{th})^2$$

$$1mA = \frac{(\mu_p C_{ox} W/L)}{2} (|V_{GS}| - |V_{th}|)^2$$

$$1mA = \frac{200cm^2/Vs \cdot 10^{-7} F/cm^2 \cdot 100}{2} \left[|V_{GS}| - (0{,}7) \right]^2$$

$$2mA = 2mA/V^2 \; \left[|V_{GS}| - 0{,}7 \right]^2$$

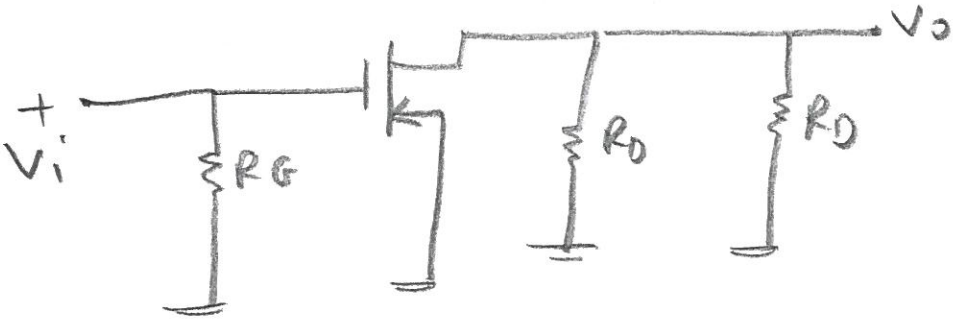
$$\left[|V_{GS}| - 0{,}7 \right]^2 = 1\,V^2$$

$$|V_{GS}| - 0{,}7 = \mp 1\,V$$

$|V_{GS}| - 0,7 = 1V \Rightarrow |V_{GS}| = 1,7V \Rightarrow V_{GS} = -1,7V$ olmalı (3)

pMOS için $V_{GS} < 0$ olmalı

b)



c) $\frac{V_o}{V_i} = -g_m (R_L // R_D) \Rightarrow$ $g_m = \sqrt{2\beta I_D}$

$= \sqrt{2 \cdot 2mA/V^2 \cdot 1mA}$

$= 2mA/V$

$\frac{V_o}{V_i} = -2mA/V \cdot (12k // 3k)$

$= \underline{-4,8}$

d) $V_{DS} = V_{GS} + |V_t| \rightarrow$ doyma sınır şartı (PMOS için)

$\underbrace{R_D I_D - V_{DD}}_{\text{Çevre denkleminden}} = -1,7V + 0,7$

$I_D R_D = 6V \Rightarrow \underline{R_D = 6k\Omega}$

$V_{DS} = V_{GS} - V_t \rightarrow$ doyma sınır şartı (NMOS için)

3) M_2 transistörü doymadadır $V_G = V_D$ olduğu için.

Bu durumda doymalı durumdaki akım bağıntısı

$$I_{D2} = \frac{\beta_p}{2}(|V_{GS2}| - |V_t|)^2(1 + \lambda_p |V_{DS1}|)$$

$V_{GS2} = V_{G2} - V_{S2} = V_{out} - V_{DD}$ ve $V_{DS2} = V_{GS2}$

$$100\mu A = \frac{50\mu A/V^2}{2}(|V_{GS2}| - |V_t|)^2\left(1 + 0{,}56 \cdot \frac{1}{V} \cdot |V_{DS2}|\right)$$

$$4 = (|V_{GS2}| - 0{,}5)^2\left(1 + 0{,}56 \cdot \frac{1}{V} |V_{GS2}|\right)$$

$$(\underbrace{|V_{GS2}|}_{x \text{ dersek}} - 0{,}5)^2 \cdot (1 + 0{,}56 \cdot |V_{GS2}|) = 4$$

$$(x - 0{,}5)^2(1 + 0{,}56 \cdot x) = 4 \quad \Rightarrow x = 1{,}8934$$

$|V_{GS2}| = 1{,}8934$

$V_{GS2} = -1{,}89 = V_{DS2}$

$V_{DS1} = V_{DD} + V_{DS2}$

$= 5 - 1{,}89$

$= 3{,}11.$

$$I_{D1} = \frac{\beta_n}{2}(V_{GS} - V_{th})^2(1 + \lambda V_{DS})$$

$$100\mu A = \frac{120\mu A/V^2}{2}\left(V_{GS1} - 0{,}5\right)^2(1 + 0{,}32\,V^{-1} V_{DS1})$$

$$1{,}66 = (V_{GS1} - 0{,}5)^2(1 + 0{,}32 \cdot 3{,}11)$$

$V_{GS1} = 1{,}413$

$V_{GS1} = -0{,}413$

$V_{GS1} - V_t < V_{DS1}$ olduğu için **M_1** doymadadır.

b) $r_o = r_{o1} \parallel r_{o2} \parallel 1/g_{m2}$

$r_o = 5,3k$

$g_{m1} = \sqrt{2\beta_1 I_D} = 0,15mS$

$g_{m2} = \sqrt{2\beta_2 I_D} = 0,1mS$

$r_{o1} = \frac{1}{\lambda_1 I_D} = 31,25k$

$r_{o2} = \frac{1}{\lambda_2 I_D} = 17,86k$

c) $\frac{V_o}{V_i} = -g_{m1} r_o$

$= -0,15mS\,(5,3k)$

$\cong -0,8$