Name (Last, First) ____________________________ Student ID number _________________

UNIVERSITY OF CALIFORNIA

College of Engineering
Electrical Engineering and Computer Sciences Department

EECS 145M: Microcomputer Interfacing Laboratory

Spring Midterm #2 (Closed book- equation sheet provided- calculators OK)
Full credit can only be given if you show your work.
Wednesday, April 7, 2010

PROBLEM 1 (20 points)

1.1 (10 points) When periodically sampling an arbitrary waveform, what causes frequency aliasing and how can it be reduced?

1.2 (10 points) When periodically sampling an arbitrary waveform and computing its Fourier transform, what causes spectral leakage and how can its long-range effects be reduced?

PROBLEM 2 (50 points)
You have designed and built a computer system to sample waveforms and perform the FFT.
It has the following characteristics:

- Sampling frequency = 2^{18} Hz = 262,144 Hz
- Number of samples = 2^{16} = 65,536
- Low-pass Butterworth anti-aliasing filter of order 8 and f_c = 100,000 Hz
- Raised cosine window

Answer the following questions:

2.1 (3 points) For what frequency range does the anti-aliasing filter have gain >0.99? (*Hint:* Use the Butterworth gain table on the equation sheet)

2.2 (3 points) For what frequency range does the anti-aliasing filter have gain <0.01?

2.3 (2 points) How long does it take to acquire the samples?

2.4 (3 points) To what frequencies do the FFT coefficients H_0 and H_1 correspond?

2.5 (4 points) What is the FFT coefficient with the highest frequency index and to what frequency does it correspond?

2.6 (4 points) What is the FFT coefficient that corresponds to the highest frequency and what is that frequency?

2.7 (5 points) You sample a 4,000 Hz ***sinewave*** with the system and take the FFT. What FFT coefficients should be non-zero?

2.8 (5 points) You sample a 4,000 Hz symmetric ***square*** wave with the system and take the FFT. What FFT coefficients should be non-zero? (symmetric means 50% high, 50% low)

2.9 (5 points) You sample a 4,002 Hz ***sinewave*** with the system and take the FFT. What FFT coefficients should be non-zero?

2.10 (5 points) You sample two sinewave signals, one with a frequency of 4,000 Hz and another at a nearby frequency and 10 times smaller in magnitude. How closely can the frequency of the second signal approach 4,000 Hz and still be resolved in the FFT coefficients as a separate peak?

2.11 (7 points) You sample a sinewave of frequency 2^{18} – 84,000 Hz = 178,144 Hz and take the FFT. What FFT coefficients should be non-zero? How does the magnitude of the largest FFT coefficient compare with that you would get if you sampled an 84,000 Hz sinewave?

2.12 (4 points) What would you change so that the FFT can resolve peaks twice as close as your answer to part **2.10**?

PROBLEM 3 (total 30 points):

You are given a waveform that repeats with a frequency of 10 kHz and contains frequency components only up to 10 MHz.

3.1 (10 points)
Describe the Integral Fourier Transform of this waveform and the location of the lowest and highest harmonics present.

3.2 (10 points)
You take 2000 samples of the waveform of part 3.1 at a sampling frequency of 20 MHz and take the Fast Fourier Transform.

Describe the Discrete Fourier amplitudes of this waveform and the frequency coefficients of the lowest and highest harmonics present

3.3 (10 points)
You take 2000 samples of the waveform of part 3.1 at a sampling frequency of 9.995 kHz (0.05% slower than the repeat frequency) and take the Fast Fourier Transform.

Describe the Discrete Fourier amplitudes of this waveform and the frequency coefficients of the lowest and highest harmonics present