NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES
COMPUTER SCIENCE DEPARTMENT
DECEMBER EXAMINATIONS 2005

SUBJECT: **DIGITAL SIGNALS PROCESSING**
CODE: **SCS6105**

Instructions to Candidates:
1. Answer any **five** questions only.
2. Each question carries equal marks.
3. Show all your steps clearly in any calculation.
4. Start the answers for each question on a fresh page.

3 HOURS

Question 1

(a) A sinusoidal signal with a peak to peak amplitude of plus minus five volts is digitalised with sixteen bits analogue to digital converter. Determine the quantization step size, the quantization noise power and the maximum theoretical maximum signal to quantisation noise ratio. (12 marks)

(b) Give at least three benefits of oversampling in analogue to digital conversion. (3 marks)

(c) Give at least five factors that influence the choice of sampling . (5marks)

Question 2

(a) For the linear time invariant in fig 2 give the expression for the impulse response.

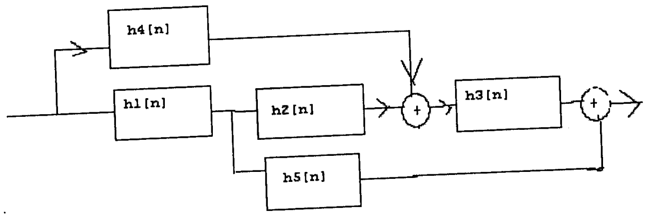

Fig 2

(6 marks)

(b) Determine the Fourier transform of

$x(t) = e^{-\alpha|t|}$ where $\alpha>0$ (8 marks)

(c) Sketch the graphical representation of the signal and its transform in (b) above . (6 marks)

Question 3

(a) Draw the block diagram that would represent a simplified hardware architecture for a special purpose digital signal processor. Give an explanation of the diagram. (14 marks)

(b) State at least four characteristics that would be included in the specification of a digital filter. (4 marks)

(c) Give the major difference between the finite impulse response digital filter and the infinite impulse response filter. (2 marks)

Question 4

(a) Draw a timing diagram to illustrate the concept of pipelining (2 marks)

(b) State three special instructions optimised for digital signal processing . (3 marks)

(c) Give at least four instructions performed in one cycle by the MACD .(4 marks)

(d) Find the z transform of x[n].The values of the sequence are x(3)=0,x(-2)=1,

x(-1)=3,x(0)=5,x(1)=3,x((2)=3, and x(3)=0 (5 marks)

(e) Show a block diagram that will produce the sequence output y[n] from x[n].

$y[n]=b_0x[n] +b_1x[n-1] +b_2x[n-2] + b_3x[n- 3] +a_1y[n-1]+ a_2y[n-2]$. (6 marks)

Question 5 Explain the complete characterisation of a continuous time linear time invariant system in terms of a unit impulse response . (20 marks)

Question 6

(a) Give at least seven advantages of digital filters that make them favoured for use in in DSP. (7 marks)

(b) Sketch the basic structure of a lattice digital filter. (5 marks)

(c) Draw the structure to represent

$$H(z) = \sum_{k=0}^{11} h(k)z^{-k}$$

Write the difference equation for the structure. (8 marks)

Question 7

(a) Find the inverse z-transform of the following :

$$X(z) = \frac{z^{-1}}{1-0.25z^{-1}-0,375z^{-2}}$$

(10 marks)

(b) Sketch the pole and zero diagram of the digital filter given by the transfer function.

$$H(z) = \frac{1-z^{-1}-2z^{-2}}{1-1.75z^{-1}+1.25z^{-2}-0.375z^{-3}}$$

(10 marks)

Question 8

(a) Give the methods used in calculating filter coefficients in the study of DSP .State and justify which method you should use in each of the following application

(1) Phase (delay) equalisation for a digital communication system,

(2) Simulation of analogue systems.

(3) Image processing

(4) High quality processing of audio systems

(5) A high throughput noise reduction system requiring a sharp magnitude frequency response filter.

