Name (Last, First) _____ Student ID number _____

UNIVERSITY OF CALIFORNIA, BERKELEY

College of Engineering
Electrical Engineering and Computer Sciences Department

EECS 145M: Microcomputer Interfacing Laboratory

Spring Midterm #2 (Closed book- equation sheet provided- calculators OK)
Wednesday, April 21, 2004

PROBLEM 1 (16 points)

1a (8 points) When periodically sampling a waveform, what causes frequency aliasing and how can it be avoided?

1b (8 points) When periodically sampling a waveform and computing its Fourier transform, what causes spectral leakage and how can it be avoided?

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PROBLEM 2 (25 points) Design a Butterworth anti-aliasing low pass filter that meets the following requirements:

- Gain > 0.99 for frequencies below 20 kHz
- Gain < 0.01 for frequencies that alias below 20 kHz
- The sampling frequency is 80 kHz
- The filter has the minimum number of components (lowest order)

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Problem 3 (total 35 points)
You are given a waveform that you know is the sum of two harmonics with frequencies f_1 and f_2. Design a system for sampling the waveform, and using the fast Fourier transform to (1) determine the frequency values to an accuracy of 1 Hz, and (2) determine the ratio of the amplitudes to an accuracy of 0.1%.
Assume the following:

- f_1 and f_2 are in the range from 1 kHz to 100 kHz
- you have a computer with an analog I/O board
- the computer can tell the I/O board where to store the samples, how many samples to take, and the sampling frequency
- the I/O board writes the digital A/D output values to a vector data[0] to data[M-1] and when all samples have been taken, writes a –1 to data[M]

3a. (5 points) Sketch your system, including and labeling all necessary hardware components and connections.

3b. (5 points) What is your sampling frequency and how many samples do you need to take?

3c. (5 points) State two types of A/D converters that you could use.

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3d. (15 points) List the hardware and software steps necessary to sample the data, to determine the frequency values, and to determine relative amplitudes.

3e. (5 points) Would your system work if $f_1 = 3000$ Hz and $f_2 = 3001$ Hz? If not, how could you modify your procedure to determine these frequencies?

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Problem 4 (24 points) Power lines operate at 60 Hz, but distortion of the harmonic waveform caused by inductive loads can introduce a 180 Hz component that is harmful to transformers. Design a system for using a computer (equipped as in problem 3) and digital filtering to continually monitor the amplitude of the unwanted 180 Hz component of the power line waveform. Assume that you continuously sample the 115 volt AC power line at 180 x 1024 Hz = 184,320 Hz.

4a. (12 points) List the hardware and software steps necessary to sample the data, to continually compute the 180 Hz amplitude using a ***finite impulse response*** digital filter, and to continually print the amplitude to the computer screen.

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4b. (12 points) Describe how you would modify the procedure in part **4a** to perform the calculation more efficiently by using ***infinite impulse response*** digital filtering.