UNIVERSITY OF CALIFORNIA
College of Engineering
Electrical Engineering and Computer Sciences Department

145M Microcomputer Interfacing Lab

Final Exam Solutions May 16, 2008

1.1 Handshaking steps:

When the receiver is ready, it sets "ready for data" (RD) TRUE

The sender detects RD TRUE and asserts the data

After the data have settled, the sender sets "data available" (DA) TRUE

The receiver detects DA true, reads the data, and sets RD FALSE

The sender detects RD false, and sets DA FALSE

[3 points off for asserting DA before asserting data]

1.2 Tri-state driver:

When the enable input is in one logic state, the output is equal to the input

When the enable input is in the other logic state, the output is in a high impedance state

[3 points off for analog I/O] [3 points off for hold rather than high impedance]

1.3 D/A glitches:

When the input number changes in more than one bit, it is impossible for both bit switches to change exactly at the same time. During the brief time between the first switch change and the last switch change, an erroneous voltage will be produced.

[4 points off for settling time and no mention of bit changes]

[2 points off for not stating that the bits cannot change simultaneously]

1.4 Statistical difference of averages:

(1) Determine the average and standard deviations of each of the two sets of measurements.

(2) Compute Student's t using the formula $t = \dfrac{\bar{a} - \bar{b}}{\sqrt{\sigma_a^2 / m_a + \sigma_b^2 / m_b}}$

(3) Look up the probability of exceeding this t value by chance

[3 points off for not looking up the probability of exceeding $|t|$]

[3 points off for $t <$ some threshold without explaining how the threshold was determined]

1.5 Spectral leakage:

Periodically sampling a waveform for a time interval S is equivalent to multiplying the waveform by a rectangular function of width S. By the Fourier frequency convolution theorem, the Fourier transform of the product in the time domain is the convolution of the Fourier transforms of the waveform and the rectangular function in the frequency domain (i.e. the sinc function). This convolution spreads each frequency component of the waveform over many neighboring frequencies.

[5 points off for explaining in time domain]

[5 points off for convolving in time domain and multiplying in frequency domain]

1.4 Aliasing

Sampling in the time domain is equivalent to a simple product of the waveform and a comb of delta functions in the time domain. The Fourier transform of the sampled data is the convolution of the Fourier transform of the wavefunction and the Fourier transform of the comb of delta functions. Since the latter is a comb of delta functions in the frequency domain, overlap will occur unless the original waveform is not frequency limited. This overlap causes aliasing and can be eliminated by increasing the sampling frequency or by bandwidth limiting the waveform so that the highest frequencies persent are sampled at least twice per cycle. See Figure 5.29 of the textbook.

[10 points off for only stating the Nyquist Theorem]

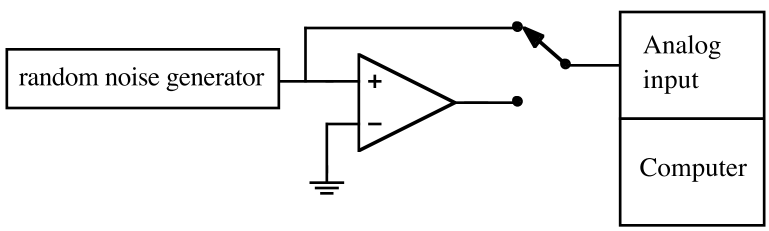
[5 points off for stating that aliasing is caused by frequency overlap but not stating that sampling is equivalent to multiplying by a train of delta function in the time domain]

Note: The above definitions were taken directly from the textbook.

2.1 TR, FL, SD
2.2 SA, HF, DS
2.3 SA, FL, HF
2.4 TR, DS, SD
2.5 DS, SD
2.6 SA, HF

[1 point off for each incorrect entry; 1 point off for each missing correct entry]

3.1



3.2

1) Connect the noise generator directly to the analog input port

2) Sample at 65,536 Hz for 1 second (or an integral number of seconds)

3) Take the FFT and compute the Fourier amplitude B_n

4) Connect the noise generator to the input of the amplifier and the output of the amplifier to the analog input port

