EE5390 Homework 1: Due Wednesday 08/02/2012

1. a) Derive the analytical expression for output current in the circuits shown in Figures 1 & 2.
   b) In each case, determine the sensitivity of output current to supply voltage given the following parameters: Vdd = 1.3V; $V_{T1,2}$ = 0.3V; k' = 200µA/V^2; $(W/L)_1 = (W/L)_2$ = 25; R_1 = 8kΩ; R_2 = 4kΩ; {sensitivity S = $(V_{DD}/I_{OUT})(\partial I_{OUT}/\partial V_{DD})$}

2. Consider the circuit shown in Figure 3. Assume that Q_2 has a saturation current of I_S, while Q_3 and Q_4 have a saturation current of nI_S. Neglect the portion of I_0 flowing through the resistors, and neglect all base currents. Determine the expression for bias current I_{BIAS} in terms of other circuit parameters.

3. Consider the circuit shown in Figure 4. Assume the MOSFETs follow the long-channel device equation $I_D = \beta(V_{GS} - V_T)^2$. You are given the following parameters: I_0 = 1mA; Vdd = 5V; β_2 = 5mA/V^2; $V_{T1,2}$ = 1V; R_1 = 1kΩ; R_2 = 5kΩ; n=3. Determine the values of V_{OUT}, V_X and I_X.

4. a) Design an NMOS high-swing cascode current mirror using device parameters from the IBM 0.13µm process file supplied to you. The circuit specifications are: $V_{OUT,\ min}$ = 0.3V; $R_{OUT,\ min}$ = 100kΩ; I_{IN} = 1µA; I_{OUT} = 100µA.
   b) Calculate the output current noise spectral density in A/√Hz (neglect flicker noise)
   c) Simulate the circuit in (a) and compare with your calculations. If you observe significant differences between calculated and simulated results, explain why there is a difference and modify your design to meet the specifications. {final I_{OUT} = 100µA ± 0.1%}
   d) Plot R_{OUT} when V_{OUT} is varied from 0.1V to 1.3V. What behaviour do you see and why?
   e) Plot output current noise spectral density in A/√Hz between 100Hz and 100MHz, and compare the value in the white noise region with that from (b). If there is a discrepancy, explain why.

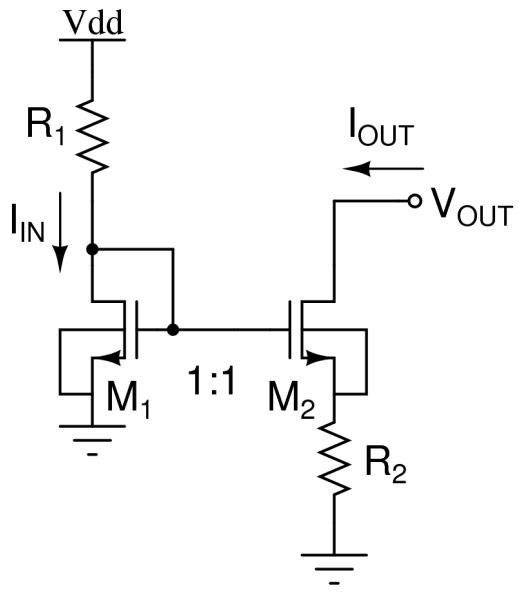

Figure 1

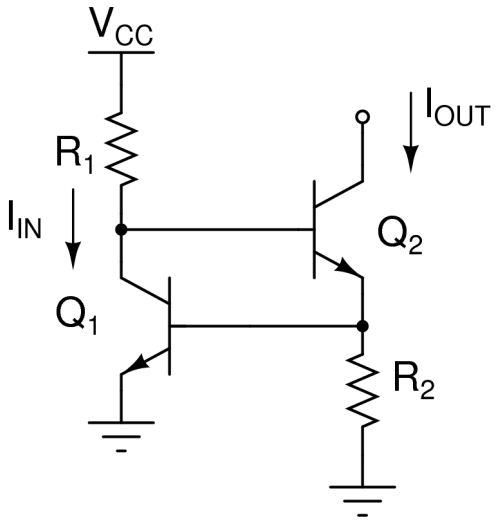

Figure 2

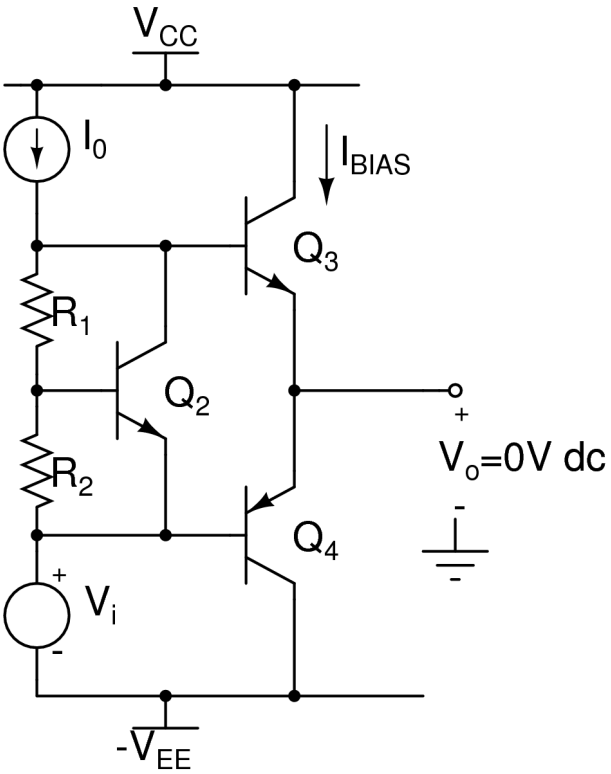

Figure 3

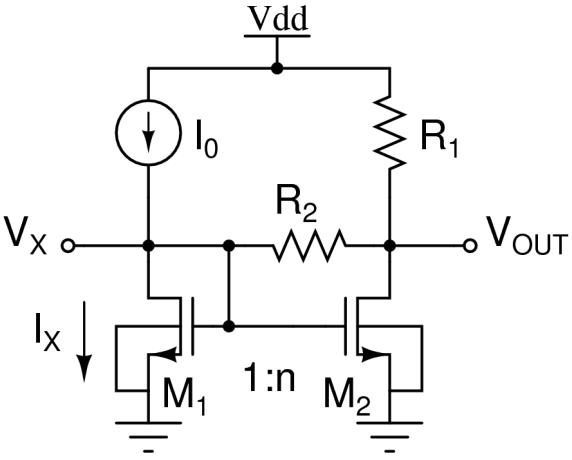

Figure 4