Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2019

Program: B Tech EE, EE-BCT, EE-IoT — **Semester: VI**
Course: Digital Signal Processing — **Time 03 hrs.**
Course Code: ELEG363 — **Max. Marks: 100**
Nos. of page(s) : 3
Instructions:

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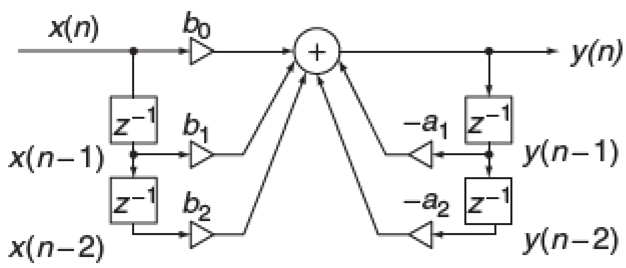
SECTION A (20 Marks)

S. No.		Marks	CO
Q 1	Determine the range of a and b for which LTI system is stable with impulse response $h[n]=\begin{cases} a^n; n>0 \\ a^n; n>0 \end{cases}$	4	CO1
Q 2	Define the convolution sum. What are the properties of the convolution sum?	4	CO1
Q 3	If X[k] is the DFT of the sequence x[n], determine the N-point DFTs of the following sequences $x_c[n]=x[n]\cos\left(\frac{2\pi}{N}k_0 n\right)$ and $x_s[n]=x[n]\sin\left(\frac{2\pi}{N}k_0 n\right)$ in terms of X[k].	4	CO2
Q 4	Briefly discuss the digital filter specifications and label on magnitude characteristics of filter.	4	CO3
Q 5	(a) A discrete time system is operated on an input sequence to produce an output sequence according to some computation algorithm: $y[n]=\sum_{k=0}^{M} b_k x[n-k]+\sum_{k=1}^{N} a_k y[n-k]$ Find its transfer function (b) Obtain the difference equation to represent the discrete time system of the **Fig.1** given below	2+2	CO4

	 **Fig.1**		
SECTION B (40 Marks)			
Q 6	(a) Evaluate the following convolution sum $y[n]=x_1[n]*x_2[n]*x_3[n]$. Where $x_1[n]=0.5^n u[n]; x_2[n]=u[n+3] \wedge x_3[n]=\delta[n]-\delta[n-1]$ (b) Consider a system with impulse response $h[n]=\begin{cases}\left(\frac{1}{2}\right)^n ; 0\le n\le 4\\ 0 ; elsewhere\end{cases}$ Determine the input x[n] for $0\le n\le 3$ that will generate the output sequence y[n] = {1, 2, 2.5, 3, 3, 3, 2, 1, 0,…}	**4+4**	**CO1**
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) Draw the butterfly flow diagram for computing 8-point DFT using decimation in time FFT algorithm.	**6+2**	**CO2**
Q 8	(a) A third-order Butterworth low pass filter has the transfer function: $H(s)=\frac{1}{(s+1)(s^2+s+1)}$ Design a digital filter H(z) with cut-off frequency 5 Hz and sampling frequency 15 Hz using Impulse Invariance method. (b) Prove that the FIR filter phase response is linear. (Assume N=7 and the impulse response satisfies the positive symmetry.	**4+4**	**CO3**
Q 9	Given a fourth-order filter transfer function $H(z)=\frac{(0.343z^2+0.6859z+0.343)(0.4371z^2+0.8742z+0.4371)}{(z^2+0.7075z+0.7313)(z^2-0.1316z+0.1733)}$ (a) Realize the digital filter using the cascade (series) form via second order sections using the direct form II; (b) Determine the difference equations for implementation	**8**	**CO4**
Q 10	Two finite duration sequences $h_1[n]$ and $h_2[n]$ of length 8 are sketched in **Fig.2.** they are related by a circular shift i.e. $h_2[n]=h_1[(n-m)_8]$. (a) What is the value of m and specify whether the magnitude of 8-point DFTs of $h_1[n]$ and $h_2[n]$ are equal. (b) Which of the following statement is correct? Justify your answer.	**8**	**CO1, CO2**

<table>
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(i) $h_1[n]$ is better low pass filter than $h_2[n]$

(ii) $h_2[n]$ is better low pass filter than $h_2[n]$

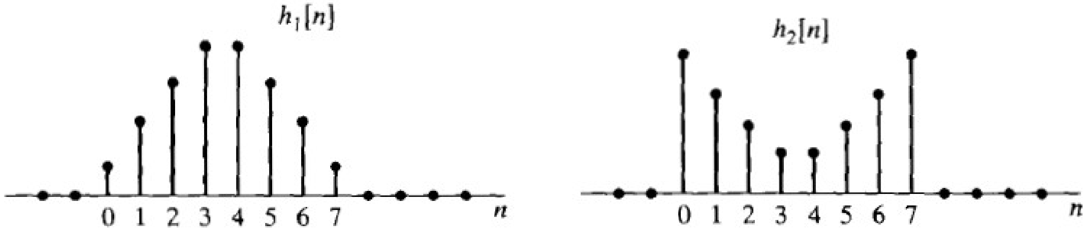


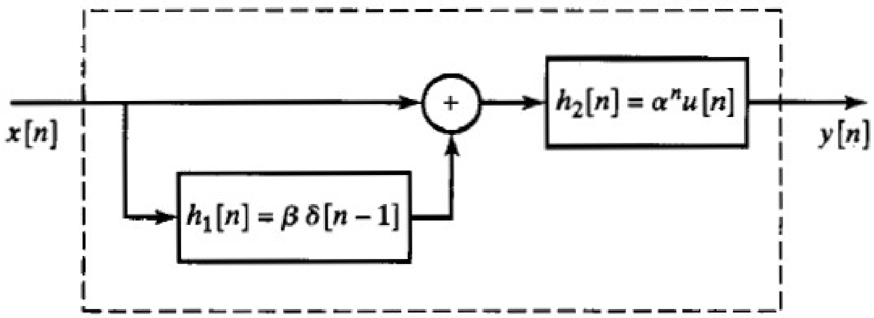
Fig.2

OR

Consider the system shown in **Fig.3**

(a) Find the overall impulse response of the system h[n].

