UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2021

Course: Digital Signal Processing **Semester: V**

Program: B Tech ECE **Duration: 03 hrs.**

Course Code: ECEG2013 **Max. Marks: 100**

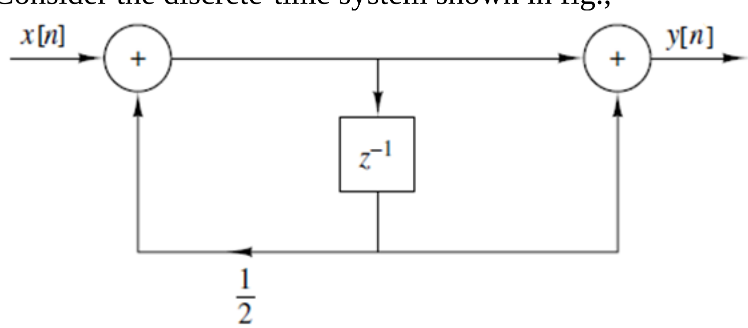
Instructions:

- Attempt all questions as per the instruction.
- Assume any data if required and indicate the same clearly. Use Table 1 data, in case if it is required.
- Unless otherwise indicated symbols and notations have their usual meanings.
- Strike off all unused blank pages

SECTION A (5Qx4 = 20 Marks)

S. No.		**Marks**	**CO**
Q 1	Define causality and stability of LTI discrete-time system with mathematical relations.	**4**	**CO1**
Q 2	Given sequence $x[k] = \begin{cases} 2; & k = 0,1,2 \\ 1; & k = 3,4 \\ 0; & otherwise \end{cases}$ Sketch the sequence x[k] and the reverse sequence $x[-k]$, the shifted sequences $x[-k+2]$ and $x[-k-3]$.	**4**	**CO1**
Q 3	Define the sampling theorem. Find the DFT of the signal $x[n] = 3\delta[n]+2\delta[n-1]+3\delta[n-2]$ and draw the DFT spectrum $X[k]$.	**4**	**CO2**
Q 4	**(a)** Draw the block diagram of the system that represented by the following difference equation: $y[n] = b_0 x[n] + b_1 x[n-1] + a_1 y[n-1]$ **(b)** Draw the magnitude characteristics of Chebyshev low pass filter (Type-I and Type-II) and label the specifications on its magnitude response plot.	**2+2**	**CO3**
Q 5	Digitize the analog filter with transfer function $H(s) = \frac{s+1}{s(s+2)}$ using the impulse invariant method, Assume the sampling frequency of 10 Hz	**4**	**CO4**

SECTION B (4Qx10 = 40 Marks)

Q 6	Consider the discrete-time system shown in fig.,  **(a)** Find the input-output relation	**10**	**CO1**

	(b) Compute the first 8-samples of its impulse response. **(c)** Check whether the given system is causal and stable.		
Q 7	**(a)** If X[k] is the 5-point DFT of the sequence $x[n] = 2\delta[n] + \delta[n-1] + \delta[n-3]$. What sequence y[n] has a 5-point DFT $$Y[k] = 2X[k]\cos\left(\frac{6\pi k}{10}\right)$$ **(b)** Compute 4-point DFT of the signal $x[n] = \{1,\ 2,\ -2,\ 1\}$ using decimation in time FFT algorithm.	**5+5**	**CO2**
Q 8	**(a)** Discuss in detail about frequency transformations. **(b)** Given the second-order IIR filter, $$H(z) = \frac{1 - 0.9\,z^{-1} + 0.1z^{-2}}{1 + 0.3z^{-1} + 0.04z^{-2}}$$ Realize H(z) and develop difference equations using the following forms: (i) Direct form I (ii) Direct form II (iii) Cascade (series) form via the first-order sections. (iv) Parallel form via the first-order sections	**5+5**	**CO3**
Q 9	Design a 5-tap FIR band pass filter with a lower cutoff frequency of 1,600 Hz, an upper cutoff frequency of 1,800 Hz, and a sampling rate of 8,000 Hz using **(a)** Rectangular window function **(b)** Hamming window function.	**5+5**	**CO4**
SECTION-C (2Qx20 = 40 Marks)			
Q 10	A band pass filter with Butterworth magnitude-frequency response satisfies the following specifications: Passband: 0.3 – 3.4 kHz Stopband: 0 – 0.2 kHz and 4 – 8 kHz Pass band attenuation= 3 dB Stop band attenuation = 25 dB Sampling frequency = 16 kHz Obtain a suitable transfer function for the filter using the bilinear transformation method and realize the filter in direct form-I and II. **OR** Two linear phase FIR bandpass filters are required to satisfy the following specifications: For filter 1: passband: 8 – 12 kHz Stopband ripple: 0.001 Peak passband ripple: 0.001 Sampling frequency: 44 kHz Transition width: 3 kHz For filter 2: passband: 8 – 12 kHz Stopband ripple: 0.01 Peak passband ripple: 0.001 Sampling frequency: 44 kHz Transition width: 3 kHz	**20**	**CO3, CO4**

	Obtain and compare the frequency response for each filter using the window method		
Q 11	In a speech recording system with a sampling rate of 10,000 Hz, the speech is corrupted by broadband random noise. To remove the random noise while preserving speech information, the following specifications are given: Speech frequency range: 0 – 3,000 kHz Stopband range: 4,000 –5,000 Hz Passband ripple = 0.1 dB; Stopband attenuation = 60 dB (a) Design the FIR filter to remove random noise with the above specifications using Blackmann's Window method. (b) Determine the difference equation and realize the FIR filter with suitable structure.	**20**	**CO3, CO4**

Table 1: Prototype Lowpass filter Functions

Filter order (N)	**3dB Butterworth Prototype Functions** $\boldsymbol{H_p(s)}$	**Chebyshev Prototype Functions with 1dB Ripple** $\boldsymbol{H_p(s)}$
1	$\frac{1}{s+1}$	$\frac{1.9652}{s+1.9652}$
2	$\frac{1}{s^2+1.4142s+1}$	$\frac{0.9826}{s^2+1.0977s+1.1025}$
3	$\frac{1}{s^3+2s^2+2s+1}$	$\frac{0.4913}{s^3+0.9883s^2+1.2384s+0.4913}$
4	$\frac{1}{s^4+2.6131s^3+3.4142s^2+2.6131s+1}$	$\frac{0.2456}{s^4+0.9368s^3+1.4539s^2+0.7426s+0.2756}$
5	$\frac{1}{s^5+3.2361s^4+5.2361s^3+5.2361s^2+3.2361s+1}$	$\frac{0.1228}{s^5+0.9368s^4+1.6888s^3+0.9744s^2+0.5805s+0.1228}$