Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

6.002 – Electronic Circuits
Spring 2007

Lab 4: Audio Playback System

Introduction

In this lab, you will construct, test and demonstrate the audio playback system which you designed in Homework #11. The lab consists of two parts: Pre-lab exercises and in-lab exercises; there are no Post-lab exercises. You should complete the Pre-lab exercises in your lab notebook before coming to lab. Then, carry out the In-lab exercises between April 30 and May 11. After completing the In-lab exercises, have a TA check your work and sign your lab notebook. You may hand in your lab notebook for grading at that time.

Before asking to get checked off, make sure you meet all the requirements in the checkoff list at the end of the In-Lab Exercises

Note that in addition to regular lab hours from April 30 to May 4, there will be staff available in the lab the following week (May 7 through 11) for checkoff. You will be notified as to the times in lecture and by email.

Reminder: You must complete all of the labs. Failure to do so will result in a deduction of one full grade in the class, no exceptions. Your lab notebook must be turned in with all Post-Labs completed and you must be checked off for all the labs.

Pre-Lab Exercises

(4-1) Copy your design for the clock from Problem 1 of Homework #11 into your lab notebook. Label all resistor and capacitor names and values.

(4-2) Next to your design for the clock, copy the graph from Part (E) of Problem 1 of Homework #11 into your lab notebook. You will use this information to determine whether the clock you construct during In-Lab Exercise 4-2 works correctly.

(4-3) Copy your design for the digital-to-analog converter from Problem 2 of Homework #11 into your lab notebook. Label all resistor names and values.

(4-4) Next to your design for the digital-to-analog converter, make a table showing the expected converter output v_{DAC} when each of the data-bit input voltages is 5 V and the others are all 0 V. Base the table on the actual resistor values used in your design. Also, note the expected value of the offset voltage v_{OFF} required to center the converter. You will use this information to determine whether the converter you construct during In-Lab Exercise 4-4 works correctly.

(4-5) Copy your design for the low-pass filter from Problem 3 of Homework #11 into your lab notebook. Label all resistor and capacitor names and values.

(4-6) Next to your design for the low-pass filter, copy the graph from Part (F) of Problem 3 of Homework #11 into your lab notebook. Also, make a table showing the expected magnitude and phase of the filter output v_{LPF} given a 2-V peak-to-peak sinusoidal input with a frequency of 4 kHz, 8 kHz and 16 kHz. Base the table on the actual resistor and capacitor values used in your design. You will use this information to determine whether the filter you construct during In-Lab Exercise 4-6 works correctly.

(4-7) Copy your design for the volume control stage from Problem 4 of Homework #11 into your lab notebook. Label all resistor and capacitor names and values.

(4-8) Next to your design for the volume control stage, make a table showing the expected magnitude and phase of the volume control stage output v_{OUT} given a 2-V peak-to-peak sinusoidal input with a frequency of 10 Hz, 100 Hz and 1 kHz. Base the table on the actual resistor and capacitor values used in your design. You will use this information to determine whether the amplifier you construct during In-Lab Exercise 4-8 works correctly.

In-lab Exercises

The In-lab exercises involve constructing and testing the individual functional blocks of the audio playback system, and then demonstrating the operation of the system as a whole.

You will need to obtain the counter and memory printed circuit board (PCB) from the stockroom, along with a small speaker. Since there is a limited supply of circuit boards and speakers available, make sure you return the memory board and the speaker when you are not using them.

The in-lab exercises are organized so that you will construct and test one functional block at a time. As each block is found to work properly, you will connect it to those which already working. Consequently, you will alternately construct and test various parts of the audio playback system. **As you develop the system in this manner, it is essential that you turn off the power to the protoboard before you make modifications to your system, or begin any new construction. Also, check your wiring carefully before turning the power back on.** This will avoid damaging the components in the system, and save you considerable debugging time.

Finally, construct the functional blocks as compactly and neatly as possible. In this spirit, you should find it easiest to use the components to wire themselves together, rather than using extra wires. This will save you considerable construction time, as well as considerable debugging time.

(4-1) If you are working in a group of two, you should attach your two protoboards together. This will simplify the circuit assembly by providing more wiring space. To minimize wiring in this lab, the counter and memory have already been assembled on a printed-circuit board. On the back of this board are pins that will plug into the protoboards in the Lab. Plug these pins into the protoboards so that each pin is inserted into a separate protoboard row. Further, locate the board so that there is considerable protoboard space on the side with the memory output data bits. This will make connection to the board easiest. For example, locating the board towards the lower left corner of the protoboard may prove best. The clock can then be constructed above the board, while the digital-to-analog converter, the low-pass filter and the buffer can be constructed to the right of the board.

Figure 1 shows the pin assignments for the printed circuit board. The pins for the eight memory output data bits as well as the clock, power and ground pins are on the right hand side. You should connect the power pin to the 5-V power supply on the protoboard, and the ground pin to ground on the protoboard.

(4-2) Following your design from Pre-Lab Exercise 4-1, construct the clock using the 74HC14 inverter chip obtained earlier. Figure 2 shows the pin assignments for the inverter chip. Use any two of the inverters in the chip, and leave the others unconnected. Do not yet connect the clock output v_{CLK} to the clock input of the counter. Rather, use one channel of the oscilloscope to observe the oscillator output v_{OSC}, and trigger the oscilloscope from that channel. Use the other channel to observe v_{CAP} and the clock output v_{CLK}. Compare what you observe with the oscilloscope to the graph prepared during Pre-Lab Exercise 4-2 to determine whether or not the clock is functioning properly. In particular, the clock output v_{CLK} should remain between 0 V and 5 V so as not to damage the counter which it drives. Also test whether the output signal is around 8 kHz.

(4-3) Provided that the clock functions properly, and most importantly that the clock output v_{CLK} remains within the range of 0 V to 5 V, connect the clock output to the clock input