# 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.

| Question | Score |
|----------|-------|
| 1        |       |
| 2        |       |
| 3        |       |
| 4        |       |
| 5        |       |
| 6        |       |
| Total    |       |

You are an engineer at Digital Recording, Inc. in charge of the design of a sound recorder (see diagram below). The user interface software displays menus of options in an LCD display. There are three keys to scroll up and down these options and select the desired menu entry. These three keys can appear on your schematic as switches, and they should cause interrupts whenever they change value. The recorder also includes a microphone for recording sound and a speaker for playing it back. Finally, assume that you have a 8K EPROM to store the software and a 32K FLASH memory for storing global variables and the recorded sound. The basic behavior of this device is that the user should be able to select from a menu that includes:

- Record

- Playback

- Erase

Other functionality may be added later, but this is all you need to worry about for this exam. During this exam you may assume the existence of any basic component that you need as long as you describe what it does.

1. **Analog Interfacing (20 points)** The microphone produces a voltage between 0 to 50mV with a desired resolution of 0.25mV which you should sample with a frequency of 8KHz. The speaker requires an analog voltage between -12V and +12V.

   (a) What is the needed ADC precision? How many bits does the ADC need to be? Will the ADCs on the 68HC11 be sufficient?

   (b) Show a detailed schematic for the microphone interface. Be sure to include the amplifier and filter. Show all components used. Remember to label resistance and capacitance values.

   (c) Show a detailed schematic for the speaker interface. Again show all components with labels.

2. **Memory Mapped Interfacing (20 points)**

   (a) Show your memory map. Hint: be sure to consider how all components that you need are to be interfaced. All memory mapped components should appear in your memory map. You may want to start the next question first.

   (b) Design your address decoder and other logic for controlling the signals to your memory mapped devices. You may assume that the 8K EPROM has read timing similar to Figure 9.48 in the book. You may also assume that the 32K FLASH memory and other memory mapped devices have timing as shown in Figures 9.53 to 9.55.

3. **Hardware (30 points)** Draw a schematic for the sound recorder. Include as much detail as possible including all external circuitry and any connections to any pin used. You may show your microphone, speaker, and memory interfaces as one block each as their internal implementation is shown in the previous problems.

4. **Software (20 points)** Answer the following questions about the software for the sound recorder.

   (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.

5. **Rituals (20 points)** While it is not good style, you have decided to combine all the initializations that you need into a single ritual. Show the assembly code for this ritual.

6. **ARM versus 6811 (10 points)** Assume that you are going to redesign the sound recorder using the ARM board that Professor Regehr described in class.

   (a) What are some advantages of using this board?

   (b) In what ways would you need or want to change the design to use the ARM board?