Solutions for Midterm 2 - EECS 145M Spring 1996

PROBLEM 1

1a Aliasing avoided by using Butterworth filter and sampling at 100 kHz- maximum time period between samples is 10 µs (80 kHz and 12.5 µs also accepted)

Note: Butterworth filter provided has G = 0.99 at 20 kHz, 0.45 at 25 kHz, 0.06 at 30 kHz, 0.002 at 40 kHz, and 0.0002 at 50 kHz.

[3 points off for 40 kHz and 25 µs- severe aliasing of signal components between 20 and 25 kHz down to the 15-20 kHz region]

1b ±0.015% is ±1 part in 6666, or ±1/2 LSB in 3333- need a minimum of 12 bits (13 bits also accepted).

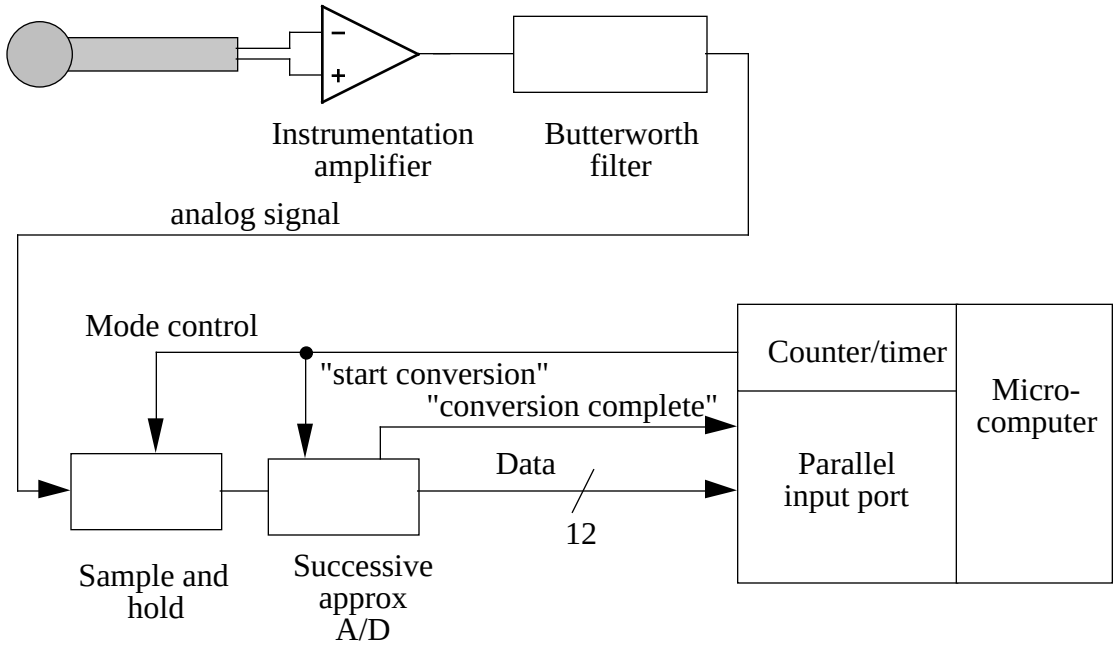
1c Since checking status bit and reading two bytes takes a total of 3 µs, and allowing for synchronization mismatches between the A/D and the computer, the maximum safe conversion time would be 6 µs. Full credit if the answer to 1c is 3 µs less than the answer to 1a (even if 1a was wrong).

1d If we did not have to worry about windowing, sampling for 10 s would give a frequency resolution of 0.1 Hz, but the Hanning window doubles the width of the FFT response, so sampling for 20 s is necessary.

[2 points off for 10 s]

1e 20 s times 100 kHz means 2 x 10^6 samples.

1f



1g

1. Program sets up and starts the timer/counter to produce 6 µs wide pulses every 10 µs.
2. The counter/timer pulse goes to the “start conversion” input of the A/D converter.
3. The counter/timer pulse also puts the sample/hold into hold mode during the 6 µs of conversion.
4. When conversion is complete, the A/D pulses its “conversion complete” output.
5. The “conversion complete” status bit is read by the program, and the two data bytes are read into memory.
6. Steps 2 - 6 are repeated for 20 s (2 x 10^6 samples).
7. Multiply the samples by the Hanning window
8. Take the FFT of the windowed data, compute and display magnitude vs. frequency.

1h The fundamental at 100 Hz would occur at Fourier amplitude H_{2000}. (100 Hz has 2000 cycles per 20 s.) (also at H_{M-2000}, where $M = 2^{20}$, but this was not required.) H_{1000} was also accepted.

1i The mth harmonic would occur at Fourier amplitude H_{2000m}. (also at $H_{M-2000m}$, where $M = 2^{20}$, but this was not required.) $H_{1000m}$was also accepted.

PROBLEM 2

2a See 145M course textbook, Chapter 3

2b See 145M course textbook, Chapter 3

2c Flash (8 bits required), Half-flash also accepted.

2d Successive approximation A/D (16 bits required) Integrating also accepted, since lectures and textbook did not make it clear that successive approximation could do 16 bits. Tracking was not accepted because it has the same accuracy as successive approximation but is much slower)

Midterm #2 class statistics:

Problem	max	average	rms
1	70	52.9	10.6
2	30	20.7	8.0
total	100	73.4	17.5

Grade distribution:

Range	number	*approximate* letter grade
1-10	0	
11-20	0	
21-30	1	F
31-40	0	
41-50	0	
51-60	2	C
61-70	1	C-B
71-80	4	B
81-85	6	B-A
86-90	1	A
91-100	1	A+