TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

# Examination Control Division

**2081 Bhadra**

| Exam. | | Regular | |
|---|---|---|---|
| **Level** | BE | **Full Marks** | 80 |
| **Programme** | BCT, BEI | **Pass Marks** | 32 |
| **Year / Part** | IV / I | **Time** | 3 hrs. |

## ***Subject:*** - Digital Signal Analysis and Processing (*CT 704*)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*



1. Determine if the signal $x[n] = \cos\left(\frac{2\pi n}{5}\right) + \sin\left(\frac{\pi n}{3}\right)$ is periodic or not. If the signal is periodic, find its fundamental period. [4]

2. Find the output of an LTI System with impulse response $h[n] = 2\delta[n+1] + 2\delta[n-1]$ when an input of $x[n] = \delta[n] + 2\delta[n-1] - \delta[n-3]$ is applied to it. [5]

3. Define ROC of z-transform. Find the inverse z-transform using partial fraction expansion of

$$X(z) = \frac{2z^3-5z^2+z+3}{(z-1)(z-2)} \text{ for ROC } |z| < 1$$ [1+5]

4. Plot the pole – zero in z plane and draw magnitude response (not to the scale) of the system described by difference equation [3+7]

$$y[n] - 0.4\, y[n-1] + 0.25\, y[n-2] = x[n] - 0.4\, x[n-1]$$

5. Compute the lattice and ladder coefficients and draw lattice-ladder structure for the given IIR system [6+4]

$$H(z) = \frac{1 + z^{-1} + z^{-2}}{(1 + 0.5z^{-1})(1 + 0.3z^{-1})(1 + 0.4z^{-1})}$$

6. Design a low pass FIR filter using suitable window to meet following specifications: [8]

$$0.99 \le |H(e^{jw})| \le 1.01 \quad for\ 0 \le |w| \le 0.3\pi$$

$$|H(e^{jw})| \le 0.01 \qquad for\ 0.35\pi \le |w| \le \pi$$

7. What do you mean by optimum filter? Describe the Remez exchange algorithm for FIR filter design along with the flowchart. [1+6]

8. Design a digital low pass IIR filter using Bilinear transformation to meet following specifications: [12+3]

$$0.9 \le |H(e^{jw})| \le 1 \quad for\ 0 \le |w| \le \frac{\pi}{2}$$

$$|H(e^{jw})| \le 0.2 \qquad for \frac{3\pi}{4} \le |w| \le \pi$$

Use Butterworth approximation for design with sampling frequency of 1Hz. Compare Impulse Invariance Method and Bilinear Transformation method.

9. How does FFT reduce computational complexity compared to direct calculation of DFT?

Compute 8-point DFT of $x[n] = \{1, -2, -4, 3, 0, 1\}$ using DIT-FFT algorithm. [2+7]

10. If $X_1(k)$ and $X_2(k)$ are the 5-point DFT of $x_1(n) = 3^n \; 0 \le n \le 3$ and $x_2(n) = 2^n \; 0 \le n \le 4$. Find $x_3(n)$ if $X_3(k) = X_1(k)X_2(k)$ [6]

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TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

# Examination Control Division

**2080 Bhadra**

| **Exam.** | **Regular** | | |
|---|---|---|---|
| **Level** | BE | **Full Marks** | 80 |
| **Programme** | BEI, BCT | **Pass Marks** | 32 |
| **Year / Part** | IV / I | **Time** | 3 hrs. |

## ***Subject:*** - Digital Signal Analysis and Processing (*CT 704*)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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1. A discrete time system has input x(n) and output y(n). The input output relation of the system is given by



$$y(n) = \sum_{k=0}^{n} x(k)$$

Check whether the system is memory less, time invariant and stable or not? [2+2+2]

2. Determine whether the given signal is periodic or not. If the signal is periodic, determine the fundamental period $x[n] = e^{\frac{j\pi n}{16}} \cos\left\{\frac{n\pi}{17}\right\}$. [5]

3. Define the Region of Convergence (ROC) [1+6]

Find the inverse of $H(z) = (1 + 2z^{-1} + z^{-2})/\ (1 - 0.75z^{-1} + 0.125z^{-2})$; ROC $0.25 < |z| < 0.5$

4. Plot the pole-zero on the z-plane and draw Magnitude response (not to the scale) of an LTI system described by the equation, $y(n) = x(n) + 0.8x(n-1) + 0.8x(n-2) + 0.49\ y(n-2)$. [3+7]

5. Draw the Lattice structure from the following system function.

$$H(z) = \frac{1}{1 - 0.2z^{-1} + 0.4z^{-2} + 0.6z^{-3}}$$ [10]

6. Design the symmetric FIR Low Pass Filter (LPF) for which the desired frequency response is expressed as [10]

$H_d(W) = e^{-jW\tau}, |W| \leq Wc$ and 0 elsewhere. The length of the filter should be 7 and $Wc = 1$ rad/sample. Make use of the Hanning window.

