## EEL 6586: HW#1

Assignment is due Friday, January 13, 2004 in class. Late homework loses  $e^{\# of \ days \ late} - 1$  percentage points. See the current late penalty at http://www.cnel.ufl.edu/hybrid/harris/latepoints.html

This is a short review of some DSP topics relevant for speech processing. You should not use Matlab to do any of these problems however you are welcome (and encouraged) to use Matlab to check your answers.

1. (25 points)

A stable digital filter has the following transfer function

$$H(z) = \frac{z^4 + 1}{(z + .5)(z - .5)^2}$$

- (a) (5 points) Derive the poles and zeros of H(z) and sketch them on a pole/zero plot. State the ROC.
- (b) (20 points) Derive a stable h[n] from the given H(z)
- 2. (25 points) You are given the following difference equation:

$$y_1[n] = x[n] + 2y_1[n-1] - 2y_1[n-2]$$
(1)

$$y_2[n] = y_1[n] - y_1[n-1]$$
(2)

- (a) (5 points) Derive  $H(z) = Y_2(z)/X(z)$
- (b) (10 points) Derive a causal impulse response h[n].
- (c) (10 points) Provide a new set of difference equations (to replace (1) and (2) on the last page) such that a stable and causal system exists that has the same magnitude response as H(z). (Note: you can do this part even if you are not able to complete part b).
- 3. (25 points) A generalized linear, FIR, causal filter has zeros at the following locations: 1, -1, and 1/2. (hint: some of these can be multiple zeros and there can be zeros at other locations).

Answer the following questions (hint: you can answer them in any order)

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- (a) (5 points) What other zero must be present if this filter is one of the four filter types (I-IV)?
- (b) (5 points) Can this filter be type I? Either give an example impulse response h[n] or explain why it can't be created with this type.
- (c) (5 points) Can this filter be type II? Either give an example impulse response h[n] or explain why it can't be created with this type.
- (d) (5 points) Can this filter be type III? Either give an example impulse response h[n] or explain why it can't be created with this type.
- (e) (5 points) Can this filter be type IV? Either give an example impulse response h[n] or explain why it can't be created with this type.
- 4. (25 points) Short Answer
  - (a) (5 points) Can an all-pass filter be minimum phase? Either give an example or explain why it is not possible.
  - (b) (5 points) Is it possible for a minimum phase FIR filter to have linear phase? Either give an example or explain why it is not possible.
  - (c) (5 points) You are given a stable pole-zero system with all of its poles inside the unit circle. Does this system have to be causal? Either explain why the system has to be causal or provide a counter example.
  - (d) (5 points) Given a pole/zero plot with poles at .9j and -.9j and zeros at .9 and -.9, sketch the magnitude of  $|H(e^{jw})|$ .
  - (e) (5 points) Given the following filter:

$$y[n] = \sum_{k=-\infty}^{n} x[k]$$

Derive Y(z) as a function of X(z).

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