NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

COMPUTER SCIENCE DEPARTMENT

APRIL 2009 EXAMINATIONS

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 ONE

(a) Draw and describe a typical analogue to digital system and adigital to analogue system .Explain the operation of each block in the system (12)

(b) State three properties of convolution. (3)

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

(d) Give three specific signals found in digital signal processing .Give the characteristic s of each signal. (3)

QUESTION TWO

The difference equation describing the input –output relationship of a discrete time linear time invariant system is given by

$$y[n]-y[n-1]+0.5y[n-2]=x[n]+x[n-1].$$

(a) Determine the transfer function H(z). (5)

(b) Determine the impulse response h[n] (7)

(c) Obtain the output response when a unit step function is applied at n=0. (8)

QUESTIN THREE

(a) Given that the the sequence $x_1[n]$=[4.2, 40 , -10 ,0. ,5] and sequence $x_2[n\ ]$= [6 , 36 ,0 ,3 .—2]. Generate thre other sequences. $y_1[n] = x_1[n\ ].x_2\ [n\ ], y_2(n) = x_1[n] + x_2[n]$ and $y_3[n] = 5/2x_2[n]$ (6)

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

$y[n]=b_0x[n] + b_1x[n-1] + b_2x[n-2] + b_3x[n- 3] + a_1y[n-1] + a_2y[n-2]$. (8)

QUESTION FOUR

(a) Using an 8-point sequence explain the efficient computation of the Fast Fourier Transform algorithm. What is its advantage.? (14)

(b) Draw a block diagram to represent the input and output of the discrete time linear system described by the equation $y[n] = \frac{1}{4}y[n-1] + \frac{1}{2}x[n] + \frac{1}{2}x[n-1]$ where x[n] is the input and y[n] is the output of the system. (6)

QUESTION FIVE

Find the convolution of two signals

x[n]={4,3,2,1}

h[n]={1,2,3,4}.

Determine y[n]=x[n]*h[n]. Show the steps numerically and graphically within a window. (20)

QUESTION SIX

(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)

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

QUESTION SEVEN

(a) Give at least six advantages of a digital filter when compared with an analogue filter. (6)

(b) Show the realisation structure of the following Finite Impulse Response filters

(i) Transversal filter (3)

(ii) Frequency sampling filter (4)

(iii) Fast convolution filter (6)

(c) Explain the term pipelining when used in digital signal processing operations . (1)

QUESTION EIGHT

(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)

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

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

(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)

SOME COMMON z-TRANSFORM PAIRS

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

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