Microelectronics Circuit Analysis and Design
Homework(11st)

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10.44 Consider the MOSFET current-source circuit in Figure P10.44 with $V^+ = +2.5\text{V}$ and $R = 15\ \text{k}\Omega$. The transistor parameters are $V_{TN} = 0.5\text{V}, k_n' = 80\mu\text{A}/\text{V}^2, , W/L = 6$, and $\lambda = 0$. Determine I_{REF}, I_O, and $V_{DS2}(\text{sat})$.

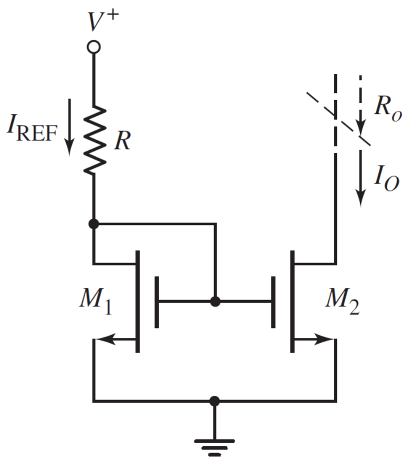

Figure 1: Problem 10.44

Solution:

Because of KCL and MOSFET:

$$\frac{V^+ - V_{GS}}{R} = K_n(V_{GS} - V_{TN})^2 \Rightarrow V_{GS} = 1.12\text{V}$$

So $I_{REF} = I_O = \dfrac{V^+ - V_{GS}}{R} = 92.05\mu\text{A}, V_{DS2(sat)} = V_{GS} - V_{TN} = 0.62\text{V}$

10.54 The transistor circuit shown in Figure P10.54 is biased at $V^+ = +5\text{V}$ and $V^- = -5$ V.The transistor parameters are $V_{TP} = -1.2V, k'_p = 80\mu A/N^2, \lambda = 0, (W/L)_1 = (W/L)_2 = 25,$ and $(W/L)_3 = (W/L)_4 = 4$. Determine $I_{\text{REF}}, I_O,$ and $V_{SD2}(\text{sat})$.

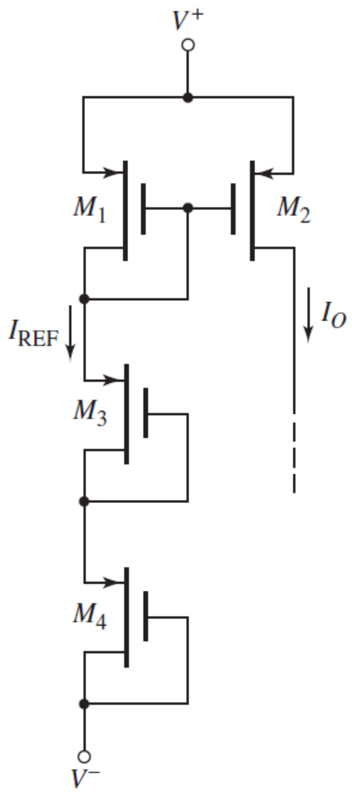

Figure 2: Problem 10.54

Solution:

$$\begin{cases} I_{REF} = K_{p1}(V_{SG1} + V_{TP})^2 = K_{p3}(V_{SG3} + V_{TP})^2 = K_{p4}(V_{SG4} + V_{TP})^2 \\ V_{SG1} + V_{SG3} + V_{SG4} = V^+ - V^- \end{cases}$$

$$\Rightarrow V_{SG1} = 2.45\text{V}, I_{REF} = I_O = 1.14\text{mA}$$

So $V_{SD2(sat)} = V_{SD2} + V_{TP} = 1.25\text{V}$

10.60 The transistors in the circuit shown in Figure P10.60 have parameters $V_{TN} = 0.4\text{V}, V_{TP} = -0.4\text{V}, k'_n = 100\mu\text{A}/V^2, k'_p = 60\mu\text{A}/\text{V}^2$,and $\lambda_n = \lambda_p = 0$. The transistor width-to-length ratios are $(W/L)_1 = (W/L)_2 = 20$, $(W/L)_3 = 5$, and $(W/L)_4 = 10$. Determine $I_O, I_{\text{REF}},$ and $V_{DS2}(\text{sat})$. What are the values ofV_{GS1}, V_{GS3}, and V_{SG4}?

