EECE2412 Spice Project 3

Prof. Charles A. DiMarzio
Joseph L. Hollmann, TA
Department of Electrical and Computer Engineering
Northeastern University

Spring Semester 2013

Consider the following circuit. We want to amplify the signal, V_{sig}, which we can assume is a 0.8 mV sine wave at 1 kHz. The problem is that the wires connecting the signal to our amplifier are susceptible to picking up stray voltage signals radiated by power wires at 400 Hz, a power frequency commonly used on aircraft. We model this unwanted contamination of the signal as a voltage source, V_{common}, with an amplitude of 5 mV. The very symmetric configuration in the circuit shown in the figure at the end of the problem statement provides a differential gain which we hope will remove this voltage that is common to both wires.

a. Plot the characteristic curves of the two transistors (amplifier and current–mirror) for V_{DS} or V_{SD} from 0 to 15 V, and V_{GS} or V_{SG} from 0 to 5 V in steps of 1 V. Use a separate circuit for this part, with just the transistor and appropriate voltage sources. Using the model editor, make note of L and W, as you will need to adjust these later.

a'. Now, to explore the effects of the differential amplifier, start with a circuit that contains one amplifier transistor, one current mirror, and two voltage sources. In other words, use half of the given circuit, M2 and M4, without the differential feature. You will need to connect the drain to the gate on M2, when you remove M1.

b. Now use the circuit in the figure at the end of the problem. Identify the function of each transistor in the circuit.

c. Now design the circuit so that the four transistors, M_1 through M_4

have DC currents of 125 μA. Add resistors to the circuit specifically to simulate the r_0 associated with M_1 and M_2. Assume $r_0 = 200$ kΩ for both. Why are these resistors needed to make the circuit work?

d. Test your design by plotting (1) the input signal (2) the voltage at the gate of M_3 (the negative input), (3) the voltage at the gate of M_4 (the positive input), and (4) the output voltage across the load resistor.

e. What is the voltage gain? What is the gain in dB?

f. The current through M_5 is shared by both M_3 and M_4. Why is this a good idea? What would happen if there were a separate M_5 for each of the two paths?

g. Explore what happens if the transistors are not perfectly matched. For example, try playing with W and L for one of the transistors, and try playing with the r_0 values.