Roll No.											

PRESIDENCY UNIVERSITY

BENGALURU

End - Term Examinations – December 2025

Date: 16 – 12- 2025 **Time:** 09:30am – 12:30pm

School: SOE	**Program:** B. Tech. in VLSI	
Course Code: ECE2508	**Course Name:** Signal Processing	
Semester: III	**Max Marks**: 100	**Weightage**: 50%

CO - Levels	CO1	CO2	CO3	CO4	CO5	CO6
Marks	**16**	**20**	**20**	**16**	**16**	**12**

Instructions:

(i) Read all questions carefully and answer accordingly.

(ii) Do not write anything on the question paper other than roll number.

Part A

Answer ALL the Questions. Each question carries 2marks. **10Q x 2M=20M**

1.	State the defining condition for a signal to be classified as causal, anti-causal, and non-causal. Then, classify the following signal into these categories based on the conditions you stated. $y(t) = x(t) + x(t-1)$	**2 Marks**	**L2**	**CO1**
2.	Explain the fundamental difference between the Discrete-Time Fourier Transform (DTFT), the Discrete Fourier Transform (DFT), and the Fast Fourier Transform (FFT).	**2 Marks**	**L2**	**CO1**
3.	Explain the fundamental difference between the Z-transform and the Discrete-Time Fourier Transform (DTFT).	**2 Marks**	**L2**	**CO1**
4.	Explain the fundamental difference between IIR and FIR filters concerning their impulse response and use of feedback.	**2 Marks**	**L2**	**CO4**
5.	State the key characteristic of a Butterworth filter's passband and the primary trade-off involved in its design.	**2 Marks**	**L2**	**CO4**
6.	Explain the primary advantage of the Direct Form II structure over the Direct Form I structure for realizing IIR filters.	**2 Marks**	**L2**	**CO4**

7.	Explain the fundamental difference between the Rectangular and Hamming windows in terms of their main lobe width and side lobe level.	**2 Marks**	**L2**	**CO5**
8.	State the key property of an FIR filter's impulse response that guarantees a linear phase response.	**2 Marks**	**L2**	**CO5**
9.	Explain the primary advantage of the Linear Phase Structure for realizing FIR filters over the Direct Form structure.	**2 Marks**	**L2**	**CO5**
10.	Explain the fundamental difference between cascade and parallel realizations of IIR filters. Support your answer with a neat block diagram.	**2 Marks**	**L2**	**CO6**

Part B

Answer the Questions. **Total Marks 80M**

11.	**a.**	Determine whether the signal $x(t) = 2\cos(10\pi t + \frac{\pi}{4})$ is periodic. If it is, find its fundamental period.	**10 Marks**	**L3**	**CO1**
	b.	A linear-phase FIR lowpass filter is designed using the Rectangular window method with the following specifications: • Filter length $N = 9$ • Normalized cutoff frequency $f_c = 0.25$ (cycles/sample) Analyze this design by performing the following tasks: **i.** Determine the filter coefficients $h[n]$. **ii.** Identify the type of symmetry present in $h[n]$ and explain how it ensures linear phase. **iii.** Predict the expected frequency-domain behavior of this filter, specifically commenting on the main lobe width and side lobe levels, and justify your prediction based on the window used.	**10 Marks**	**L4**	**CO5**
Or					
12.	**a.**	Determine whether the signal $x(t) = 3A\sin(t)$ is an energy signal or a power signal. Calculate its average power.	**10 Marks**	**L3**	**CO1**
	b.	A linear-phase FIR lowpass filter is designed using the Hamming window method with the following specifications: • Filter length $N = 9$ • Normalized cutoff frequency $f_c = 0.25$ (cycles/sample)	**10 Marks**	**L4**	**CO5**

		• Hamming window: $w[n] = 0.54 - 0.46\cos(\frac{2\pi n}{8}), 0 \le n \le 8$ Analyze this design by performing the following tasks: i. Compute the filter coefficients $h[n]$. ii. Verify the type of symmetry in the coefficients and confirm it satisfies the condition for linear phase. iii. Compare the expected frequency response of this Hamming window design with an equivalent rectangular window design, focusing on trade-offs in main lobe width and side lobe attenuation.			

13.	**a.**	Using the standard analysis formula, compute the Discrete Fourier Transform (DFT) $X[k]$ for the finite-length sequence $x[n] = \{2,0,1,3\}$.	**10 Marks**	**L3**	**CO2**
	b.	Given the frequency samples $X[k] = \{6, 1+3j, 0, 1-3j\}$, show that the IDFT recovers the original time-domain sequence $x[n]$.	**10 Marks**	**L3**	**CO2**
		Or			
14.	**a.**	Using the standard analysis formula, compute the Discrete Fourier Transform (DFT) $X[k]$ for the finite-length sequence $x[n] = \{1, 0, 2, 4\}$.	**10 Marks**	**L3**	**CO2**
	b.	Given the frequency samples $X[k] = \{7, 1-2j, 1, 1+2j\}$, show that the IDFT recovers the original time-domain sequence $x[n]$.	**10 Marks**	**L3**	**CO2**

15.	**a.**	Demonstrate the Radix-2 Decimation-In-Time (DIT) FFT algorithm to compute the 4-point DFT of the sequence $$x[n] = [2,4,1,3]$$	**10 Marks**	**L3**	**CO3**
	b.	Demonstrate the Radix-2 Decimation-In-Time (DIT) FFT algorithm to compute the 4-point DFT of the sequence $$x[n] = [3,1,4,2]$$	**10 Marks**	**L3**	**CO3**
		Or			
16.	**a.**	Compare the number of complex multiplications and complex additions required by the direct DFT and the Radix-2 FFT for an $N = 512$ point transform. Compute the overall operation counts and the speedup factors.	**10 Marks**	**L3**	**CO3**
	b.	Compare the number of complex multiplications and complex additions required by the direct DFT and the Radix-2 FFT for	**10 Marks**	**L3**	**CO3**

		an $N = 1024$ point transform. Compute the overall operation counts and the speedup factors.			

17.	**a.**	Design a first-order low-pass Butterworth filter with a cutoff frequency of $f_c = 1$ kHz. Find the transfer function $H(s)$.	**10 Marks**	**L3**	**CO4**
	b.	Three IIR filters are connected in cascade with the following transfer functions: • $H_1(z) = \frac{1}{1-0.6z^{-1}}$ • $H_2(z) = \frac{1}{1+0.4z^{-1}}$ • $H_3(z) = \frac{1}{1-0.1z^{-1}}$ Analyze the overall system by: i. Finding the overall transfer function $H(z)$ of the cascaded system. Express your answer as a rational function in positive powers of z. ii. Determining the locations of the poles and zeros of the overall system and commenting on its stability.	**10 Marks**	**L4**	**CO6**
Or					
18.	**a.**	Design a first-order low-pass Butterworth filter with a cutoff frequency of $f_c = 2$ kHz. Find the transfer function $H(s)$.	**10 Marks**	**L3**	**CO4**
	b.	Three IIR filters are connected in parallel with the following transfer functions: • $\boldsymbol{H_1(z) = \frac{1}{1-0.5z^{-1}}}$ • $\boldsymbol{H_2(z) = \frac{1}{1+0.3z^{-1}}}$ • $\boldsymbol{H_3(z) = \frac{1}{1-0.7z^{-1}}}$ **Analyze the overall system by:** **i.** Finding the overall transfer function $H(z)$ of the parallel system. Express your answer as a rational function in positive powers of z. **ii.** Determining the locations of the poles and zeros of the overall system and commenting on its stability.	**10 Marks**	**L4**	**CO6**