Midterm II-November 5, 1999
EE524-Dr. Dickerson
Answer all four problems

Name:

Social Security Number

Problem Number	Points	Score
1	30	
2	25	
3	25	
4	20	

Show all work for credit.

Name:

1. An ideal Hilbert transformer is an all-pass filter that imparts a 90 degree phase shift on the signal at its input. The frequency response of the ideal Hilbert transform is specified as:

$$H_d(\omega) = \begin{cases} -j & 0 < \omega < \pi \\ j & -\pi < \omega < 0 \end{cases}$$

a. Is this a linear phase system? Sketch the frequency and magnitude response of this filter.(10points)

b. Verify (i.e. show in detail how to go from the frequency to the time domain) that the unit sample response is(10points)

$$h_d[n] = \begin{cases} \frac{2}{\pi n} \sin^2(\pi n / 2) & n \neq 0 \\ 0 & n = 0 \end{cases}$$

c. Design a Hilbert transformer using the Blackman Window with a window length of N=55. Sketch the magnitude response and clearly calculate and label the transition bandwidths, amplitudes, and the passband ripple. (10points)

Name:

2. Consider the comb filter

$$H(z) = \frac{1 - a^3 z^{-3D}}{1 - a z^{-D}}$$

a. Sketch the magnitude response and pole-zero diagram of this filter for |a|<1 and D=4.(13 points)

b. Comment on the following conditions for this filter: all-pass, minimum phase, maximum phase, and linear phase. Which hold and don't hold and why? Answers without explanation will get zero points.(12 points)

Name:

3. We would like to design a digital bandpass filter from a second order analog lowpass Butterworth filter prototype using the bilinear transformation. The cutoff frequencies (measured at the half power points) for the digital filter should lie at $\omega = 5\pi/12$ and $\omega = 7\pi/12$. The lowpass analog prototype is given by: $H(s) = \frac{1}{s^2 + \sqrt{2}s + 1}$ with the half power point at $\Omega = 1$.

a. Describe how to design this filter starting from the analog prototype. Give the transformations that you would use at each step. Do **NOT** work out all the algebra. (15 points)

b. Convert the analog lowpass prototype into the digital domain using the impulse invariance method (Do the math here). Sketch the discrete transfer function that results. (10 points)

Name:

4. Linear Phase

A type 4 linear phase filter has an antisymmetric impulse response and an even length.The condition on the impulse response coefficients is:

$$h[n] = -h[N-n] \qquad\qquad 0 \le n \le N$$

a) For N = 5 show that a filter that meets this symmetry condition must be linear phase. Calculate the group delay for this filter. (10 points)

b) Can a linear phase FIR filter be all pass- why or why not? (5 points)

c) Is the filter with the pole-zero diagram shown below linear phase? Why or why not?(5 points)