Name (Last, First) ______________________________ Student ID number ___________________

UNIVERSITY OF CALIFORNIA

College of Engineering
Electrical Engineering and Computer Sciences Department

EECS 145M: Microcomputer Interfacing Laboratory

Spring Midterm #1 (Closed book- calculators OK)
Monday, March 2, 1998

PROBLEM 1 (30 points)

Design an interface and computer program that allows a computer to control a temperature sensor and reliably read its digital output.

- The temperature sensor has a “take data” control line and converts the temperature into a 12-bit digital number whenever the “take data” line goes from low to high.
- The temperature sensor also produces an "output data available" line that goes from low to high when the 12 digital output lines are stable and valid.
- When the “take data” line is brought low, the temperature sensor brings its “output data available” line low.
- The computer has a digital I/O port with 16 lines of input and 16 lines of output
- Your program can use "GetSingleValue(&value)" and "PutSingleValue(value)" functions to read from and write to the digital I/O port.
- After "PutSingleValue(value)", the value is continually asserted on the output lines until a new value is written.

Do the following:

1a. (12 points) Draw a block diagram of your system, showing and labeling all essential components, connections, and signals.

Name (Last, First) ____________________________ Student ID number __________________

1b. (12 points) In proper time sequence, list the program and hardware steps necessary for your system to read the temperature sensor. (You may assume that initially the "take data" and "data available" lines are low.)

1c. (6 points) Draw a timing diagram (i.e. digital state vs. time) for the signals described in part b.

Name (Last, First) ____________________________ Student ID number _________________

PROBLEM 2 (50 points)

Design an interface and computer program that allows the computer to simultaneously start the two temperature sensors and read them as soon as possible after their values are ready. (The computer and temperature sensors are as described in problem 1).

- As above, the computer has a single digital I/O port with 16 lines of input and 16 lines of output
- You have available four 8-bit tri-state drivers and each has 8 inputs, 8 outputs, and an "output enable" input. When the "output enable" line is low, all 8 outputs are the same as the corresponding inputs. When the "output enable" is high, all 8 outputs are in a high impedance state.

2a. (20 points) Draw a block diagram of your circuit design, showing and labeling all essential components, connections, and signals.

Name (Last, First) ____________________________ Student ID number _________________

2b. (20 points) In proper time sequence, list the program and hardware steps necessary for your system to simultaneously start both temperature sensors and read them as soon as they are ready. (You may assume that initially all “take data” and “data available” lines are low.)

2c. (10 points) Draw a timing diagram (i.e. digital state vs. time) for the signals described in part b.

Name (Last, First) ______________________________ Student ID number ___________________

PROBLEM 3 (20 points)

You have just designed a low-cost integrated circuit amplifier whose gain is set by the ratio of two internal resistors. G = 100 kΩ/1 kΩ = 100. The silicon foundry producing your integrated circuits can make resistors whose values have a Gaussian distribution with a fractional uncertainty σ_R/R = 1%. (The average error is much smaller and for simplicity can be neglected in this problem.)

a. (20 points) To keep costs low, you do not measure the gain of every amplifier. Based on the uncertainty in resistor values, what fractional uncertainty σ_G/G do you expect for the gain of an individual amplifier? (*Hint:* use the error propagation formula below.)

Equations, some of which you might find useful:

$$G(a) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left[-\frac{1}{2}\left(\frac{a-\mu}{\sigma}\right)^2\right] \qquad \mu \approx \bar{a} = \frac{1}{m}\sum_{i=1}^{m} a_i$$

$$\sigma_a^2 = \mathrm{Var}(a) = \left(\frac{1}{m-1}\right)\sum_{i=1}^{m} R_i^2 = \left(\frac{1}{m-1}\right)\sum_{i=1}^{m}\left(a_i - \bar{a}\right)^2 \qquad \mathrm{Var}(\bar{a}) = \mathrm{Var}(a)/\ m$$

$$t = \frac{\Delta}{\sigma_\Delta} = \frac{\bar{a}-\bar{b}}{\sqrt{\sigma_{\bar{a}}^2 + \sigma_{\bar{b}}^2}} = \frac{\bar{a}-\bar{b}}{\sqrt{\sigma_a^2/m_a + \sigma_b^2/m_b}} \qquad \sigma_f^2 = \left(\frac{\partial f}{\partial a_1}\right)^2 \sigma_{a1}^2 + \left(\frac{\partial f}{\partial a_2}\right)^2 \sigma_{a2}^2 + \cdots + \left(\frac{\partial f}{\partial a_n}\right)^2 \sigma_{an}^2$$

$$f = k(a+b) \qquad \sigma_f^2 = k^2\left(\sigma_a^2 + \sigma_b^2\right) \qquad f = kab \qquad \sigma_f^2 \big/ f^2 = \sigma_a^2 \big/ a^2 + \sigma_b^2 \big/ b^2$$