University of Limerick

OLLSCOIL LUIMNIGH

College *of* Informatics *and* Electronics

Department of Computer Science
and Information Systems

Final Assessment Paper

Academic Year:	2005/2006	Semester:	Autumn
Module Title:	Intro. to Applied Digital Signal Processing	Module Code:	CS4156
Duration of Exam:	$2\frac{1}{2}$ hours	Percent of Semester Marks:	60
Lecturer:	P. Healy	Paper marked out of:	100

Instructions to Candidates:

- Answer all questions
- Each question counts for 20 marks.

1. A signal composed of sinusoids is given by

$$x(t) = 7\cos(800\pi + \frac{\pi}{4}) - 3\cos(1600\pi t - \frac{\pi}{3}) + 3\cos(3200\pi t)$$

   (a) Sketch the spectrum of this signal, indicating the complex size of each frequency component. (8 marks)

   (b) Is $x(t)$ periodic? If so, what is its period? (6 marks)

   (c) Consider the signal defined as

$$x'(t) = x(t) + 5\cos(1000\pi t + \frac{\pi}{2})$$

   Is $x'(t)$ periodic? If so, what is the period? (6 marks)

2. Suppose that an LTI system has a system function

$$H(z) = 1 + 5z^{-1} - 3z^{-2} + 2.5z^{-3} + 4z^{-8}$$

   (a) Determine the difference (or, system) equation that relates the output $y[n]$ to the input $x[n]$; (6 marks)

   (b) What is the order of the system? (4 marks)

   (c) Determine the output sequence $y[n]$ when the input is $x[n] = \delta[n]$; (6 marks)

   (d) Plot the output sequence $y[n]$ you determined in the previous part. (4 marks)

3. One form of the *deconvolution* process starts with the output signal and the filter's impulse response, from which it should be possible to find the input signal. Determine the input signal, $x[n]$, in each of the following three cases, if

   (a) the output of an FIR filter with $h[n] = \delta[n-2]$ is (6 marks)

   $$y[n] = u[n-3] - u[n-6]$$

   (b) the output of a first-difference FIR filter is (6 marks)

   $$y[n] = \delta[n] - \delta[n-4]$$

   (c) the output of a 4-point averager is (8 marks)

   $$y[n] = -5\delta[n] - 5\delta[n-2]$$

4. An LTI system is described by the difference equation

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

   (a) Determine the system function $H(z)$ for this system. Express $H(z)$ as a ratio of polynomials in z^{-1} (negative powers of z) and also as a ratio of polynomials in positive powers of z; (5 marks)

   (b) Plot the poles and zeros of $H(z)$ in the z-plane; (5 marks)

   (c) From $H(z)$ obtain an expression for $H(e^{j\hat{\omega}})$, the frequency response of this system; (5 marks)

   (d) Show that $|H(e^{j\hat{\omega}})|^2 = 1$ for all $\hat{\omega}$. (5 marks)

5. Write MATLAB statements for each of the following tasks

   (a) Create a vector, `oo`, of 11 1s; (5 marks)

   (b) Create a vector, `hh`, of 11 $\frac{1}{11}$s; (5 marks)

   (c) Create a 51-point sample vector, `xx`, of $\cos(0.07\pi t)$; that is, `xx[i]` sample should have value $\cos(0.07\pi i), 0 \leq i \leq 50$; (5 marks)

   (d) Determine the output of an 11-point running average system when given input `xx` as above. (5 marks)