7. Kaiser window is to be used to design a linear phase FIR filter that meets following specification [2+2+2]

$|H(e^{j\omega})| \leq 0.01, \quad 0.21\pi \leq |\omega| \leq \pi$

$0.95 \leq |H(e^{j\omega})| \leq 1.05, \quad 0 \leq |\omega| \leq 0.19\pi.$

Calculate the optimum value of ripple, attenuation and window length.

8. Using Bilinear transformation, design a Butterworth low pass filter which satisfies following conditions:

$0.9 \leq |H(e^{jw})| \leq 1, \quad \text{for } 0 \leq w \leq \frac{\pi}{2}$

$|H(e^{jw})|\ 0.2, \quad \text{for } \frac{3\pi}{4} \leq w \leq \pi$ [12]

Consider sampling frequency of 1 Hz.

9. Compute 8-point DIF-FFT of sequence x(n) = {2, 1, 2, 1, 1, 2, 1, 2}. [8]

10. Obtain the circular convolution of the following sequences:

$x_1(n) = \{1, 2, 3, 1\}$ and $x_2(n) = \{4, 3, 2, 2\}$ [6]

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TRIBHUVAN UNIVERSITY
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**Examination Control Division**
**2081 Baishakh**

| **Exam.** | | **Back** | |
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***Subject:*** - Digital Signal Analysis and Processing (*CT 704*)

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1. A discrete-time LTI system is given by difference equation $y(n) = x(n) + e^a y(n-1)$. Check this system for BIBO stability. [5]

2. Find the output y (n) of LTI system having impulse response $h(n) = \left(\frac{1}{3}\right)^n u(n-3)$ and input $x(n) = \left(\frac{1}{6}\right)^{n-6} u(n)$. [6]

3. Determine the inverse z-transform of $X(z) = \frac{1}{1-0.8z^{-1}+0.12z^{-2}}$. (i) if ROC is $|z| > 0.6$ (ii) if ROC is $|z| < 0.2$ (iii) if ROC is $0.2 < |z| < 0.6$ [2+2+3]

4. Plot the pole-zero in z plane and draw the magnitude response (not to the scale) of the system described by difference equation $y(n) = 0.67\,x(n) - 0.3\,x(n-1) + 2.75\,y(n-1)$ [3+7]

5. a) Draw the cascaded form structure of $H(z) = 10(1-0.25z^{-1})(1-0.667z^{-1})(1+2z^{-1}) / (1-0.75z^{-1})(1-0.125z^{-1})\{1-(0.5+j0.5)z^{-1}\}\{1-(0.5-j0.5)z^{-1}\}$ [5]

   b) Draw the lattice structure for the given FIR filter and also check whether the system is stable. $H(z) = 1 + (13/24)z^{-1} + (5/8)z^{-2} + (1/3)z^{-3}$ [5]

6. Design a linear phase FIR filter using suitable window to meet following specifications: [10]

   $$0.99 \le |H(e^{jw})| \le 1.01, \quad \text{for } 0 \le |w| \le 0.3\pi$$

   $$|H(e^{jw})| \le 0.01, \quad \text{for } 0.35\pi \le |w| \le \pi$$

7. What is Gibbs phenomenon and how can it be minimized? Why Kaiser window is better than other fixed windows in FIR filter design? [3+3]

8. Differentiate between bilinear transformation and impulse invariance. Design a Butterworth digital IIR lowpass filter using bilinear transformation by taking T = 0.1 second, to satisfy the following specifications. [2+10]

   $$0.6 \le |H(e^{j\omega})| \le 1, \quad 0 \le \omega \le 0.35\pi$$

   $$|H(e^{j\omega})| \le 0.1, \quad 0.7\pi \le \omega \le \pi$$

9. Why Decimation in Time Fast Fourier Transform (DITFFT) Algorithm is better than direct computation of DFT? Find 4 point DFT of the sequence x(n) = {2,2,4} using DITFFT algorithm. [2+6]

10. Compute circular convolution of the following two sequences using DFT.x(n) = {1,2,4,5} and h (n) = {2,1,6,8} [6]

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# Examination Control Division

**2080 Baishakh**

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## *Subject:* - Digital Signal Analysis and Processing (*CT 704*)

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1. Check whether following signals are periodic or not. If yes, state their periodic time. [2+2]
   a) $x[n] = \mathrm{Sin}(n\pi) + \mathrm{Cos}\,(n\pi)$
   b) $x[n] = \mathrm{Sin}(3n\pi/5) + \mathrm{Cos}\,(4n\pi/7)$

2. Find the output of LTI system having impulse response $h[n] = (1/2)^{n} * u[n]$ and input $x[n] = 5e^{i\pi n/3}$ for $-\infty < n < \infty$. [5]

3. Define ROC. Find inverse z-transform of $X(z) = (1+2z^{-1}+z^{-2})/(1-1.5z^{-1}+0.5z^{-2})$, ROC : $|z|>1$. [1+5]

4. Differentiate between FIR system and IIR System. The poles of a system are located at $0.45 \pm j1.6$ and zeros at $0.58 \pm j2.06$. Map the poles and zeros in the z-plane and plot the magnitude response (not in scale) of the system. [4+6]

