ENGINEERING & MANAGEMENT EXAMINATIONS, JUNE – 2009
DIGITAL SIGNAL PROCESSING
SEMESTER – 6

Time : 3 Hours] [Full Marks : 70

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : 10 × 1 = 10

i) If $X_1(n)$ and $X_2(n)$ are finite length sequences of sizes L and M repectively, their linear convolution has length

a) $L + M - 2$ b) $L + M$

c) $L + M - 1$ d) Max $\{L, M\}$.

ii) A system having impulse response $h(t)$ will be BIBO stable if

a) $\int_{-\infty}^{\infty} |h(t)|\,dt < \infty$ b) $\int_{-\infty}^{\infty} h(t)\,dt < \infty$

c) $\int_{-\infty}^{\infty} |h(t)|\,dt > \infty$ d) $\int_{-\infty}^{\infty} |h(t)|\,dt = 0$.

iii) Why 16 point DFT is preferable than 4 point DFT ?

a) Resolution of spectrum is poor for 4 point DFT than 16 point DFT

b) Resolution of spectrum is high but not reliable in 4 point DFT

c) Calculation of 4 point DFT is more complex

d) None of these are true.

iv) Given a system with $h(n) = a^n u(n)$, a is constant, then the system is

a) IIR system b) FIR system

c) both IIR and FIR system d) none of these.

v) Overlap save method is used to find

a) Circular convolution b) Linear convolution

c) DFT d) Z-transform. ☐

vi) If F_{S_t} is the minimum sampling rate, F_{max} is the highest frequency available in the analog signal, then at Nyquist rate

a) $F_{S_t} = 2F_{max}$ b) $F_{S_t} = 0{\cdot}5F_{max}$

c) $F_{S_t} = F_{max}$ d) $F_{S_t} < F_{max}$. ☐

vii) The energy of constant amplitude complex valued exponential function $X(n) = A\exp(j\omega)$ where A and ω are constant, is given by

a) A^2 b) $\frac{A^2}{2\omega}$

c) $\frac{A^2}{2}$ d) $\frac{A^2}{\omega}$. ☐

viii) Determine if the systems described by the following input-output equations are causal or non-causal.

1. $y(n) = x(n^2)$
2. $y(n) = \sum_{n=0}^{N-1} x(n)$

a) 1 is linear, 2 is non-linear b) 2 is linear, 1 is non-linear

c) 1 and 2 both are linear d) 1 and 2 both are non-linear. ☐

ix) If the Fourier transform of a sequence $x(n)$ is $X(e^{j\omega})$, then the Fourier transform of $x(n-k)$ is

a) 0 b) $(e^{-j\omega k}) \times (e^{j\omega})$

c) $(e^{-j\omega}) \times (e^{j\omega})$ d) cannot be determined. ☐

x) Zero padding indicates

a) zero appending in $X(K)$ sequence

b) value of $X(K)$ is zero

c) Dummy sample added with zero value in $X(K)$

d) none of these. ☐

xi) If $x(n) \overset{z}{\longleftrightarrow} X(z)$, then the valid one is

a) $x(-n) \longleftrightarrow X(z)$ b) $x(-n) \longleftrightarrow zX(z)$

c) $x(-n) \longleftrightarrow \frac{X(z)}{z}$ d) $x(-n) \longleftrightarrow X\left(\frac{1}{z}\right)$. ☐

xii) The value of the twiddle factor W_8^4 is given by

a) 1 b) $-j$

c) $\frac{1}{\sqrt{2}} - \frac{j}{\sqrt{2}}$ d) -1. ☐

xiii) $\left(\frac{1}{2}\right)^n u(n)$ is

a) energy signal b) power signal

c) both of these d) none of these. ☐

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following questions. $3 \times 5 = 15$

2. Differentiate between analog and digital signals. Why is digital signal processing widely used than analog signal processing ? 5

3. Determine the convolution of the two following finite sequences using overlap add method : 5

$x(n) = \{3, 2, 1, 2\}$ $h(n) = \{1, 2, 1, 1\}$

4. The impulse response of linear time invariant system is $h(n)=\{1, \underset{\uparrow}{2}, 1, -1\}$. Determine the response of the system to the input signal $x(n)=\{\underset{\uparrow}{1}, 2, 3, 1\}$. 5

5. Show that if a discrete-time LPF is described by the difference equation

$y[n]=-\sum_{k=1}^{N} a_k\, y[n-k]+\sum_{k=0}^{M} b_k\, x[n-k]$; then the discrete-time filter described by $y[n]=-\sum_{k=1}^{N}(-1)^k a_k\, y[n-k]+\sum_{k=0}^{M}(-1)^k b_k\, x[n-k]$ is a high-pass filter. 5

6. Design a digital Butterworth filter using following specifications using Impulse Invariant method : 5

$0{\cdot}9 < H(J\Omega) < 1$ for $0 < \Omega < 0{\cdot}2$ pi $H(J\Omega) < 0{\cdot}2$ for $0{\cdot}4$ pi $< \Omega <$ pi.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following questions. $3 \times 15 = 45$

7. a) A low-pass filter should have the frequency response given below. Find the filter coefficients $h_d(n)$. Also determine τ so that $h_d(n)=h_d(-n)$.

$$H_d(e^{j\omega})=\begin{cases} e^{-j\omega\tau}, -\omega_c \le \omega \le \omega_c \\ 0, \omega_c < |\omega| < \pi \end{cases}$$ 6

b) A filter is to be designed with the following desired frequency response :

$$H_d(e^{j\omega})=\begin{cases} 0, -\frac{\pi}{4} \le \omega \le \frac{\pi}{4} \\ e^{-j2\omega}, \frac{\pi}{4} \le \omega \le \pi \end{cases}$$

Determine the filter coefficients $h_d(n)$ if the window function is defined as

$$w(n)=\begin{cases} 1, 0 \le n \le 4 \\ 0, \text{elsewhere} \end{cases}$$ 9

8. a) Realize the system with difference equation :

$$y(n)=\frac{3}{4}y(n-1)-\frac{1}{8}y(n-2)+x(n)+\frac{1}{3}x(n-1)$$ in cascade form. 8

b) Define LTI system with an example. 5

c) What is window technique ? 2

9. a) What is ROC ? State its properties. 2

b) Find the system function and impulse response of the system described by

$$y(n) = x(n) + 2x(n-1) - 4x(n-2) + x(n-3)$$ 5

c) Find the inverse Z-transform of

$$X(z) = z(z^2 - 4z + 5)/(z-3)(z-2)(z-1) \quad 2 < z < 3.$$ 5

d) Prove that an LTI system is BIBO stable if the ROC system function includes the unit circle. 3

10. a) Distinguish between FIR and IIR filters.

b) What is warping effect ? How can you remove this effect ?

c) Convert the analog filter with the system function $G(s) = \frac{s + 0{\cdot}1}{(s + 0{\cdot}1)^2 + 16}$ into a digital filter using bilinear transformation. The digital filter should have a resonant frequency of $w_r = \frac{\pi}{4}$ rad. 15

11. a) Find the DFT of the sequence { 1, 1, 1, 1, 2, 2, 2, 2 } using radix-2 Decimation-in-Time FFT. Sketch the magnitude and phase plot. 10

b) What is the need for FFT ? 3

c) What is bit reversal ? 2

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