NAME (please print) ____

STUDENT (SID) NUMBER ______________________________

UNIVERSITY OF CALIFORNIA

College of Engineering
Electrical Engineering and Computer Sciences
Berkeley

EECS 145M: Microcomputer Interfacing Lab

LAB REPORTS:

1 __________________	2 __________________	3 __________________
8 __________________	9 __________________	10 __________________
21 __________________	22 __________________	23 __________________
24 __________________		

Total of top 4 Lab Grades	_______________	(400 max)
Total of top 2 Question Sections	_______________	(50 max)
Lab Participation	_______________	(100 max)
Mid-Term #1	_______________	(100 max)
Mid-Term #2	_______________	(100 max)
Final Exam	_______________	(200 max)
Total Course Grade	_______________	(950 max)

COURSE LETTER GRADE

Spring 2000 FINAL EXAM (May 19)

Answer the questions on the following pages completely, but as concisely as possible. The exam is to be taken ***closed book***. Use the reverse side of the exam sheets if you need more space. Calculators are OK. **In answering the problems, you are not limited to the particular equipment you used in the laboratory exercises.**

Partial credit can only be given if you show your work.

FINAL EXAM GRADE :

1 __________ (40 max) 2 __________ (40 max)

3 __________ (70 max) 4 __________ (50 max)

TOTAL __________ (200 max)

Initials ________________________

PROBLEM 1 (total 40 points):

1a. (10 points) When periodically sampling an arbitrary waveform, under what conditions does aliasing occur?

1b. (15 points) Explain aliasing using the Fourier frequency convolution theorem.

1c. (15 points) Give two approaches for reducing aliasing and explain how they work.

Initials ________________________

PROBLEM 2 (total 40 points):

2a. (10 points) When periodically sampling an arbitrary waveform, under what conditions does spectral leakage occur in the Fourier transform?

2b. (15 points) Explain spectral leakage using the Fourier frequency convolution theorem

2c. (15 points) Give an approach for reducing spectral leakage and explain how it works.

Initials ________________________

PROBLEM 3 (total 70 points):

Imagine that many years ago, a spacecraft was sent to measure the magnetic fields in the great void between the sun and the nearest star. Every 100 seconds the measurements are digitized and then phase and amplitude encoded (like the 56 kbaud modem that connects your computer to the internet) to produce a one-second long analog-like signal with a frequency content between 1 Hz and 3,000 Hz. Because the spacecraft is far from earth and has limited battery power, the data signal is weaker than the background noise from the rest of the universe.

To be able to detect the weak data signal, you use three techniques:

(i) the signal is band-pass filtered before transmission

(ii) the spacecraft sends the same one-second-long signal 100 times with a period of exactly one second.

(iii) you use your knowledge of the FFT of a periodic signal to further separate the background noise from the data signal

To do this, you perform the following steps to the signal received at the earth:

1 low-pass filter the signal (weak data signal plus background noise)

2 sample the filtered signal for exactly 100 s at 10,486 Hz (2^{20} = 1,048,576 samples)

(assume that the time it takes for the signal to reach the earth is known at all times so that sampling always begins at the exact start of the first one-second long signal.

