NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

COMPUTER SCIENCE DEPARTMENT

DECEMBER EXAMINATIONS 2004

SUBJECT: DIGITAL SIGNALS PROCESSING

CODE: SCS6105

INSTRUCTION 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

Time: 3 hours

QUESTION ONE

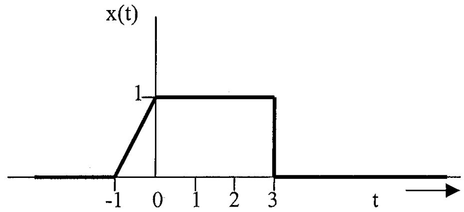

Fig 1

Fig 1 shows a continuous signal x(t) .Sketch and label the signal found after processing x(t)

(i) x(t-1)

(ii) x(3-t)

(iii) x(2t)

(iv) x(t+2)u(t) (12)

(b) Give a brief description of independent variables found in signals. .Give examples of signals discussed. (5)

(c) State the characteristics of signals that are needed in order to choose the method of extraction of information in a signal . (3)

QUESTION TWO

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

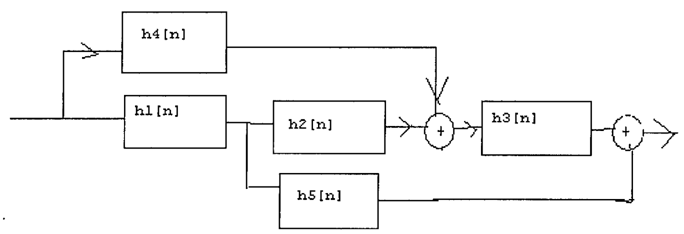

Fig 2 (6)

(b) Determine the Fourier transform of

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

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

QUESTION THREE

(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)

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

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

QUESTION FOUR

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

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

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

(d) Find the z transform of $x[n]=[3(2^n)-4(3^n)]U[n]$ (5)

(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)

QUESTION FIVE

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

QUESTION SIX

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

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

(c) Draw the structure to represent the equation below.

Write the difference equation for the structure. (8)

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

QUESTION SEVEN

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

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

(10)

(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)

QUESTION EIGHT

(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) equalization 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)

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

END OF QUESTION PAPER

GOOD LUCK!

$f(t)$	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	$s^n F(s)-s^{n-1}f(0)-.....-\frac{d^{n-1}f(0)}{dt^{n-1}}..$
$\int_0^t f(t)dt$	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)		$\frac{1}{s^2}$
$t^n u(t)$		$\frac{n!}{s^{n+1}}$
$te^{-at}u(t)$		$\frac{1}{(s+a)^2}$
$t^n e^{-at}u(t)$		$\frac{n!}{(s+a)^{n+1}}$

SOME COMMON z-TRANSFORM PAIRS

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