GUJARAT TECHNOLOGICAL UNIVERSITY

Advanced Digital Signal Processing
SUBJECT CODE: 3710501
ME 1st Semester

Type of course: Advanced Statistical ,Adaptive and Multirate Signal Processing

Prerequisite: Higher Engineering Mathematics, Digital Filter Structure and Design, Estimation and Linear Prediction, Estimation of spectra from finite duration signals, Periodogram, Nonparametric and Parametric methods and model based spectral estimation**.**

Rationale: PG Students of EC Engineering need to possess good understanding of the fundamentals and applications of Digital filters, predictive filters,Adaptive systems and multirate DSP including estimation theory and random variables for implementing changing real world into DSP system. They are expected to be able to design Adaptive Digital filters and process real world signals as per desired communication applications. They will be guided in designing Adaptive Filters using various Algorithms using MATLAB/Scilab/CCS software.

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)	
3	0	2	4	70	30	30	20	150

Content:

Sr.No.	Course Content	Teaching hours	Module weightage
1	**Overview of DSP**:Characterization in time and frequency **Digital filter design and structures**: Basic, Cascaded, lattice FIR/IIR filter structures, Frequency sampling structures of FIR systems ,lattice-ladder structures, parallel realization of IIR systems. design techniques of FIR filters,Design of IIR filters from analog filters by approximations of derivatives ,impulse invariance, bilinear transformation methods	**09**	**20%**
2	**RandomSignals :**Random Processes- Stationary Random processes, discrete time random signals,Estimation,Linear Systems with Stationary Random Inputs, Whitening and Innovations Representation,Special types of Random Processes: AR,MA ,ARMA processes ,Yule-Walker equations	**06**	**05%**
3	**Linear prediction & optimum linear filters:** Linear prediction: Forward and Backward linear prediction, filters,solution of normal equations, Properties of the Linear Prediction error filters,AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction-FIR and IIR Wiener filter ,Noncausal IIR filter, Kalman Filter	**10**	**15%**

4	**Adaptive Filters:** Introduction to Adaptive System, Adaptive Linear Combiner, Properties of Quadratic Performance Surface, Searching the Performance Surface, Gradient Estimation and its Effect on Adaptation, Method of Steepest Descent, LMS Algorithm, RLS Algorithms. Applications of adaptive filters : System Modelling,Channel equalization, Echo Cancellation,Narrowband interference,Adaptive Array	**10**	**30%**
5	**Multi rate DSP** :Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, CIC filters,QMF, digital filter banks, Applications in subband coding.	**08**	**20%**
6	**Application of DSP & Multi rate DSP**: Application to Radar, Introduction to wavelets, application to image processing, DSP in speech processing & other applications	**05**	**10%**

Reference Books:

1. J.G.Proakis and D.G.Manolakis"Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Prentice Hall, 2007.
2. Stearns, Bernard Widrow and Samuel Stearns, " Adaptive Signal Processing "
3. N. J. Fliege, "Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets", 1st Edition, John Wiley and Sons Ltd, 1999.
4. Li Tian,Digital Signal Processing Fundamentals and Applications Elsevier 2nd Edition
5. S.K. Mitra - Digital Signal Processing: A computer based approach, TMH, 2001
6. P.P. Vaidyanathan, Multirate systems and Filter banks, Pearson,1996
7. Bruce W. Suter, "Multirate and Wavelet Signal Processing",1st Edition, Academic Press, 1997.
8. M. H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley & Sons Inc., 2002.
9. S.Haykin, "Adaptive Filter Theory", 4th Edition, Prentice Hall, 2001.
10. D.G.Manolakis,V.K. Ingle and S.M.Kogon, "Statistical and Adaptive Signal Processing", McGraw Hill, 2000

Course Outcomes:

At the end of this course, students will be able to

- Design different digital filters in software
- Apply various transforms in time and frequency
- Perform decimation and interpolation To understand theory of different filters and algorithms
- Study Random Variables and random process
- Understand theory of multirate DSP, solve numerical problems and write algorithms
- Understand theory of linear prediction and solution of normal equations
- Use MATLAB and C language for adaptive system Analysis and design
- Study and Design Adaptive System for various applications.
- Analyse the applications of DSP at block level.

Tutorials/Teacher Guided Student Activity:

- As a part of this activity students can perform following activities.

- Refer scholarly articles from well known journal/conferences such as IEEE, ELSEVIER, and SPRINGER etc
- Student can be assigned topics for seminars on some research topics.
- Perform practicals using MATLAB/SCILAB

- Basic Signal Representation
- Correlation Auto And Cross
- Determine Mean, Mean Square, variance of a random process
- Sampling FFT Of Input Sequence
- Butterworth Low pass And High pass Filter Design
- Chebychev Type I,II Filter
- FIR filter design
- State Space Matrix from Differential Equation
- Implement system function of forward and backward prediction filters.
- Normal Equation Using Levinson Durbin
- Implement lattice structure and system function for AR, MA, ARMA process.
- Write a MATLAB program for Wiener-Hopf equation.
- Implement comb filter and CIC filter.
- Implement LMS and RLS algorithm.
- Decimation And Interpolation Using Rationale Factors
- Maximally Decimated Analysis DFT Filter
- Cascade Digital IIR Filter Realization
- Convolution And M Fold Decimation &PSD Estimator
- Estimation Of PSD
- Separation (Decomposition) Of System Function
- Parallel Realization of IIR filter

Major Equipments: PC with MATLAB and CCS, Digital Storage Oscilloscope, DSP Processor Kit TMS X 6713

List of Open Source Software/ Learning website:

1. Scilab (software)
2. www.nptel.ac.in