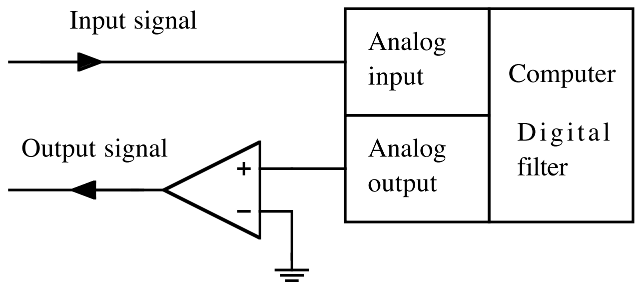
5) Take the FFT and compute the Fourier amplitude C_n

6) Compute the frequency response $A(f_n) = C_n/B_n$, where $f_n = n$ Hz

[8 points off for not measuring and taking the FFT of both the noise generator and the output of the amplifier since the frequency content of the noise generator was not given]

[2 points off for not specifying a sampling frequency]

4.1



4.2

1) Problem 3 determined the frequency response of the amplifier $A(f_n) = C_n/B_n$

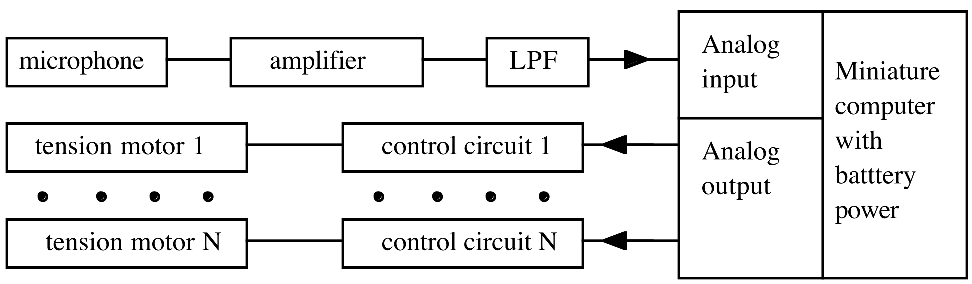
2) The digital filter needs to have a frequency response of $1/A(f_n)$ so that the combined frequency response is the same for all frequencies

3) To determine the FIR digital filter coefficients, take the inverse FFT of $1/A(f_n)$

[5 points off for not filtering continuously]

[10 points off for not showing how the filter coefficients are determined]

5.1



5.2

1) Assume in tune mode

2) Pluck a string

3) Sample acoustic signal for at least one second for 1 Hz accuracy. If the highest note to be tuned is f_{max}, use a LPF that blocks frequencies above 2 f_{max} and sample at a rate 4 f_{max}. Alternatively, sample at a frequency at least twice the frequency response of the microphone and amplifier.

4) Take FFT and compute amplitude at each frequency

5) Detect harmonic peaks, compare with table of desired frequencies, identify string to tune

6) If frequency low, send positive voltage to increase string tension and go back to step 2

7) If frequency high, send negative voltage to decrease string tension and go back to step 2

8) If frequency is within 1 Hz of desired, stop

[Note: A raised cosine type window was not required for full credit because spectral leakage would not interfere with determining the frequency of strong harmonic signals]

[4 points off if the sampling frequency is not specified or if aliasing is not suppressed since some instruments could have strong higher harmonics]

[4 points off for sampling at the highest frequency present; f_s should be at least 2 f_{max}]

[6 points off for assuming that control voltage can be determined at step 5 and iteration back to step 2 is not required]

6.1 ZigBee

6.2 WiFi

6.3 ZigBee

145M Final Exam Grades:

Problem	1	2	3	4	5	6	Total
Average	47.1	17.9	36.2	38.5	36.0	4.7	180.4
rms	5.4	4.7	4.4	2.9	3.5	1.6	12.9
Maximum	50	24	40	40	40	6	200

145M Numerical Grades:

	Short labs	Long labs	Lab Partic.	Midterm #1	Midterm #2	Final	**Total**
Average	92.2	383.2	100	77.2	85.0	180.4	**918.1**
rms	5.8	9.5	0	13.5	8.2	12.9	**39.2**
Maximum	100	400	100	100	100	200	**1000**

145M Letter Grade Distribution

Letter Grade	Course Totals (1000 max)
A+	963
A	943, 943, 947, 950, 951
A–	928, 931, 938, 938
B+	902, 912, 919
B	896
B-	865, 870
C+	
C	
C–	811
D+	
D	