M.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING
FIRST YEAR FIRST SEMESTER EXAMINATION, 2025

ADVANCED 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.

$$\mathbf{y(n) = x(n) + 0.6\, y(n-1) - 0.08\, y(n-2)}$$

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.

$$\mathbf{y(n) = 0.1\, x(n) - 0.9\, y(n-1)}$$

Compute the frequency response and hence obtain the dc gain. 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.

$$\mathbf{y(n) = x(n) - x(n-4)}$$

Compute and sketch its magnitude and phase response. 10

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b) Determine the coefficients of a linear phase FIR filter

$$y(n) = b0.x(n) + b1.x(n-1) + b2.x(n-2)$$

such that
(i) it rejects completely a frequency component at $w = 2.(\pi/3)$, and
(ii) its response is normalized at dc.

10

3. a) Obtain expressions for amplitude and phase frequency responses of a Type-I 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 Type-II linear phase FIR filters. 10

b) Consider the following system function of a filter.

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

Obtain the cascade form realization structure of the filter. 10

4. a) Design the simplest possible first-order FIR highpass 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) Obtain the pole-zero plot for the filter with the system function given below. Comment on the nature of the filter intuitively from the plot itself. Justify your comment analytically.

$$H(z) = 1 \,/\, (1 + z^{-2})$$ 10

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

$$H(z) = 1 - 1.3435\, z^{-1} + 0.9025\, z^{-2}$$

b) Obtain the lattice structure realization of a second-order all-pole IIR filter. 10

6. a) Give the definition of an I - fold up-sampler. Given the following sequence, x(n),

$$x(n) = \{ \ldots\ldots\ldots, 3, \underset{\uparrow}{5}, 2, 9, 6, \ldots\ldots\ldots \}$$

obtain its up-sampled version, y(n), when the factor I is 3; What is the relationship between X(z) and Y(z), in this case? How many spectral images will be present in the spectrum of y(n)? How does it affect the overall structure of an interpolator? 10

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

Original sampling rate = 8 kHz
Decimation factor, D = 4
Frequency of interest = 0 - 800 Hz
Passband ripple = 0.02 dB
Stopband attenuation = 46 dB

Draw the block diagram of the decimator. Determine the window type, filter length, and cutoff frequency if the window method is used for the anti-aliasing 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,

$$f = (2, 2, 4, 6, 8, 8, 12, 10)$$

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