Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech (ECE-OLD)/SEM-6/EC-601/2013

2013

DIGITAL SIGNAL PROCESSING

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) The relation between unit impulse and unit step functions may be described by

      a) $\delta(n) = u(n) - u(n+1)$

      b) $\delta(n) = u(n) - u(n-1)$

      c) $\delta(n) = u(-n) - u(n+1)$

      d) $\delta(n) = u(n) - u(-n+1)$.

   ii) The system described by $y(n) = x^2(n)$ is

      a) linear and time-invariant

      b) non-linear and time-invariant

      c) linear and time-varying

      d) non-linear and time-varying.

iii) A signal $y(n) = x(n-3)$ indicates

a) $y(n)$ is advanced version of $x(n)$ by 3 samples

b) $y(n)$ is delayed version of $x(n)$ by 3 samples

c) $y(n)$ is scaled version of $x(n)$ by 3 samples

d) $y(n)$ is folded version of $x(n)$ by 3 samples.

iv) A signal $x(n)$ is said to be energy signal, if the energy E and average power of the signal are given by

a) $0 < E < \infty$ and $P = \infty$

b) $E = 0$ and $0 < P < \infty$

c) $0 < E < \infty$ and $P = 0$

d) $E = \infty$ and $0 < P < \infty$.

v) If ROC of a system is outside the unit circle in z-plane then the system is said to be

a) causal

b) non-causal

c) anticausal

d) neither causal nor anticausal.

vi) An LTI system having system function $H(z)$ is said to be stable if

a) all the poles of $H(z)$ are located on the origin of the unit circle in z-plane

b) all the poles of $H(z)$ are located outside the unit circle in z-plane

c) all the poles of $H(z)$ are located on the unit circle in z-plane

d) all the poles of $H(z)$ are located inside the unit circle in z-plane.

vii) If z-transform of $x(n)$ is $X(z)$ the z-transform of $x(n-3)$ is to be

a) $z^3 X(z)$ b) $z^{-3} X(z)$

c) $zX(z-3)$ d) $zX(z+3)$.

viii) The first three points of a 4-point DFT of real valued sequence are $\{6, -2+j2, -2\}$. The remaining point is

a) $2-j2$ b) $2+j2$

c) $-2-j2$ d) $6-2j$.

ix) For a sequence the frequency resolution in DFT may be increased

a) by scaling up the magnitude of the sequence values

b) by scaling down the magnitude of the sequence values

c) by decreasing the number of points in DFT

d) by increasing the number of points in DFT.

x) The best realization technique to minimize the quantization error is

a) direct-form I b) direct-form II

c) cascade-form d) parallel form.

xi) The poles of Butterworth low pass filter lie on

a) an ellipse b) a circle

c) a parabola d) a rectangle.

xii) An FIR filter is

a) always stable and has non-linear phase characteristics

b) always unstable and has non-linear phase characteristics

c) always stable and has linear phase characteristics

d) always unstable and has linear phase characteristics.

xiii) The TMS32054x is a

a) floating point 16 bit processor

b) floating point 32 bit processor

c) fixed point 16 bit processor

d) fixed point 32 bit processor.

GROUP – B

(Short Answer Type Questions)

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

2. Briefly explain what is mean by a BIBO stable system ? Investigate the stability of the following system :

$h(n) = 3^n \; u(n - 3)$ 2 + 3

3. 'Any discrete-time signal can be expressed in terms of shifted impulse function.' Justify the statement.

4. What are the conditions to be satisfied for a system to be LTI ? Using the conditions how do you prove that the system is LTI ? 2 + 3

5. Illustrate how direct form II realization requires less memory locations than direct form I realization. Consider any example of 2nd order system.

6. What is pipelining ? Write down the different buses of TMS320C5x and their functions. 1 + 4

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Show that $x(n) * \delta(n - n_0) = x(n - n_0)$.

   b) Determine the impulse response of the system described by the difference equation $y(n) = 0{\cdot}6y(n - 1) - 0{\cdot}08y(n - 2) + x(n)$.

   c) Express the z-transform of $y(n) = \sum_{k=-\infty}^{n} x(k)$ in terms of $X(z)$.

   d) Determine the convolution of the following pair of signals by means of z-transform :

   $x_1(n) = u(n)$, $x_2(n) = \delta(n) + (1/2)^n u(n)$.

   2 + 4 + 3 + 6

8. a) Justify whether the following signal is periodic or not. If periodic, find the fundamental period.

$x(n) = 3\cos(5n + \pi/6)$

b) What is twiddle factor ? Mention the properties of twiddle factor which make the FFT algorithm efficient.

c) Find the DFT using the radix-2 decimation-in-frequency (DIF) FFT algorithm of the following function :

$x(n) = n; \quad 0 \le n \le 7$

$= 0 \quad$ elsewhere.

d) Explain how by an FFT algorithm computational effort is reduced for evaluation of DFT. 3 + (1 + 2) + 7 + 2

9. a) What do you mean by fast convolution ? What are the advantages of such convolution ?

b) Consider any fast convolution method to find out the output of the system for the following input :

$x(n) = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12\}$

The impulse response of the system is $h(n) = \{1, 0, 1\}$.

c) Compute convolution of the following pair of signals :

$x(n) = u(n+1) - u(n-5)$

$h(n) = \delta(n+1) - \delta(n) - \delta(n-1) + \delta(n-3)$.

$(1+2) + 6 + 6$

10. a) A digital IIR low pass filter is required to meet the following frequency domain specifications :

pass band ripple ≤ 1 dB pass band edge frequency = 0·15 π rad

stop band attenuation ≥ 40 db stop band edge frequency = 0·35 π rad

The digital filter is to be designed by applying bilinear transformation on an analog system function. Determine the order, N of Butterworth and Chebyshev filters needed to meet the specifications in digital implementation. Compare and justify the results.

b) A Chebyshev I filter of order $N = 3$ and unit bandwidth is known to have pole at $S = -1$.

i) Find the two other poles of the filter and parameter ε.

ii) The analog filter is mapped to z-domain using the bilinear transformation with $T = 2$. Find the transfer function $H(z)$ of the digital filter.

$(3+3+2) + (3+4)$

11. a) Discuss the advantages and disadvantages of FIR filter over IIR filter.

b) Mention the main disadvantage of Fourier series method for FIR filter design. Explain the phenomenon which occurs due to the application of the above method.

c) Design an FIR filter, approximating the ideal frequency response

$$H_d\left(e^{j\omega}\right) = e^{-j\alpha\omega} \qquad \text{for } |\omega| \le \frac{\pi}{6}$$

$$= 0 \qquad \text{for } \frac{\pi}{6} \le |\omega| \le \pi$$

Determine the filter coefficients for $N = 15$ for Hamming window. $4 + (1 + 2) + 8$