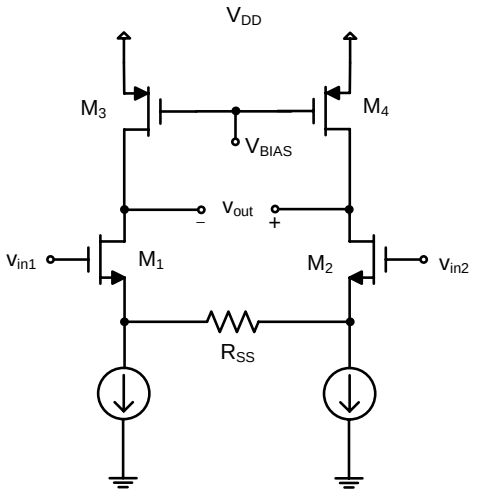
American University of Beirut
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
EECE 311 – Electronic Circuits (Sections 1 & 2)
Spring 2008

HOMEWORK 4
Due Wednesday April 7, 2008 at 1:00 PM

Problem 1.

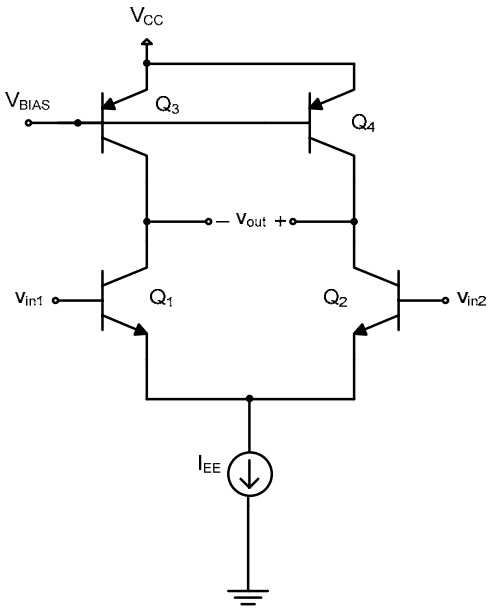
Calculate the differential voltage gain $v_{out}/(v_{in1}-v_{in2})$ in the circuit shown below. Assume perfect symmetry, but do *not* neglect channel length modulation. *Hint:* Use the half-circuit technique.



Problem 2.

The circuit shown below should provide a differential gain of 100 V/V at a power budget of 1 mW. Assume $V_{A,n}$ = 6 V, V_{CC} = 2.5 V, and very large β.

a) Find the bias current I_{EE}.
b) Estimate g_{mN} and r_{oN}.
c) Calculate r_{oP} and estimate $V_{A,p}$.
d) Estimate the input bias current if β_N is 200.
e) Estimate the input offset current if β_N is matched to within +/– 2%.



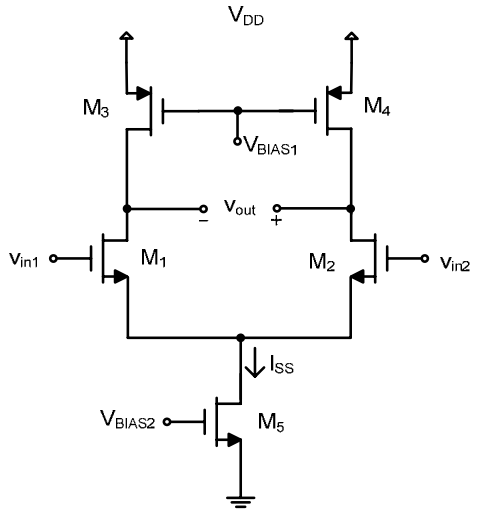
Problem 3.

Design the MOS differential amplifier shown in Figure 7.1 in the textbook for a differential voltage gain of 5 V/V and a power dissipation of 1 mW if the overdrive voltage must be at least 150 mV.
Assume $k'_n = 100\ \mu A/V^2$ and $V_{DD} = 1.8$ V. Neglect channel length modulation.
Find the values of I, R_D, and (W/L) for the MOSFETs.

Problem 4.

The differential amplifier shown below must provide a differential gain of 40 V/V. Assume that all transistors have the same overdrive voltage, and a circuit power budget of 2 mW. Also assume that $V_{A,n} = 10$ V, $V_{A,p} = 5$ V, $k'_n = 100\ \mu A/V^2$, $k'_p = 50\ \mu A/V^2$, and $V_{DD} = 1.8$ V.

a) Design the circuit by calculating the current I_{SS}, the overdrive voltage, and the (W/L) ratios of all MOSFETs.
b) Find the CMRR of the amplifier when the output is single-ended.



Problem 5.

Design the *telescopic* cascode amplifier shown below, for a differential voltage gain of 600 V/V with a power budget of 4 mW. Assume an overdrive voltage of 100 mV for the NMOS devices and 150 mV for the PMOS devices. Using $V_{A,n} = 10$ V, $k'_n = 100\ \mu A/V^2$, $k'_n = 50\ \mu A/V^2$, and $V_{DD} = 1.8$ V, determine the required value of $V_{A,p}$. Determine (W/L) for MOSFETs M_1 to M_8. Assume that $M_1 - M_4$ are identical, and so are $M_5 - M_8$.