GUJARAT TECHNOLOGICAL UNIVERSITY

BIO-MEDICAL ENGINEERING (03)
DIGITAL SIGNAL PROCESSING
SUBJECT CODE: 2150307
B.E. 5th SEMESTER

Type of course: Core

Prerequisite: Fourier series, Ordinary differential equations, system models: input output, description, Linear system concepts, Laplace transform.

Rationale: To prepare the students with basics of Signals and Systems, types of response of discrete time system, transform techniques to analyze discrete time system, realization of digital filters and designing of digital filters for various applications.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	30	0	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment; OEP-Open Ended problem; AL-Active learning;

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**INTRODUCTION OF SIGNALS SYSTEMS:** Size of a signal, Signal Operations, Classification of Signals, Some Useful Signal models, even and Odd Functions, Classification of Systems, Convolution, Correlation- auto correlation and cross correlation, Impulse response, Time Response analysis of Discrete time systems, Frequency Response analysis of Discrete time systems, Phase and group delays, Minimum Phase, Maximum Phase, Sampling, Aliasing, Anti aliasing filter, Reconstruction of signals.	**14**	25
2	**TRANSFORM DOMAIN TECHNIQUE:** **DISCRETE FOURIER TRANSFORM**: Representation of Periodic sequences: The discrete Fourier series, Properties of discrete Fourier Series, Fourier Transform of Periodic Signals, Sampling the Fourier Transform, The Discrete-Fourier Transform, Properties of DFT, Linear Convolution using DFT. **COMPUTATION OF DFT:** Goertzel Algorithm, Decimation-in-Time FFT Algorithms, Decimation-in-Frequency FFT Algorithm. **Z-TRANSFORM:** Region of convergence (ROC), Properties of the Z-Transform, Z-transform solution of linear difference equations, Frequency response from pole zero location.	**18**	25
3	**STRUCTURES FOR DIGITAL FILTERS:** Block Diagram representation of Linear Constant-Coefficient Difference equations, Basic Structures of IIR and FIR Systems- Direct, Canonic,	**10**	15

	Cascade and parallel, Transposed structures, Lattice structures.		
4	**DIGITAL FILTERS:** Ideal filters- Low pass, High pass, Band pass, Band stop, All pass filter, Analog filter approximation- Butter worth and Chebshew, Comparision between Butterworth and Chebyshev Filter, Frequency Transformation in Analog Domain and digital domain. **DESIGN OF IIR FILTERS FROM ANALOG FILTERS:** Approximation of Derivatives, impulse invariance technique, bilinear transformation, matched z-transform, Mapping between S-plane and Z-plane. **DESIGN OF FIR FILTERS:** Linear phase FIR filter and its frequency response, Design of FIR filters using windows - Rectangular, Triangular or Bartlett, Hanning, Hamming, Blackman, Kaiser, Frequency sampling method, Optimum Equiripple Approximation. Comparison between IIR and FIR filter, Adaptive filters, Finite word length effect in digital filters . **APPLICATIONS OF DIGITAL FILERS FOR BIOMEDICAL SIGNALS**: Removal of noise and periodic events using different IIR and FIR filters, Motion artifacts from ECG signal, Removal of baseline drift in ECG using digital filters, QRS Detection, Detection of Alpha, Beta and Gamma wave, Arrhythmia detection algorithms, Heart rate variability analysis.	**18**	35

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15%	**30%**	**20%**	**25%**	**10%**	-

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Digital Signal Processing By N. G. Palan
2. Digital Signal Processing: Principles, Algorithm & Application, Proakis, Manolakis.
3. Discrete Time Signal Processing: Oppeheim, Schafer, Buck Pearson education publication.
4. Digital Signal Processing: A Computer Based approach, Sanjit Mitra, McGrawHill.
5. Digital signal processing: P. Ramesh Babu.
6. Principles of linear systems and signals: B.P. Lathi.
7. Biomedical signal processing: Principles and Techniques, D C Reddy.
8. Biomedical Digital Signal Processing, Willis J. Tompkins.
9. Biomedical signal processing, N. Vyas.

Course Outcome:

After learning the course the students should be able to:

1. Analyze the time and frequency response of discrete time systems.
2. Design the digital filters for various applications such as speech processing, communication, biomedical signal processing, etc.
3. Realize the digital filters transfer function into digital filter structures.

4. Design algorithms for ECG, EEG, EMG, Heart rate variability, Arrhythmia detection.

List of Experiments: (Outlines)

1. To generate common periodic and Aperiodic waveforms.
2. To implement convolution, correlation and linear filtering of sequences.
3. To plot the impulse response and step response of discrete time system.
4. To plot the frequency response of discrete time system.
5. To compute the DFT and IDFT of the sequence and plot the magnitude and phase response.
6. To compute z-transform of discrete time system equation.
7. To design IIR filters.
8. To design FIR filters.
9. To design algorithms for QRS detection.
10. To design algorithms for EEG analysis.
11. To design algorithms for Arrhythmia detection.

Design based Problems (DP)/Open Ended Problem:

To design digital filters for biomedical signals processing.

Major Equipment:

MATLAB/SCILAB, NI LABVIEW software

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.