M.E. (ETC) 1st Semester Final Examination, 2011-2012
Digital Processing & Control of Signal (ETC- 908)

Full Marks: 70 **Time: 3 hours**

Use separate answer scripts for each half

FIRST HALF

Answer *Q. No. 1* and any *two* from the rest

1.

(a) Fig.1 (a) shows two finite duration sequences. Sketch their N-point circular convolution for N=6 and N=10

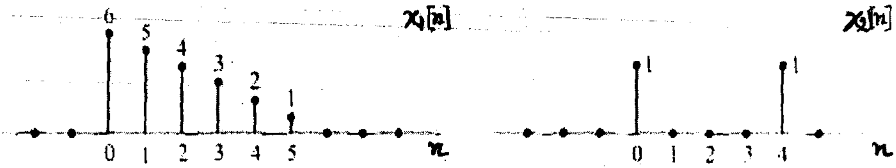

Fig. 1 (a)

(b) The impulse response of a LTI system is shown in Fig. 1(b). Determine and sketch the response of the system to the input x[n] = u[n-4].

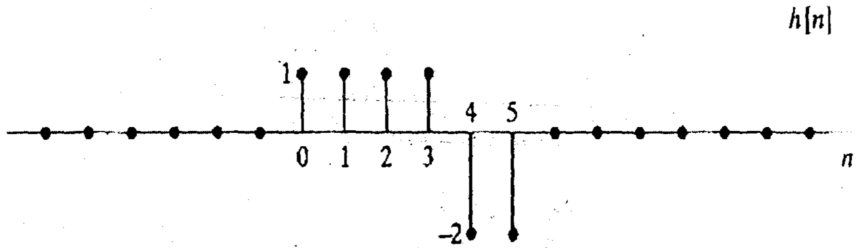

Fig. 1 (b)

15

2. Determine the inverse Z-transform for the following:

(a)

$$X(z) = \frac{3z^{-3}}{\left(1 - \frac{1}{4}z^{-1}\right)^2}, \qquad x[n] \text{ left sided}$$

(b)

$$X(z) = \frac{1}{\left(1 + \frac{1}{2}z^{-1}\right)^2 (1 - 2z^{-1})(1 - 3z^{-1})}, \qquad \text{stable sequence}$$

(c)

$$X(z) = \frac{z^7 - 2}{1 - z^{-7}}, \qquad |z| > 1$$

10

3. Describe the decimation in time FFT algorithm, drawing the signal flow graph for 16 point DFT in various stages.

10

4. Write notes on:
   (a) Digital IIR filter design using impulse invariance
   (b) Sampling rate reduction by an integer factor

10

SECOND HALF

Answer ***Q. No. 5*** and any ***two*** from the rest

5. Given the following FIR filter:

$$y(n) = 0.1\,x(n) + 0.25\,x(n-1) + 0.2\,x(n-2)$$

Determine the transfer function, filter length, non-zero coefficients and impulse response of the filter.
What do you mean by minimum phase system?
Consider a continuous time LTI system, described by the transfer function

$$H(s) = \frac{(s+1)(s-5)(s+10)}{(s+2)(s+4)(s+6)}$$

Is it a minimum phase system? Is the system causal and stable?
Briefly discuss about the relative advantages and disadvantages associated with different types of windows used in FIR filter design.

15

6. Consider a system consisting of two sensors, each making a single measurement of an unknown constant x. Each measurement is noisy and may be modeled as follows:

$$y(1) = x + v(1)$$
$$y(2) = x + v(2)$$

where $v(1)$ and $v(2)$ are zero-mean uncorrelated random variables with variances σ_1^2 and σ_2^2, respectively.
   (a) In the absence of any other information, the best linear estimate of x of the form $x' = k_1 y(1) + k_2 y(2)$ is to be found. Find the values for k_1 and k_2 that produce an unbiased estimate of x that minimizes the mean square error.
   (b) Repeat part (a) for the case where the measurement errors are correlated by $E\{v(1)v(2)\} = \rho\sigma_1\sigma_2$, where ρ is the correlation coefficient.

10

7. Design a three-step predictor using a first-order FIR filter which, when driven by an input $x(n)$, produces the minimum mean-square estimate of $x(n+3)$.
If the autocorrelation values of $x(n)$ for lags 0 to 4 are given by:

$r_x = [1.0,\ 0,\ 0.1, -0.2, -0.9]^T$, solve the Wiener-Hopf equations and find the optimum three-step predictor.

10

8. Examine the influence of zero-order hold on the continuous output responses $y(t)$ in Fig. 8 (a) and Fig. 8 (b) respectively by letting $G_1(s) = \frac{1-e^{-s\Delta t}}{s}$ and $G_2(s) = \frac{k}{s\tau+1}$. The input signal $x(t)$ is a unit step input.

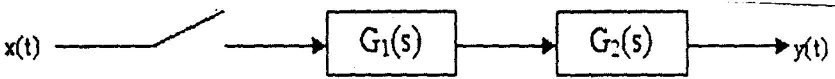

Fig. 8 (a)

Fig. 8 (b)

10