Electronics II, EXAM-3, Spring 2018

Department of Communication Engineering, National Central University

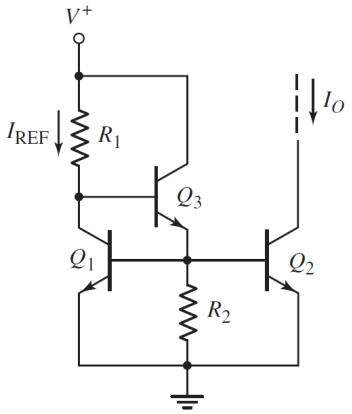
May 25, 2018, Prof. Dah-Chung Chang (E1-311)

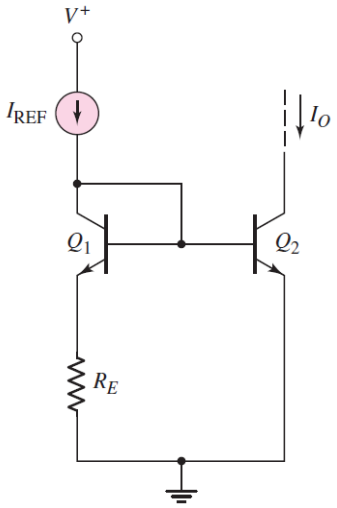
Exam Time: 10:00AM-12:30PM, 2018/5/25

1. (30%) The transistor parameters are $\beta = 80, V_{BE}(\text{on}) = 0.7\,\text{V}$ and $V_A = \infty$.

   (a) Derive the expression for I_O in terms of $I_{REF}, \beta, V_{BE}(\text{on})$, and R_2.

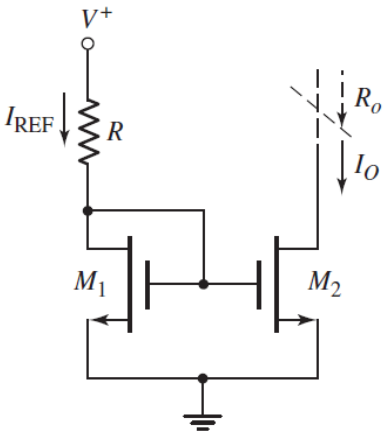
   (b) For $R_2 = 10k\Omega$ and $V^+ = 10\text{V}$, find R_1 such that $I_O = 0.7\text{mA}$.

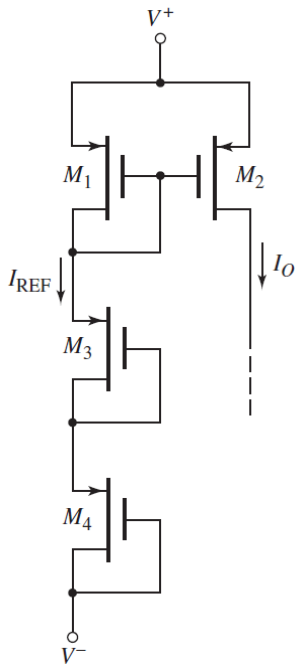




2. (20%) Neglect base currents and assume $V_A = \infty$, $I_{REF} = 100\mu\text{A}$, and $R_E = 700\Omega$. For transistor parameters (reverse saturation currents from collector to emitter) of $I_{S1} = I_{S2} = 5\times10^{-15}\,\text{A}$, find I_O.

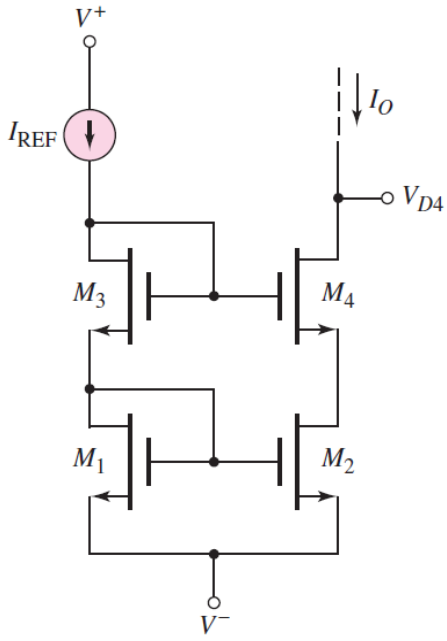
3. (20%) Consider the circuit with $V^+ = +2.5\text{V}$ and $R = 15k\Omega$. The transistor parameters are identical, with parameters $V_{TN} = 0.5\text{V}, k_n' = 80\mu\text{A/V}^2$, W/L=6, and $\lambda = 0$. Determine I_O.

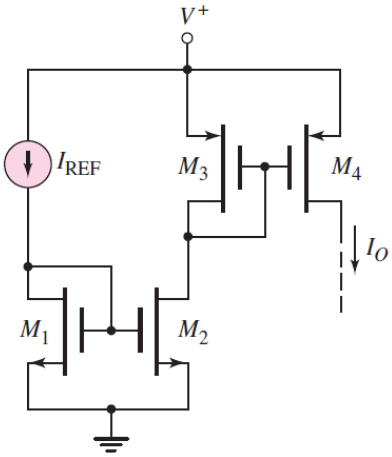




4. (25%) Consider the circuit with $V^+ = +5\text{V}$ and $V^- = -5\text{V}$. The transistor parameters are $V_{TP} = -1.2\text{V}, k_p' = 80\mu\text{A/V}^2$, $(\text{W/L})_1 = (\text{W/L})_2 = 25$, $(\text{W/L})_3 = (\text{W/L})_4 = 4$, and $\lambda = 0$. Determine I_O.

5. (20%) Consider the circuit with $V^+ = +5\text{V}$ and $V^- = -5\text{V}$. All transistors are identical, with parameters $V_{TN} = 1\text{V}$, $K_n = 80\mu\text{A/V}^2$, and $\lambda = 0.02\text{V}^{-1}$. Let $I_{REF} = 20\mu\text{A}$, determine the output resistance R_o looking into the drain of M_4.





6. (20%) Transistor parameters are $V_{TN} = 0.4\text{V}$, $k_n' = 100\mu\text{A/V}^2$, $V_{TP} = -0.6\text{V}$, $k_p' = 40\mu\text{A/V}^2$, and $\lambda_n = \lambda_p = 0$. The width-to-length ratios are $(\text{W/L})_1 = 15$, $(\text{W/L})_2 = (\text{W/L})_3 = 9$, and $(\text{W/L})_4 = 20$. Let $I_{REF} = 200\mu\text{A}$, determine
   (a) I_O, and
   (b) the minimum V_{SD4} such that M_4 is biased in the forward active mode.

7. (15%) Transistor parameters are $V_{TN} = 1\text{V}$, $K_n = 1\text{mA/V}^2$, and $\lambda_n = \lambda_p = 0.01\text{V}^{-1}$. Assume M_1 and M_2 are matched and $I_{REF} = 0.5\text{mA}$. Find the small-signal voltage gain for the load resistance of $R_L = 100k\Omega$.