Ex/PG/ ETCE/T/116A/2024

MASTER IN ILLUMINATION ENGINEERING

M.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING

FIRST YEAR FIRST SEMESTER EXAMINATION, 2024

DIGITAL SIGNAL PROCESSING

Time: Three Hours | Full Marks: 100

Answer ***any five*** questions.

1. a) An IIR filter is described by the following difference equation.

$$\mathbf{y(n) = x(n) + 1.6\, y(n-1) - 0.63\, y(n-2)}$$

Draw the direct form - I structure of the filter. Convert it into a suitable structure and hence obtain the impulse response intuitively. 10

b) An IIR filter is described by the following difference equation.

$$\mathbf{y(n) = b\, x(n) + 0.9\, y(n-1)}$$

Obtain the frequency response and hence determine **b** so that dc gain equals to 1. Determine the cutoff frequency of the filter. Is this filter lowpass bandpass or highpass? 10

2. a) An FIR filter is described by the following difference equation.

$$\mathbf{y(n) = x(n) - x(n-1)}$$

Compute and sketch its magnitude and phase response. What is the name of this filter? What is its possible use? 10

b) Design a first-order allpass filter whose pole is placed at $\mathbf{z = -0.6}$. Obtain the lattice realization of the filter thus designed. Mention some of the applications of allpass filters. 10

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3. a) Obtain expressions for amplitude and phase frequency responses of a Type II (Even-length symmetric) FIR filter. Is this a linear phase filter? What is the advantage of a linear phase FIR filter? Comment on the automatic zero locations of linear phase FIR filters. 10

b) Consider the following system function of a filter.

$$\mathbf{H(z) = (1 - 0.9\, z^{-1} - 0.1\, z^{-2}) / (1 + 0.3\, z^{-1} - 0.04\, z^{-2})}$$

Obtain the parallel form realization structure of the filter. 10

4. a) Design the simplest possible first-order FIR lowpass filter through the pole-zero placement method. Find the frequency response of the filter, plot the magnitude response, and calculate the 3-dB cutoff frequency. What is the limitation of the filter thus designed? Suggest a suitable method to overcome this limitation. 10

b) Design a filter to generate a digital tone of 1 KHz. Assume a sampling rate of 8 KHz. How to use the designed filter to generate the said tone? Which frequencies are blocked by the following FIR filter?

$$\mathbf{H(z) = 1 - 2\, z^{-1} + 2\, z^{-2} - z^{-3}}$$

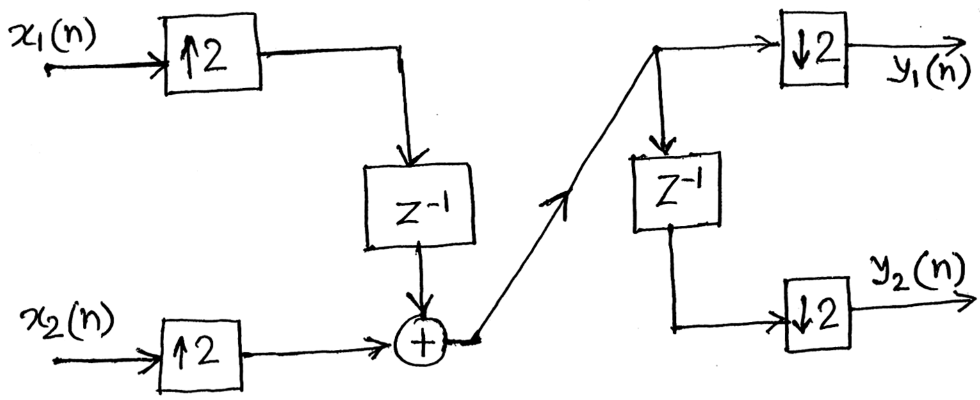
10

5. a) Determine the lattice coefficients for the following FIR filter and hence draw the corresponding lattice structure of the filter. 10

$$\mathbf{H(z) = 1 + (13/24)\, z^{-1} + (5/8)\, z^{-2} + (1/3)\, z^{-3}}$$

b) Obtain an allpass based combined realization of a tunable first-order lowpass and highpass filters and show the corresponding lattice structure. 10

6. a) Consider the following multirate system and determine its input-output relations. 10



b) For a single-stage interpolator with the following specifications:

Original sampling rate = 8 kHz
Interpolation factor, I = 3
Frequency of interest = 0 - 3400 Hz
Passband ripple = 0.02 dB
Stopband attenuation = 46 dB

Draw the block diagram of the interpolator. Determine the window type, filter length, and cutoff frequency if the window method is used for the anti-imaging FIR filter design. 10

7. a) Draw the block diagram of a two-channel filter bank and hence obtain the condition for perfect reconstruction in terms of the filter system functions. 10

b) Obtain 1-level and 2-level Haar transform for the following signal,

$$f = (4, 6, 10, 12, 8, 6, 5, 5)$$

and hence obtain the first averaged signal A^1, the first detail signal D^1, the second averaged signal A^2 and the second detail signal D^2, following MRA (Multi Resolution Analysis) using Haar wavelets. 10

8. Discuss in detail any application of Digital Signal Processing. 20