GUJARAT TECHNOLOGICAL UNIVERSITY

POWER ELECTRONICS (29)
DISCRETE TIME SIGNAL PROCESSING
SUBJECT CODE: 2712910
SEMESTER: I

Type of course: Discrete Time Signal Processing

Prerequisite: Engineering Mathematics, Fundamental knowledge of signals and systems, Mathematical representation of signals and system , modeling in time as well as frequency domain. Transforms like Laplacian, Fourier and Z. Difference between basic analysis and synthesis procedure

Rationale: PG Students of Power Electronics Engineering need to possess good understanding of the fundamentals and applications of discrete-time signals and systems, including sampling, convolution, filtering, and Discrete Fourier Transforms. They are expected to design digital filters using the Discrete Fourier Transform. They will be practiced in sampling, processing and on other signals using MATLAB software running on PCs , this includes both the analysis and synthesis

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	PA (V)		PA (I)		
						ESE	OEP	PA	RP	
3	2	2	5	70	30	20	10	20	0	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**Discrete Time Signals:** Sequences & systems, Convolution & Correlation, linear time invariant systems & their properties, Difference equations. Frequency domain representations of discrete time signals & systems. DTFT & its properties.	6	14
2	**Sampling of Continuous Time Signals:** Periodic Sampling, Sampling Theorem, Frequency domain representation of sampling, reconstruction of a band-limited signal from its samples, discrete time processing of continuous time signals, continuous time processing of discrete time signals, changing the sampling rate using discrete time processing ,aliasing & its remedies.	6	14
3	**Z-Transform and Analysis of LTI System** Properties, properties of ROC for the Z-transform, inverse Z-transform, unilateral Z-transform. Frequency response of LTI systems, systems functions frequency response for rational system functions, relationship between magnitude & single-phase , All-pass systems, Minimum phase system.	7	18
4	**Structures Of Discrete Time Systems:** Signal flow graph representation of linear constant coefficient difference equation. Basic structures of FIR & IIR systems. Design of FIR filters by windowing; Kaiser window. Design of IIR filters from continuous time filter.	8	18

5	**Discrete Fourier Transform:** Discrete Fourier Series & its Properties, Fourier Transform of Periodic Signal, DFT & its properties, Linear convolution using DFT, Decimation in time FFT algorithm, Decimation in frequency FFT algorithm.	8	20
6	**Digital Signal Processor:** General and Special purpose digital signal processors, DSP architectures & applications, selection criteria, Implementation of DSP algorithms.	7	16

Reference Books:

1. Discrete-Time Signal Processing – Alan V. Oppenheim & Ronald W. Schafer & Buck PHI, Pvt., Ltd., New Delhi.
2. Digital Signal Processing, Proakis & Monolakis , PHI
3. Theory & Application of Digital Signal Processing – L. R. Rabiner & B. Gold, PHI.
4. Data Books and Application Notes of DSP chip from Manufacturers.
5. Digital Signal processing, Sanjit Mitra, McGraw-Hill Science/Engineering/Math;
6. Digital Signal Processing by Emmanuel C.Ifeachor & Barrie W.Jervis, Pearson Edu.
7. Digital Signal Processing in Power Electronics Control Circuits by Sozanski K., Springer.
8. Digital Signal Processing using MATLAB, Vinay K. Ingle & John Proakis, Thomson

Course Outcome:

After learning the course the students should be able to:

1. To Analyze and implement digital signal processing systems in time domain.
2. To Compute the Fourier series and DTFT of Discrete time signal.
3. To Analyze digital signal processing systems using Z-transform and the DTFT.
4. To Design frequency-selective digital filters.
5. To Design digital filters using windows.
6. To Sample and reconstruct analog signals.
7. To Compute circular convolution & DFT of discrete-time signals.
8. To Analyze and implement digital systems using the DFT and the FFT.
9. To Use MATLAB for DSP system analysis and design.

List of Experiments: (with Open Ended Problems)

1. To generate and plot the basic sequences.
2. To observe the effect of Signal Addition, Signal Multiplication, Scaling, Shifting, Folding on sequences.
3. Generate and plot the following sequences
   i) $x(n) = 2\delta(n+2) - \delta(n-4)$; $-5 \leq n \leq 5$.
   ii) $x(n) = \{ \ldots.5,4,3,2,1, \underline{\mathbf{5}},4,3,2,1, 5,4,3,2,1\ldots\}$
   iii) $x(n) = n[u(n) – u(n-10)] + 10\, e^{-0.3(n-10)} [u(n-10) – u(n-20)]$; $0 \leq n \leq 15$
4. If $x(n) = \{ \underline{\mathbf{1}},2,3,4,5,6, 5,4,3,2,1 \}$. Determine and plot the following sequence $y(n) = 2\, x(n-5) - 3x(n+4)$.
5. Generate the complex valued signal. Plot its magnitude, phase, the real part and the imaginary part in four separate subplots.
6. Determine the convolution $y(n) = x(n)^* h(n)$.
7. For the following difference equation. $y(n) – y(n-1) + 0.9\, y(n-2) = x(n)$; Calculate and plot the step response at u(n) at n = -20, ……60.
8. For $x(n) = \{ \underline{\mathbf{1,}} 0,-1,1,2,1\}$, $h(n) = \{\underline{\mathbf{1}}, 1,1 ,1,1\}$; determine and plot co-relation.

9. Determine DTFT of $x(n) = (0.5)^n u(n)$. Evaluate $X(e^{jw})$ between $[0, \pi]$ and plot its magnitude, angle, real and imaginary parts.
10. Determine DTFT of the following finite duration sequence
    $x(n) = \{ 1, \underline{\mathbf{2}}, 3,4,5\}$. Compute DTFT of sequence x(n) between $[0, \pi]$.
11. If $x(n) = = (-0.75)^n : -5 \leq n \leq 5$. Verify the conjugate symmetry properties of its Discrete Time Fourier Transform.
12. Determine the frequency response $H(e^{jw})$ of a system characterized by $h(n) = (0.5)^n u(n)$. Plot the magnitude and phase response.
13. Let $x_1(n)$ and $x_2(n)$ be two random sequences uniformly distributed between [0,1] over $0 \leq n \leq 20$. Verify the following property of DTFT:
    i) Linearity property.
    ii) Time shifting property
14. Find out Auto -Correlation R_{xx} of the sequence.
15. Plot the magnitude v/s frequency and phase v/s frequency for
    unit step function
    $a^n u(n)$
    $\cos(w_o n) u(n)$.
16. For a unit step function x(n)

    Determine X(z) and sketch its pole-zero plot.
    Plot its magnitude and phase response

17. Compute the z- transform & inverse z- transform
18. Given causal system $y(n) = 0.8\, y(n-1) + x(n)$;
    Determine H(z) and sketch its pole-zero plot.
    Plot its magnitude and phase response.
    Also, determine the impulse response

Major Equipments:

Digital Storage Oscilloscopes, Circuit Simulation Tools: open source software to simulate power electronic converter circuits, Basic equipment for measurement, Different loads: R, RL, and Motors etc.

List of Open Source Software/learning website:

http://nptel.iitm.ac.in/coursecontents_elec.php