## EEL6586 – Spring 99 Exam 1 February 26, 1999

## NAME:

This exam is open-book and calculator. You may use any books or papers that you like. There are four problems on this exam, you have two full class periods. State your assumptions and reasoning for each problem. Justify your steps and clearly indicate your final answers.

1	/25
2	/25
3	/25
4	/25
TOTAL	

## 1. (25 points)

Assume an infant with a vocal tract length of 8.5cm and a fundamental frequency of 400 Hz utters a vowel sound with a vocal tract of uniform cross-section area. Estimate the first 3 formant locations (in Hz).

 $use\ this\ space\ if\ necessary$ 

## 2. (25 points)

Consider an exponential window given by

$$w(n) = \frac{a^n}{1-a} \quad \text{for } n = 0...\infty$$

where 0 < a < 1.

(a) (10 points) Write an equation for the short-term average power  $P_s(m)$  of a speech signal s(n) over a frame ending at time m. For simplicity, use construction principle 2 (framing after the operation is performed).

(b) (10 points) Derive a simple recursive relation for  $P_s(m)$  in terms of  $P_s(m-1)$ .

(c) (5 points) What is the major advantage of the exponential window over the Hamming window (one sentence)? What is the major disadvantage (one sentence)?

3. (25 points) Assume that white noise excitation w(n) is filtered by an *all-zero* vocal-tract model  $\Theta(z) = 1 + z^{-2}$  to produce a speech signal s(n). w(n) is defined by:

$$E\{w(n)w(m)\} = \begin{cases} \sigma^2 & m = n \\ 0 & m \neq n \end{cases}$$

Note that  $\Theta(z)$  is all-zero, it is usually all-pole for vocal tract models. In this problem you will use LPC to derive an all-pole approximation to  $\Theta(z)$ .

(a) (10 points) Compute the autocorrelation function r(0), r(1) and r(2) for the speech signal s(n).

(b) (5 points) Compute the LPC coefficients for two delays.

(c) (5 points) Derive  $\hat{\Theta}(z)$ , the all-pole approximation to  $\Theta(z)$ .

(d) (5 points) Sketch the magnitude responses for  $\hat{\Theta}(z)$  and  $\Theta(z)$ .

- 4. (25 points) Short Answer.
  - (a) (5 points) A speech synthesizer creates speech by concatenating prerecorded phonemes together. What is the major problem with this technique?

(b) (5 points) The discrete-time vocal-tract model we developed includes a switch to input either random noise or an impulse train of the proper pitch period. Clearly there is no such switch in the biological process so why do we need to include this switch in our synthetic vocal-tract model?

(c) (5 points) Compute the complex cepstrum of  $H(z) = 1 + z^{-2}$ 

(d) (5 points) For what human languages do LPC techniques perform most poorly? Explain.

(e) (5 points) 6-parameter LPC analysis was performed on a voiced phoneme recorded with  $F_S = 10$ kHz. The resulting pole/zero plot is as shown in the following figure:



Estimate which phoneme was recorded? You may want to refer to Figure 2.11 in the book. List the Arpabet symbol of the phoneme and explain your reasoning.