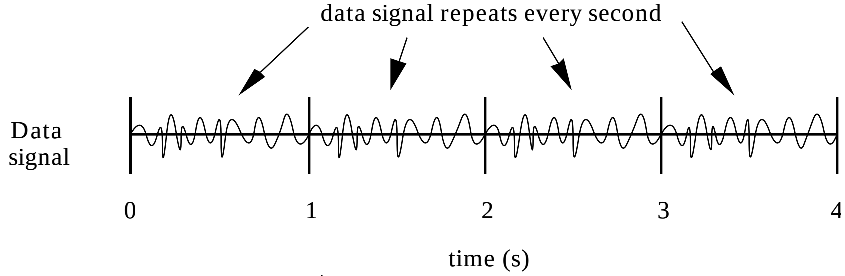
3 take the FFT

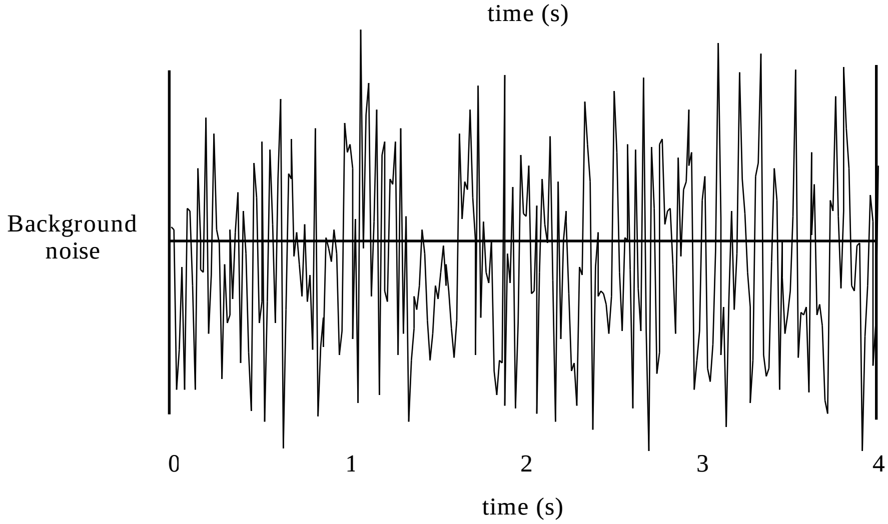
4 subtract as much of the background noise as possible

5 recover one cycle of the data signal

6 demodulate to transform the one-second modulated analog signal into the original digital signal (assume that you have a modem that does this)

Note: If a(t) = b(t) + c(t), then FFT(a) = FFT(b) + FFT(c)





3a. (15 points) Describe (or sketch) the Fourier magnitudes F_n from the FFT in step 3 as a function of the frequency index n.

3b. (5 points) To what frequency does the Fourier magnitude F_n correspond?

3c. (20 points) Design a Butterworth low-pass anti-aliasing filter that has a gain > 0.99 for frequencies below 3,000 Hz and a gain < 0.001 for all frequencies that could alias below 3,000 Hz.

3d. (10 points) Explain whether a Hanning window would improve the recovered waveform.

3e. (20 points) Describe in detail how a computer program would implement steps 2-6.
(Note: there are over seven program steps)

Initials ________________________

PROBLEM 4 (50 points)

Every year people are injured by bullets fired into the air at random by gun-owners "celebrating" the Fourth of July. Design a system that

1. Senses gunshot sounds at various locations using microphones, analog amplification, and a comparator set to detect signals that are sufficiently loud.
2. Uses a 1 kHz, 16-bit dedicated digital timer at each location that is read when a gunshot is detected. (The speed of sound in air is approximately one ft per ms.)
3. Uses "data available" and "ready for output data" handshaking for data transmission to a central computer.
4. Uses a central computer that first resets the remote timers, waits for digital timing data from the sensing station computers, reads them whenever they have data, and computes the location of the gun using time differences (assume that you have a program function that does this).
5. Transmits the gun location to waiting police cars with on-board map displays.

[Note: similar systems have been used in major cities for several years.]

Assume the following:

- The digital timer has two digital input lines ("reset" and "stop") and 16 digital output lines.

  A pulse on the “reset” line sets the counter to zero and starts counting

  A pulse on the “stop” line stops the counter

  The 16 output lines contain the time since the counter was last reset
- All stations and the central computer are connected with 16 timing data lines plus 2N +1 control and handshaking lines, where N is the number of sensing stations.

Hint: Remember the set/reset latch. A pulse on the "set" input makes the output high and a pulse on the "reset" input makes the output low.

4.a. (25 points) Sketch your design, showing and labeling all essential components and lines.

4.b (25 points) List the steps (hardware and software) involved in (i) system startup, (ii) detecting and processing the first gunshot, and (iii) making the system ready for the next gunshot. (Do not worry about the details involved in computing map coordinates from time differences and in transmitting coordinates to the police cars.)