(b) Is this system causal? Under what condition would the system be stable?



$h[n]$

Fig.3

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SECTION-C (40 Marks)

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<td>Q 11</td>
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(a) Design a digital band pass filter with a Butterworth filter characteristics satisfies the following specifications:
Pass band edge frequencies: 200 Hz and 300 Hz;
Stop band edge frequencies: 50 Hz and 450 Hz;
Passband ripple = 3 dB; stop-band attenuation = 20dB, and a sampling frequency of 1,000 Hz. (use bilinear transformation method)

(b) Determine difference equation and realize the above filter using direct form – I and II

OR

Determine the transfer function for a 7-tap FIR band pass filter with a lower cutoff frequency of 1.5 kHz and an upper cutoff frequency of 3 kHz, a sampling rate of 8,000 Hz using the frequency sampling method. Also, realize the filter structure using direct form-II.

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<td>**15+5**</td>
<td>**CO3, CO4**</td>
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<td>Q 12</td>
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Given a speech equalizer shown in **Fig.4** to compensate midrange frequency loss of hearing and the following specification: Sampling rate = 8,000 Hz;
Band pass FIR filter with Hamming window

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<td>**15+5**</td>
<td>**CO3, CO4**</td>
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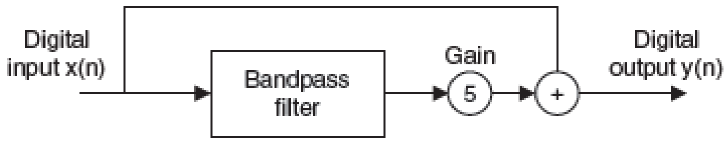
	Frequency range to be emphasized = 1,500–2,000 Hz Lower stopband = 0–1,000 Hz; Upper stopband = 2,500–4,000 Hz Passband ripple = 0.1 dB; Stopband attenuation = 45 dB, (a) Determine the filter length and its coefficients. (b) Determine the difference equation of the filter and realize with suitable structure.  **Fig.4**		

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SECTION A (20 Marks)

S. No.		**Marks**	**CO**
Q 1	Define causality and stability of LTI discrete-time system with mathematical relations.	**4**	**CO1**
Q 2	Define cross-correlation and auto-correlation sequence. Also write relation between linear convolution and correlation	**4**	**CO1**
Q 3	(a) Distinguish between Linear convolution and circular convolution (b) What is FFT? Calculate the number of multiplications needed in the calculation of DFT using FFT algorithm with 32-point sequence.	**2+2**	**CO2**
Q 4	What are the necessary and sufficient conditions for linear phase characteristics in FIR filter?	**4**	**CO3**
Q 5	(c) Draw the block diagram of the system that represented by the following difference equation: $y[n]=b_0 x[n]+b_1 x[n-1]+a_1 y[n-1]$ (d) 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**	**CO4**

SECTION B (40 Marks)

Q 6	(a) 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 $x[-k-3]$. (b) Find the discrete time convolution sum of the following $y[n]=x[n]*u[n-2]$. Where $x[n]=3^n u[-n+3]$.	**4+4**	**CO1**
Q 7	(a) State and prove the any three properties of DFT (b) Compute the DFT of the sequence $x[n]=\{1,-1,1,0,-1,1,1,-1\}$ using decimation in time FFT algorithm.	**3+5**	**CO2**
Q 8	(a) Compare the impulse invariance and bilinear transformation methods (b) Find the order and poles of a low pass Butterworth filter that has a 3db bandwidth of 400 Hz and an attenuation of 20db at 1KHz **OR** Consider the following Laplace transfer function: $H(s)=\frac{s+5}{(s+2)(s^2+3s+2)}$ Determine H(z) and the difference equation using the impulse invariant method if the sampling rate is 10 Hz.	**3+5**	**CO3**
Q 9	Given a filter transfer function, $H(z)=\frac{(0.4371z^2+0.8742z+0.4371)}{(z^2+0.7075z+0.7313)}$ (a) Realize the digital filter using direct form I and using direct form II; (b) Determine the difference equations for each implementation.	**8**	**CO4**
Q 10	Consider discrete-time system is described with following difference equation: $y[n]+\frac{1}{a}y[n-1]=x[n-1]$ (a) Find the impulse response of the system h[n], as a function of the constant a. (b) Is this system causal? Under what condition would the system be stable?	**8**	**CO1**
SECTION-C (40 Marks)			
Q 11	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 ripple= 3 dB Stop band attenuation = 25 dB Sampling frequency = 32 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** Design a 7-tap FIR band pass filter with a lower cutoff frequency of 1,600 Hz, an	**20**	**CO3, CO4**

	upper cutoff frequency of 1,800 Hz, and a sampling rate of 8,000 Hz using (a) Rectangular window function (b) Hamming window function.		
Q 12	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 Kaiser Window method. (b) Determine the difference equation and realize the FIR filter with suitable structure.	**15+5**	**CO3, CO4**