Due at 12:00 am Thursday Dec. 1 in box in 240 Cory Hall. Be sure to put the name of your Discussion Section TA on your paper, together with your name and that of your collaborator if appropriate.

Reading: There will be a question on the final about some sort of practical device or system that is either described in lectures, in your text (references are below), in a homework problem you’ve done, or in your lab work. Please review the ones that have been included in these ways in the course.

“Practical Applications” occur in Hambley on pp. 32 (strain gauge), 94 (electric vehicle), 137 (photoflash), 179 (electric auto), 203 (global positioning system), 364 (pacemaker) and 529 (stud finder). Also see discussions of a position sensor (p. 58) and the “LVDT” (linear variable differential transformer, p. 139-30) that is used frequently by mechanical engineers.

In addition you’ve heard about or used electric devices to measure temperature, acceleration and the filling of a container of liquid.

Problems:

Problem 1. (10 points) Working with a complex circuit. Find the gains of all six operational amplifier circuits that are in the circuit for the noise-cancellation earphones described in lecture on Nov. 22.

Problem 2. Hambley 7.46. (20 points) In addition to the tasks listed, verify your result from using a Karnaough map by employing the rules of Boolean algebra that are scattered through this chapter. Draw both the layout of logic gates for a direct implementation of the logic function and then the implementation of the simplified logic function using the arrangement of Fig. 7.22 (variables come in from the top, etc.) to make it easier for the reader to grade.

Problem 3. (15 points) The purpose of simplifying logic functions is to reduce the number of transistors used to make the actual circuits. This reduces the silicon area needed and hence the cost of the circuit, since silicon “real estate” is relatively expensive.

a. For the logic function of Problem 2, before simplification how many PMOS transistors are used? (Note: You can make an AND gate by following a NAND gate with an inverter – NOT gate.)
b. How many NMOS transistors are required?
c. For the simplified logic function how many transistors in all are required?

Problem 4. (15 points) Processor speed.

a. Suppose your company’s circuit designer claimed that by reducing the bias voltage on his CMOS circuits from 5 volts to 1.5 volts she could reduce the dissipated power by 95%. Do you believe her (explain your answer)?
b. Another circuit designer in your company says that he wants to start a processor product line where the bias voltage on his conventional silicon CMOS circuits will be set at just 0.1 volts, thereby reducing the dissipated power by a whopping 2500 times. Should you give him a raise and a year-end bonus, or point out a flaw in his reasoning (if flaw, explain it)?
c. A new hire from UCB put a note in the Company suggestion box advising the Company to reduce the power dissipation in its processors by substituting a high-permittivity dielectric, titanium dioxide (relative permittivity about 100), for the silicon dioxide insulators used in the gates of its transistors (the relative permittivity of silicon is 3.9). What will you tell the new graduate (be quantitative)?