**Department of Electrical Engineering**
**Indian Institute of Technology, Kanpur**

**EE 210** **Assignment #6** **Assigned: 10.2.25**

1. An n-channel MOSFET is to be designed to carry a drain current of 100 μA, remaining in the saturation region with the least value of $V_{DS}$ equal to 100 mV, and at this bias point, its output resistance must equal 1 MΩ. Design the values of its W and L, assuming $dX_d/dV_{DS}$ = 10 nm/V. Assume $k'_N = 40\ \mu A/V^2$, and $\lambda V_{DS} << 1$.

2. Determine the output current $I_0$ and the output resistance of the bipolar current mirror shown in Fig.1, for $V_0$ = 1 V, 5 V, and 30 V: i) neglecting any non-idealities, and ii) including all non-idealities. For each case, find the percent change between the ideal and the non-ideal performances. All the transistors have the same emitter-base junction areas. Assume $V_A$ = 130 V and β = 50.

3. Consider the npn ratioed current mirror shown in Fig.2, with $V_{CC}$ = 5 V and $R_1$ = 1 kΩ. Choose the values of R and $R_2$, such that the output resistance of the mirror is at least 10 MΩ, and the circuit should operate properly for $V_0$ all the way down to 0.5 V. What is the output current $I_0$? Using the calculated value of $I_{REF}$, determine the value of $I_0$, for which the simple approximation for the ratioed current mirror would ***just*** break down. What are the corresponding values of $R_2$, $V_{0(min)}$, and $R_0$? Neglect base currents and Early effect for the dc analysis of the circuit, and assume $V_A$ = 130 V for ac analysis.

4. Determine the quiescent currents flowing in all the branches of the circuit shown in Fig.3, and calculate the output resistance $R_0$. Neglect base currents, and assume $V_A$ = 130 V.

5. Determine the output current and the output resistance of the circuit shown in Fig.4. Neglect base currents and assume $V_A$ = 130 V.

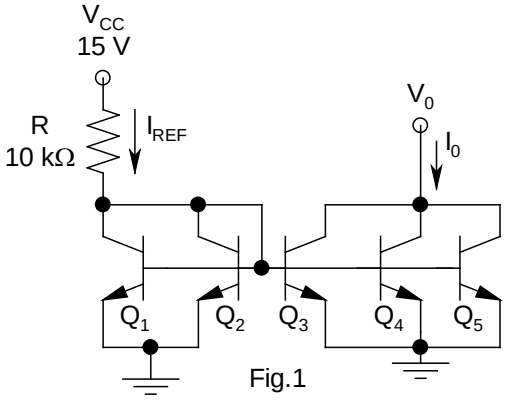

Fig.1

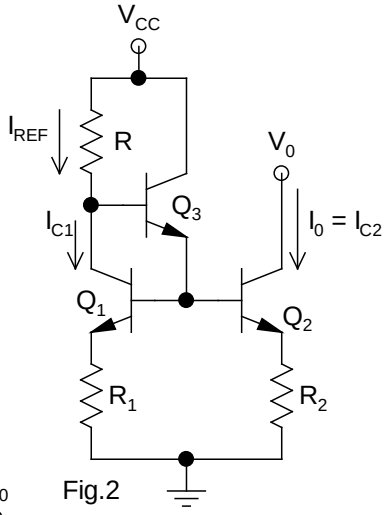

Fig.2

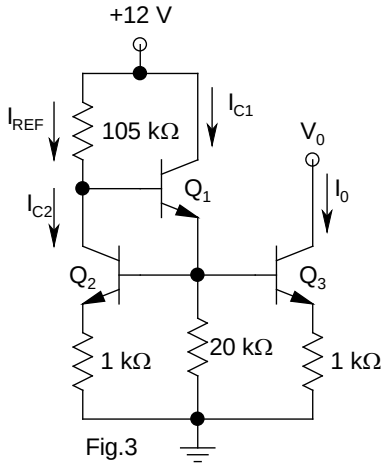

Fig.3

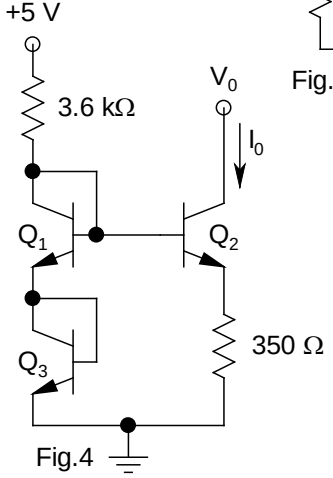

Fig.4