New Mexico State University
Klipsch School of Electrical Engineering

EE395 - Introduction to Digital Signal Processing

Fall 2009
Exam #1

Name: _____

Prob. 1	/ 25 points
Prob. 2	/ 25 points
Prob. 3	/ 25 points
Prob. 4	/ 25 points
Total	/ 100 points

Prob. 1

Consider the following continuous-time signals

$$\begin{aligned} x_1(t) &= \cos(200\pi t) \\ x_2(t) &= \cos(1200\pi t). \end{aligned}$$

(a) Assume the signals are sampled at a rate of $F_T = 1500$ samples/s. Show that the sampled signals $x_1[n] = x_1(nT)$ and $x_2[n] = x_2(nT)$ are different (not equal).

(b) Assume the signals are sampled at a rate of $F_T = 250$ samples/s. Show that the sampled signals $x_1[n] = x_1(nT)$ and $x_2[n] = x_2(nT)$ are the same (equal).

(c) Use p. 65 equations (2.57) and (2.58) to explain your results in (a) and (b).

(d) Determine the energy and power of $x_1[n]$ in (b) over a single period. Each answer should be a number (not summation).

Prob. 2

Consider two discrete-time systems described by the linear constant-coefficient difference equations (LCCDEs) (assume the systems are at rest)

$$\begin{aligned} \text{System 1}: \; y_1[n] &= x[n] - x[n-1] + x[n-3] \\ \text{System 2}: \; y_2[n] &= \frac{1}{2} y_2[n-1] - x[n] + x[n-2]. \end{aligned}$$

Suppose you are given a MAT-file containing a vector x whose elements are input samples. Assume that in the MATLAB command window you have already typed `load 'input.mat'`.

(a) Write a MATLAB code which computes the output of System 1, $y_1[n]$.

(b) Write a MATLAB code which computes the output of System 2, $y_2[n]$.

(c) Write a MATLAB code which computes the impulse response of System 2, $h_2[n]$ for $0 \leq n \leq 10$.

Prob. 2 (cont.)

(d) Write a MATLAB code which plots the magnitude response, $|H_1(e^{j\omega})|$ vs. ω of System 1. Assume units of decibels (dB) for $|H_1(e^{j\omega})|$ and radians/sample for ω.

(e) Write a MATLAB code which plots the (wrapped) phase response, $\angle H_2(e^{j\omega})$ vs. ω of System 2. Assume units of radians for $\angle H_2(e^{j\omega})$ and radians/sample for ω.

Prob. 3

A discrete-time system has a frequency response

$$H(e^{j\omega}) = \frac{1}{1 - \frac{1}{4}e^{-j\omega}}.$$

(i) Express the following input cosine signals as a superposition of complex exponentials.
(ii) Use the eigenfunction theory to determine the output of the system for the given input.
(iii) For this system, your answer can and should be in the form $y[n] = A\cos(\omega n + \phi)$.

(a) $x[n] = \cos(\pi n)$

(b) $x[n] = \cos(\pi n/2)$

Prob. 4

A discrete-time system has a frequency response

$$H(e^{j\omega}) \;=\; \frac{2e^{j\omega}}{1-\frac{1}{2}e^{-j\omega}}.$$

(a) (+5 points) Sketch the magnitude response, $|H(e^{j\omega})|$ vs. ω. Please include magnitude response values for $\omega = 0,\ \pi/2$, and π.

(b) (+5 points) Determine the impulse response, $h[n]$.

(c) (+5 points) Sketch the impulse response $h[n]$ vs. n.

Prob. 4 (cont.)

(d) (+2.5 points) Is the system finite impulse response (FIR) (Y/N)? Provide a short reason for your answer.

(e) (+2.5 points) Is the system a highpass filter (Y/N)? Provide a short reason for your answer.

(f) (+2.5 points) Is the system bounded input, bounded output (BIBO) stable (Y/N)? Provide a short reason for your answer.

(g) (+2.5 points) Is the system causal (Y/N)? Provide a short reason for your answer.