Name (Last, First) _____

UNIVERSITY OF CALIFORNIA

College of Engineering
Electrical Engineering and Computer Sciences Department

EECS 145M: Microcomputer Interfacing Laboratory

Spring Midterm #2
Monday, April 20, 1997

- Closed book (equation sheet handed out with this midterm)
- Calculators OK
- You must show your work to get full credit

PROBLEM 1 (40 points)

Describe four A/D converter circuits in terms of the following characteristics:

- conversion accuracy (maximum number of bits)
- differential linearity
- cost (number of internal A/D circuit components)
- speed (number of steps the A/D needs to perform one conversion)
- external circuits needed for full performance

1a. (10 points) Successive approximation

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1b. (10 points) Flash

1c. (10 points) Integrating (or Dual Slope)

1d. (10 points) Half flash

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PROBLEM 2 (60 points)

You have been asked to help design a Doppler ultrasound system for measuring the speed of liquid in a large pipe. You may assume that the speed is the same throughout the cross section of the pipe. Your emitter produces a continuous tone of 100 kHz sound waves and there is a receiver alongside that receives the Doppler-shifted echo. Your part in the project is to design the sampling and signal processing hardware and software, starting from the echo receiver.

- The Doppler-shifted frequency is given by $f' = f / [1 - v/c]$, where v is the speed of the approaching liquid and c is the speed of sound in the liquid (assume 2000 m/s).
- For small v/c, you may use the approximation $f' \approx f [1 + v/c]$.
- The echo receiver circuit provides an output with 10 volt peak-to-peak (p-p) primary 100 kHz tone and 0.1 volt p-p echo.
- The echo circuit has wide-band amplification with white noise, so you decide to use an low-pass 8-pole Butterworth anti-aliasing filter that effectively accepts frequencies below f_1 and rejects frequencies above $2 f_1$, where f_1 is a frequency of your choosing.

2a. (5 points) What are the echo frequencies for liquid speeds of 10 m/s, 11 m/s, and 200 m/s.

2b. (5 points) How long must your sampling window be to clearly distinguish 10 m/s from 11 m/s?

2c. (5 points) How can you reduce the spectral leakage from the 10 volt p-p 100 kHz primary onto the 0.1 v p-p echo frequency?

2d. (5 points) What is the minimum sampling frequency required to be able to handle speeds of 100 m/s?

2e. (5 points) Considering your answer to 2d above, what value of f_1 does your low pass filter require?

2e. (5 points) How many samples will you take for each measurement?

2f. (5 points) If you want to record the echo signal to an accuracy of 5%, how many bits does the A/D converter need?

2g. (5 points) What type of A/D converter would you use for this application?

2h. (20 points) After taking the necessary number of samples from the echo receiver circuit, you take the FFT. Sketch all FFT magnitudes vs. frequency index for a fluid speed of 10 m/s. You will need to use a vertical axis labeled in powers of ten. Provide an additional label for the horizontal axis in Hz. Assume that before anti-aliasing the magnitude of each Fourier coefficient contains white noise that is 10% of the Fourier magnitudes that contain the echo signal.