Final Exam

- Fill in your name:
- This exam is open book and open notes.
- The exam is 120 minutes and worth 120 points. Spend about one minute per point.
- Explain your solutions well, but you do not need to write an essay.
- The exam is a design problem so some questions are deliberately left open-ended. Be creative.

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You are an engineer at Heating and Cooling, Inc. in charge of the design of a remote control thermostat (see diagram below).

The thermostat includes a keypad and LED display for the user interface to configure the desired temperature. The keypad is a 16-key matrix-scanned keypad. The LED display is a three digit scanned LED display. It also includes an infrared transmitter to communicate with the wall mounted heating/cooling system. Assume that you have a chip (SPI2IR) that interfaces between the SPI interface and the infrared transmitter. Finally, the thermostat includes a temperature sensor.
1. **(20 points)** The range of the temperature sensor is 0 to 120°F with a desired resolution of 0.2°F. The temperature sensor has a maximum slope of 20°F/s. The temperature sensor produces a voltage between 0 and 36mV.

   (a) What is the needed ADC precision? How many bits does the ADC need to be?

   (b) Assume an ADC conversion time of 10ms. Is a sample-and-hold necessary? Why or why not?

   (c) Will the ADCs on the 68HC11 be sufficient?

   (d) What is the maximum allowable noise at the input to your amplifier?

   (e) What does your amplifier’s gain need to be?
2. **(30 points)** Draw a block diagram for the remote control thermostat. Include as much detail as possible. Be sure to consider what ports the I/O devices are connected to. Be sure to include all external circuitry (Sensors, amplifiers, filters, DACs, logic, etc.). You may assume the existence of any component that you need as long as you describe what it does.
3. **(20 points)** Answer the following questions about the software for the infrared transmitter device driver.

   (a) What global data structures would you provide?

   (b) What initialization routines would you provide? What would they do?

   (c) What regular I/O calls would you provide that the client software could use to perform I/O? Describe each in a few words.

   (d) What software support (interrupt handlers) would be needed? Assume that gadfly is not an acceptable option.
4. **(30 points)** Assume that the display is to be scanned. Write the assembly language code required to output the digits one at a time. Be sure to consider the fact that the display should not flicker. Also, remember to use the ports from your diagram. You may assume that the values to be output on the display are determined elsewhere.

(a) What global variables do you need?

(b) Give the assembly code for the ritual.

(c) Give the assembly code for the interrupt handler.
5. **(20 points)** Assume that the control of the heating and cooling device takes a 12-bit value where 0 represents the coolest setting and 4096 represents the warmest. The value is transmitted from the remote to the heating and cooling device using the infrared transmitter. Design a fuzzy logic controller that attempts to find the correct setting for the heating and cooling device which matches the desired temperature. Be creative in your controller design.

(a) What are your control inputs and outputs?

(b) What crisp inputs will you use?

(c) What input fuzzy membership sets will you use?

(d) What output fuzzy membership sets will you use?

(e) Give four example fuzzy rules.