5. Compute Lattice-ladder coefficients and draw lattice structure for given system
   $H(z) = (2 - 0.7z^{-1} + 0.5z^{-2})/(1-0.3z^{-1} + 0.25z^{-2})$. [6]

6. Realize the given system in Cascade Form of 2nd order section flow graph representation.
   $H(z) = \{(1-0.4\ z^{-1})\ (1+0.2\ z^{-1})\ (1-0.3e^{j\pi/6}\ z^{-1})\ (1-0.3e^{-j\pi/6}\ z^{-1})\}/\{(1-0.5e^{j\pi/3}\ z^{-1})\ (1-0.5e^{j\pi/3}\ z^{-1})\ (1+0.7e^{j\pi/4}\ z^{-1})\ (1+0.7e^{-j\pi/4}\ z^{-1})\}$. [4]

7. In which case do we choose FIR filter and IIR filter? Design a linear phase FIR filter using Kaiser Window to meet the following specifications: [2+8]

   $0.99 \le |H(e^{jw})| \le 1.01$ for $0 \le w \ge 0.016\pi$

   $|H(e^{jw})| \le 0.01$ for $0.08\pi \le w \le 2\pi$

8. Explain in detail about how Gibb's oscillation arise while using the rectangular window in FIR filter design. [5]

9. Design a low pass digital IIR filter by Billinear Tranformation method to an approximate Butterworth low pass filter, if passband edge frequency is 0.26 π radians and maximum deviation of 0.99 dB below 0 dB gain in the passband. The maximum gain of -14.99 dB and frequency is 0.58π radians in stopband, Consider sampling frequency 0.5 Hz. [11]

10. Describe digital domain Spectral Transformation features and parameters for low pass to high pass in IIR Filter design. [4]

11. How fast is FFT? Find 8-point DFT of sequence x[n] = {1,1, 0, 0,1,1,2} using Decimation in Time Fast Fourier Transform(DITFFT) algorithm. [2+6]

12. Write the complexity of DFT and FFT? Obtain the circular convolution of the following sequences: [2+5]

    $X_1[n] = \{1, 2, 3, 1\}$ and

    $X_2[n] = \{4, 3, 2, 2\}$

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
**Examination Control Division**
**2079 Bhadra**

| Exam. | Regular | | |
|---|---|---|---|
| Level | BE | Full Marks | 80 |
| Programme | BEI, BCT | Pass Marks | 32 |
| Year / Part | IV / I | Time | 3 hrs. |

***Subject:*** - Digital Signal Analysis And Processing (*CT 704*)

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1. Define energy and power signal. Determine whether the signal $x[n] = \cos[\frac{2\pi n}{5}] + \sin[\frac{\pi n}{3}]$ is periodic or non-periodic and if it is periodic, find its fundamental period. [2+2]
2. Find the output of LTI system having input signal x[n] = δ[n]+2 δ[n-1]-δ[n-3] and h[n] =2δ[n+1] +2δ[n-1]. [5]
3. Find inverses Z-transform of X(z) = $(2z^4+2z^3-3z+2)/(z^2-1.5z-1)$, ROC: $|z|<0.5$, using partial fraction expansion method. [6]
4. Plot the pole-zero in z-plane and draw the magnitude response (not to the scale) of the equation of the system describe by difference equation:

   y [n] - 0.35y [n-1] + 0.25 y [n-2] = x [n] -0.75 x [n-1]. [3+7]
5. Draw direct form I and Direct form II realization of the following system. y [n] – 0.25 y[n-2] + x [n] + 0.4x [n-1] + 0.5x [n-2] [2+2]
6. Given a 3-stage lattice filter for all zero polynomial with coefficients $K_1 = 1/4$, $K_2 = 1/2$ and $K_3 = 1/3$. Obtain the system function and FIR filter coefficients of this filter. [6]
7. Define Gibb's phenomenon. Design the FIR filter using Kaiser window technique for the specifications: [2+8]

   $$0.899 \le |H(e^{jw})| \le 1 \qquad \text{for } |w| \le 0.2\pi$$

   $$|H(e^{jw})| \le 0.01 \qquad \text{for } 0.4\pi \le w \le \pi$$
8. Discuss the Remez exchange algorithm for FIR filter design. [5]
9. Design a low pass discrete time Butterworth filter using bilinear transformation having following specifications: [11+4]

   Passband frequency ($W_p$) = 0.25π radians
   Stopband frequency ($W_s$) = 0.55π radians
   Passband ripple ($\delta_P$) = 0.11
   Stopband ripple ($\delta_S$) = 0.21. Consider sampling frequency of 0.5 Hz.

   Also, covert the obtained digital low pass filter to high pass filter with new pass band frequency, $W'_P$ = 0.45π using digital domain transformation.
10. Why we need FFT? Find the 8-point DFT of the following sequence using radix-2 DITFFT algorithm. [2+6]
11. If $X_1$ (k) and $X_2$ (k) are DFT of sequence $x_1[n] = \{1, 0, 0, 1\}$ and $x_2[n] = \{2, 0, 2\}$ respectively then find the sequence $X_3[n]$; if DFT of $x_3[n]$ is given by $X_3$ (k) = $X_1$ (k). $X_2$ (k). [7]

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