BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE

BSc HONS DEGREE IN COMPUTER SCIENCE

CS405: DIGITAL SIGNAL PROCESSING

DURATION: 2 HOURS 30 MINUTES **TOTAL MARKS: 100**

INSTRUCTIONS TO CANDIDATES MAR 2024

The paper consists of **five (5)** questions, candidates are expected to answer **all** questions.

Question 1

a. Describe the components of a Digital Signal Processor. **[10]**

b. Applications of digital signal processing (DSP) may be divided into two categories: 'real time' and 'non real time'. Explain these terms and give **one (1)** example in each category. **[6]**

c. Describe the use of Nyquist-Shannon sampling theorem in sampling of analog signals before digitization. **[4]**

Question 2

a. An analogue signal $x_a(t)$ is band-limited to a frequency range below F_{Hz}. This signal is sampled at $f_{S\ Hz}$ to obtain the discrete time signal $\{x[n]\}$. Explain how it is possible, in principle, to reconstruct an exact replica of $x_a(t)$ from $\{x[n]\}$ provided $f_S > 2F$. **[8]**

b. Explain each of the following properties of discrete time signal processing systems:

i. Linearity **[2]**

ii. Time-invariance **[2]**

iii. Causality **[2]**

iv. Stability **[2]**

c. Explain why analogue signals are generally low-pass filtered before they are converted to digital form. **[4]**

Question 3

a. Outline **three (3)** advantages and **three (3)** disadvantages of infinite impulse-response (IIR) digital filters as compared with finite impulse-response (FIR) types. **[6]**

b. Produce the block diagram or signal flow representation of the discrete time system described by $y[n] = x[n] + 0.5\,x[n-1] - 0.5\,x[n-2]$. **[8]**

c. Consider the impulse response of a system, which is linear and time-invariant: $h[n] = 2^n u[n+1]$.

Determine if this system is:

i. Causal **[3]**

ii. Stable **[3]**

Question 4

a. Give any **two** applications of DTF in signal processing. **[2]**

b. Compute the 4-point DFT for the sequence $x[n] = \{1, 0, 1, 0\}$. **[10]**

c. Find the Z- transform of the sequences x[n] = $2\delta[n] + 3\delta[n-1] + 5\delta[n-2]$. **[8]**

Question 5

a. Determine the inverse Z-transform of the function:

$$Y(z) = \frac{z-1}{(z-2)(z-3)}$$ **[10]**

b. Explain the term 'quantisation noise'. **[4]**

c. Clipping is a form of distortion that limits a signal once it exceeds a threshold. Describe how clipping can be avoided in signal processing. **[4]**

d. Explain the round off effect in digital filters. **[2]**

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. $[r^n \cos \Omega_0 n]u[n]$	$\frac{1-[r\cos\Omega_0]z^{-1}}{1-[2r\cos\Omega_0]z^{-1}+r^2z^{-2}}$	$\lvert z\rvert > r$
12. $[r^n \sin \Omega_0 n]u[n]$	$\frac{[r\sin\Omega_0]z^{-1}}{1-[2r\cos\Omega_0]z^{-1}+r^2z^{-2}}$	$\lvert z\rvert > r$

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