Ref. No. : Ex/MECE 516(A)/2024

M.TECH. INTELLIGENT AUTOMATION AND ROBOTICS FIRST YEAR SECOND SEMESTER – 2024

ADVANCED DIGITAL SIGNAL PROCESSING

Time: 3 hours | Full Marks: 100

Answer any Five Questions.

1. a) The Impulse response to a First Order digital filter is a unit step function. Find the transfer function of the filter.

b) Determine the frequency response of the above filter. Also plot the nature of the frequency response.

c) For the given transfer function, $G(z) = z/(z - 0.5)(z - e^{aT})$, a>0, find the residues of G(z) at the poles z=0.5 and $z=e^{-aT}$, and hence determine the z-inverse of G(z).

d) For a given digital filter, $y(z)/x(z)= (1 + 2z^{-1})/ (1 - 2z^{-1}- 3z^{-2})$, find the difference equation that describes the filter. [5+7+4+4]

2. a) Realize $G_1(z) = (1 +2 z^{-1})/ (1 - 2z^{-1}- 3z^{-2})$ by Direct form 1 and 2.

b) Realize $G_2(z) = 1/(0.1 - z^{-1}) + 0.5z^{-1}/(1 - 2z^{-1})$ by Parallel form.

c) Realize $G_1(z)$. $G_2(z)$ in cascade form, when both of them are realized by Direct form 1. [7+7+6]

3. a) State and explain with diagrams the two basic types of quantization noise.

b) Draw the probability distribution of quantization noise due to truncation, and hence evaluate the mean and variance of the truncation noise.

c) State Parseval's theorem in z-domain. Use this theorem to determine the noise variance of $D(z)= 1/(1 - bz^{-1})$, $|b|<1$.

d) The input quantization noise to $D(z)= 1/(1 - bz^{-1})$, $|b|<1$ is $\sigma^2/12$. Find the output quantization noise of the said system.

e) Show that with decrease in b (<1), the output quantization noise computed in part (d) increases.

[4+6+5+3+2]

4. a) Develop a formula for computing word-length of an ADC for an allowable noise figure of F dB and dynamic range of the analog signal = $V_{max} - V_{min}$.

[Turn over

b) The incoming signal to an ADC has saturation to threshold ratio of 250. The required noise figure is F=40 dB. What is the word-length of the ADC?

c) Develop a formulation to compute the word-length of an arithmetic unit to have a noise figure of F dB and ratio of quantization noise between input and output being K_m.

d) Given $D(z)= 1/ (1 - 0.9\ z^{-1})$, and required noise figure =40 dB. Find K_m and word-length of the arithmetic unit due to truncation. [6+4+6+4]

5. a) Define Fourier transform of a discrete signal x(n). Also define the inverse Fourier transform of X(k).

b) Given a 4 point sequence of a discrete signal: x(n) = (0 1 2 3). Defining W_N^{kn} as exp (j 2πk n/N), for k, n varying in [0, 3] and N=4, determine the matrix W_4. Also determine X_4, i.e., the discretre Fourier transform using the 4-point sequence.

c) Show that for a discrete Fourier transform, $W_N^{k+N/2} = -W_N^k$.

d) Evaluate the inverse discrete Fourier transform from the computed 4-point Fourier transform.

[4+6+4+6]

6. Write notes on the following:

a) Memory word-length selection for quantization noise in pole-shifting,

b) Mapping of s to z domain for stable system,

c) Importance of parallel realization for high speed real-time applications,

d) Defining z-transform from the Laplace transform. [5+5+5+5]