(6) A real time biomedical signal processing with minimal distortion. (12 marks)

(b) Calculate the discrete Fourier transform of the sequence [1,0,0,1] using the decimation in time FFT algorithm. (8 marks)

SOME COMMON z-TRANSFORM PAIRS

Transform pair Signal	Transform	ROC
1. $\delta[n]$	1	All z
2. $u[n]$	$\frac{1}{1 - z^{-1}}$	$\lvert z\rvert > 1$
3. $u[-n-1]$	$\frac{1}{1 - z^{-1}}$	$\lvert z\rvert < 1$
4. $\delta[n-m]$	z^{-m}	All z except 0 (if $m > 0$) or ∞ (if $m < 0$)
5. $\alpha^n u[n]$	$\frac{1}{1 - \alpha z^{-1}}$	$\lvert z\rvert > \lvert\alpha\rvert$
6. $-\alpha^n u[-n-1]$	$\frac{1}{1 - \alpha z^{-1}}$	$\lvert z\rvert < \lvert\alpha\rvert$
7. $n\alpha^n u[n]$	$\frac{\alpha z^{-1}}{(1 - \alpha z^{-1})^2}$	$\lvert z\rvert > \lvert\alpha\rvert$
8. $-n\alpha^n u[-n-1]$	$\frac{\alpha z^{-1}}{(1 - \alpha z^{-1})^2}$	$\lvert z\rvert < \lvert\alpha\rvert$
9. $[\cos \Omega_0 n]u[n]$	$\frac{1 - [\cos \Omega_0]z^{-1}}{1 - [2\cos \Omega_0]z^{-1} + z^{-2}}$	$\lvert z\rvert > 1$
10. $[\sin \Omega_0 n]u[n]$	$\frac{[\sin \Omega_0]z^{-1}}{1 - [2\cos \Omega_0]z^{-1} + z^{-2}}$	$\lvert z\rvert > 1$
11. $[r^n \cos \Omega_0 n]u[n]$	$\frac{1 - [r\cos \Omega_0]z^{-1}}{1 - [2r\cos \Omega_0]z^{-1} + r^2 z^{-2}}$	$\lvert z\rvert > r$
12. $[r^n \sin \Omega_0 n]u[n]$	$\frac{[r\sin \Omega_0]z^{-1}}{1 - [2r\cos \Omega_0]z^{-1} + r^2 z^{-2}}$	$\lvert z\rvert > r$

$f(t)$	TABLE OF LAPLACE TRANSFORM	F(s)
$f_1(t)+f_2(t)$	Linearity	$F_1(s)+F_2(s)$
$f(t)$	Definition	$\int_0^\infty f(t)e^{-st}dt$
$Kf(t)$	Linearity	KF(s)
$\frac{df(t)}{dt}$	Differention	sF(s) - f(0)
$\frac{d^n f(t)}{dt^n}$	Differentiation	$s^n F(s)-s^{n-1}f(0)-.....-\frac{d^{n-1}f(0)}{dt^{n-1}}..$
$\int_0 f(t)dt$	Integration	$\frac{1}{s}F(s)$
$tf(t)$	Complex differentiation	$-\frac{dF(s)}{ds}$
$e^{-at}f(t)$	Complex translation	F(s + a)
f(t - a)u(t - a)	Real translation	$e^{-sa}F(s)$
$f(t)$	Periodic function	$\frac{F_1(s)}{1-e^{-sT}}$
$\int_0 x(\tau)h(t-\tau)$	Convolution	H(s)X(s)
$\delta(t)$		1
u(t)		$\frac{1}{s}$
$e^{-at}u(t)$		$\frac{1}{s+a}$
$\sin\beta t u(t)$		$\frac{\beta}{s^2+\beta^2}$
$\cos\beta t u(t)$		$\frac{s}{s^2+\beta^2}$
$e^{-at}\sin\beta t u(t)$		$\frac{\beta}{(s+a)^2+\beta^2}$
$e^{-at}\cos\beta t u(t)$		$\frac{s+a}{(s+a)^2+\beta^2}$
tu(t)		$\frac{1}{s^2}$
$t^n u(t)$		$\frac{n!}{s^{n+1}}$
$te^{-at}u(t)$		$\frac{1}{(s+a)^2}$
$t^n e^{-at}u(t)$		$\frac{n!}{(s+a)^{n+1}}$