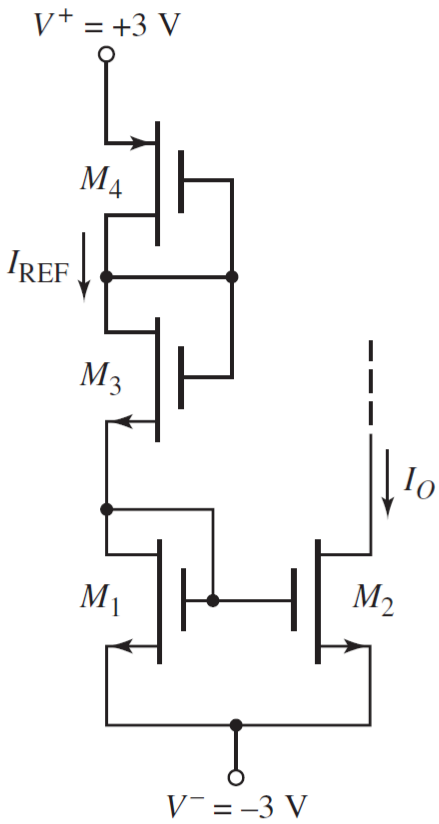

Figure 3: Problem 10.60

Solution:

$$\begin{cases} I_{REF} = K_{p4}(V_{SG4} + V_{TP})^2 = K_{n3}(V_{GS3} - V_{TN})^2 = K_{n1}(V_{GS1} - V_{TN})^2 = I_O \\ V_{SG4} + V_{GS3} + V_{GS1} = V^+ - V^- \end{cases}$$

$$\Rightarrow V_{GS1} = 1.395\text{V}, V_{GS3} = 2.389\text{V}, V_{SG4} = 2.216\text{V}$$

So:

$$I_O = I_{REF} = K_{n3}(V_{GS3} - V_{TN})^2 = 0.99\text{mA}, V_{GS2(sat)} = V_{GS1} - V_{TN} = 0.995\text{V}$$

10.84 In the circuit in Figure P10.84, the active load circuit is replaced by Wilson current source. Assume that $\beta = 80$ for all transistors, and that $V_{AN} = 120$V, $V_{AP} = 80$V and $I_{REF} = 0.2$mA. Determine the open-circuit small-signal voltage gain.

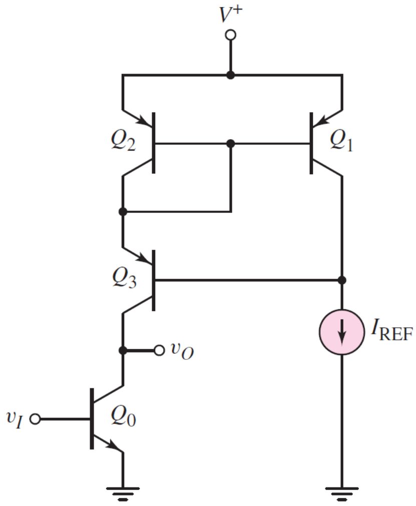

Figure 4: Problem 10.84

Solution:

Output resistance of Wilson source:

$$R_0 \cong \frac{\beta r_{03}}{2}$$

Solve out g_m and r_{03}

$$r_{03} = \frac{V_{AP}}{I_{REF}} = \frac{80}{0.2} = 400\text{k}\Omega g_m = \frac{I_{REF}}{V_T} = \frac{0.2}{0.026} = 7.692\text{mA/V}$$

Solve out A_v:

$$A_v = -g_m \left(r_0 \middle\| \frac{\beta r_{03}}{2} \right) \Rightarrow A_v = -4448$$