NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

BACHELOR OF ENGINEERING (HONS) DEGREE

Examination January 2013 **TEE3101 Digital Signal Processing**

Duration of Examination 3 Hours

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.

Question 1

Explain with the help of sketches and mathematical expression the complete characterisation of a discrete time signal in a linear time invariant system in terms of a unit impulse response .

(20 marks)

Question 2

The transfer function of a discrete time system has poles at z=0.5, z=0.1 +j0.2, z=0.1-j0.2

and zeros at z=-1 and z=1.

(i) Sketch the pole-zero diagram for the system.

(ii) Derive the system transfer function from the pole –zero diagram.

(iii) Develop the difference equation. (20 marks)

Question 3

(a) Draw the block diagram that would represent a hardware architecture for a special purpose digital signal processor. Give an explanation of why the type of architecture shown by the diagram is chosen. (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) The transfer function for a filter is given by

$H(z) = 1 - 1.3435\,z^{-1} + 0.9025\,z^{-2}$. Draw the realisation block diagram for each of the following .

(i) transversal structure,

(ii) two lattice structure, and calculate the values of the coefficient for a lattice structure. (15 marks)

(b) Give the five design steps for digital filters. (5 marks)

Question 5

(a) Determine the discrete –time signal x[n] obtained from uniformly sampling at 400 Hz a continuous time signal x(t) given below;

$x(t) = 10\cos(120\pi t) + 6\sin(600\pi t) + 4\cos(680\pi t) + 8\cos(1000\pi t) + 12\sin(1320\pi t)$ (6 marks)

(b) Using N=8 explain the eight-point decimation-in-time FFT. Draw the butterfly diagram for the computation. (14 marks)

Question 6

(a) Give three reasons that justify the use of oversampling in digital processing. (6 marks)

(b) Discuss the use of uniform and non-uniform quantization and encoding. Give examples of the typical application of each technology. (14 marks)

Question 7

(a) Find the inverse Laplace transform of

(i) $$X(s)=\frac{2s^2+11s+19}{(s+1)(s+2)(s+3)}$$

(ii) $$X(s)=\frac{2(3s^2-1)}{(s^2+1)^3}$$

(20 marks)

Question 8

(a) Find the z-transform of the following signals

(i) $x[n]=na^{n-1}$

(ii) $x[n]=3\delta[n]+5\delta[n-3]+7\delta[n-8]$

(iii) $x[n]=3^n+(-1+0.8n)5^n$

(12 marks)

(b) Find the discrete signal corresponding to the z-transform

(i) $$X(z)=\frac{3}{1-\frac{1}{2}z^{-1}}+\frac{2}{1-\frac{1}{3}z^{-1}}$$

(ii) $$X(z)=\frac{Z^3}{(z-\frac{1}{2})(z+\frac{1}{3})^2}$$

(8 marks)

SOME COMMON z-TRANSFORM PAIRS

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

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