EE 424- Digital Signal Processing
Final Exam
Fall Semester 2004

Duration: 100 minutes

Attempt all questions and **show your work.**

Bonus (2 pts)

Q 0 Let the sampling frequency be $f_s = 8\,KHz$. Normalized angular freq. $\omega_0 = \frac{\pi}{4}$ correspond to which actual frequency ? Answer: 1 KHz.

Q1 Consider the following window:

$$w[n] = \left\{ \frac{1}{6}, \frac{1}{6}, \underset{\uparrow}{\frac{2}{6}}, \frac{1}{6}, \frac{1}{6} \right\}$$

$n=0$

Design a 5-th order FIR filter with passband PB: $\left[\frac{3\pi}{4}, \pi\right] \cup \left[-\pi, -\frac{3\pi}{4}\right]$ using $w[n]$. This filter is a high pass filter.

Q2// Consider the Butterworth analog filter

$$|H(j\Omega)|^2 = \frac{1}{1+\left(j\Omega/j\Omega_c\right)^2}$$

Design a discrete-time IIR high-pass filter, with 3dB cut-off at $\omega_c = \frac{\pi}{2}$.

Q3//

Consider the I/O relation:

$$y[n] = 0.8\, y[n-1] + x[n-1] - 0.8\, x[n]$$

where $x[n]$ is the input and $y[n]$ is the output. Recursion is implemented in a causal manner.

(a) Find the frequency response and plot $|H(e^{j\omega})|$.

(b) Is this system stable? Prove your answer

(c) Will this system be stable, if the recursion is implemented in an anti-causal manner?

(d) Let the input $x[n]$ be a white, zero-mean random process with variance 1. Will $y[n]$ be a wide sense stationary random process? Determine the spectrum of $y[n]$, $S_y(e^{j\omega}) = ?$

Q4] Given the following data:

$$\{\underset{\uparrow}{1}, 0.5, 1.25, 0.8, 0.4, -0.3, -0.9, -1, -1.5, -0.9, 0.65\}$$

$n=0$ 1 2 3 4 5 6 7 8 9 10

a) Estimate the mean, variance, and the first two autocorrelation values for this data.

b) Determine the first and second order L.M.M.S.E predictors for this data (First order: $\hat{x}[n] = a_1 x[n-1]$ and second order predictor: $\hat{x}[n] = b_1 x[n-1] + b_2 x[n-2]$)

c) Determine the minimum mean square error for these predictors.

Q5// a) How do we model the speech signal in GSM voice coding systems?

b) What does "pitch period" refer in a speech signal of a voiced sound?

c) In vocoders, do we transmit actual speech samples?

d) Do we use a uniform or a non uniform quantizer in PCM (speech transmission) systems? Explain your answers in all questions.