

Soru 1.

$$a- \Delta V_I \leq \sqrt{\frac{2I_{SS}}{\mu \cdot C_{OX} \left[\frac{W}{L} \right]}} \Rightarrow I_{SS} = \frac{1}{2} \Delta V_I^2 \cdot \mu \cdot C_{OX} \left[\frac{W}{L} \right] = \frac{1}{2} \times 0.5^2 \times 40 \times 10^{-6} \times 9 = 45 \mu A$$

$$b- g_{m1} = g_{m2} = \sqrt{I_{SS} \mu \cdot C_{OX} \left[\frac{W}{L} \right]} = \sqrt{45 \mu A \times 40 \mu A / V^2 \times 9} = 127 \mu A / V$$

$$g_{o1} = \lambda_N \cdot I_D = 0.225 \mu A / V$$

$$g_{o4} = \lambda_P \cdot I_D = 0.45 \mu A / V$$

$$K_d = \frac{v_o}{v_i} = \frac{g_{mi}}{g_{di} + g_{dl}} = -188.1$$

c- Kazancın yarıya düşmesi için akım 4 katı olmalı. $I_{SS} = 4 \times 45 \mu A = 180 \mu A$

d-

$$\Delta V_I \leq \sqrt{\frac{2I_{SS}}{\mu \cdot C_{OX} \left[\frac{W}{L} \right]}} = \sqrt{\frac{2 \times 180 \mu A}{40 \mu A / V^2 \times 9}} = 1V$$

$$-1V \leq \Delta V_I \leq 1V$$

Soru 2:

$$a- \frac{(W/L)_3}{(W/L)_6} = \frac{(W/L)_4}{(W/L)_6} = \frac{1}{2} \frac{(W/L)_5}{(W/L)_7} = \frac{I_O}{2 \cdot I_7}$$

$$\frac{15}{94} = 0.159 \quad \frac{1}{2} \cdot \frac{4.5}{14} = 0.16 \quad \text{aradaki fark ihmal edilebilir. Sistemik dengesizlik yoktur.}$$

b-

$$V_{OS} = \Delta V_{T1-2} + \Delta V_{T3-4} \cdot \left(\frac{g_{m3}}{g_{m1}} \right) + \frac{(V_{GS} - V_T)_{1-2}}{2} \cdot \left[\frac{\Delta(W/L)_{1-2}}{W/L_{1-2}} - \frac{\Delta(W/L)_{3-4}}{W/L_{3-4}} \right]$$

$$g_{m3} = \sqrt{2 \cdot I_{D3} k'_N \left[\frac{W}{L} \right]_3} = \sqrt{2 \times 40 \times 10^{-6} \times 15 \mu A \times 3} = 60 \mu A / V$$

$$g_{m4} = \sqrt{2I_{D4}k'_P \left[\frac{W}{L} \right]_4} = \sqrt{2 \times 20 \times 10^{-6} \times 15 \mu A \times 15} = 94.8 \mu A/V$$

$$I_{D1} = \frac{1}{2} k'_N \left(\frac{W}{L} \right)_1 [V_{GS} - V_{TN}]^2 \Rightarrow [V_{GS} - V_{TN}] = 0.5V$$

$$V_{OS} = 2mV + 2mx \left(\frac{60}{94.8} \right) + \frac{0.5V}{2} \cdot [0.02 + 0.02] = 13.3mV$$

$$K_{V1} = \frac{g_{m1}}{g_{o2} + g_{o4}}$$

$$K_{V2} = - \frac{g_{m6}}{g_{o6} + g_{o7}}$$

$$K_V = \frac{g_{m1}}{g_{o2} + g_{o4}} \times \left(- \frac{g_{m6}}{g_{o6} + g_{o7}} \right)$$

$$g_{o2} + g_{o4} = \lambda_N I_2 + \lambda_P I_4 = 3\lambda_N I_2 = 0.45 \mu A/V$$

$$g_{o6} + g_{o7} = \lambda_N I_7 + \lambda_P I_7 = 3\lambda_N I_7 = 3.6 \mu A/V$$

$$g_{m6} = \sqrt{2I_6 k'_P \left[\frac{W}{L} \right]_6} = \sqrt{2 \times 20 \times 10^{-6} \times 120 \mu A \times 94} = 671.7 \mu A/V$$

$$K_V = 24850$$

$$\omega_I = \frac{g_{m1}}{C_C} = \frac{60 \times 10^{-6}}{3 \times 10^{-12}} = 20 \times 10^6 \text{ rad/sn} \Rightarrow f_1 = 3.18 \text{ MHz}$$

$$R_Z = g_{m6}^{-1} = \frac{1}{\sqrt{2I_6 k'_P \left[\frac{W}{L} \right]_6}} = \frac{1}{671.7 \mu A/V} = 14.9k$$

Soru 3:

$$\Delta V_I \leq \sqrt{\frac{2I_A}{k'_N \left(\frac{W}{L}\right)_1}} \Rightarrow \left(\frac{W}{L}\right)_1 = \frac{2I_A}{k'_N \cdot \Delta V_I^2} = \frac{2 \times 100 \times 10^{-6}}{40 \times 10^{-6} \cdot 1^2} = 5$$

$$G = B \cdot \sqrt{k'_n \cdot I_A \cdot \left(\frac{W}{L}\right)_1} \Rightarrow B = \frac{G}{\sqrt{k'_n \cdot I_A \cdot \left(\frac{W}{L}\right)_1}} = \frac{200 \mu A / V}{\sqrt{40 \times 10^{-6} \cdot 100 \times 10^{-6} \cdot 5}} = 1.42$$

$$\left(\frac{W}{L}\right)_{5-6} = B \cdot \left(\frac{W}{L}\right)_{3-4} \Rightarrow \left(\frac{W}{L}\right)_{5-6} = 1.42 \times 3 = 4.26$$