STATISTICAL SIGNAL PROCESSING

(Elective Subject)

Course Code:	**13M1WEC431**	**Semester:**	**4th Semester, M. Tech. (ECE)**
Credits:	**3**	**Contact Hours:**	**L-3, T-0,P-0**

Pre-requisites: Signals & Systems, Digital Signal Processing

Course Objectives:

The objective of this course to provides well understanding of

1. The random signals, random process and their statistical properties
2. Spectral methods signal analysis
3. Weiner filtering and adaptive filetring of the signals

Course Outcomes

At the end of the Statistical Signal Processing course, a student should be able to:

1. Comprehend the random variable random process and statistical feature of random signals.
2. Analyze and understand the modeling styles or methods of the random signals.
3. Analyze and understand the FIR , IIR Wiener filtering, and Kalman filtering.
4. Analyze and understand the various power spectral estimation methods of the statistical signals.
5. Understand the least mean square (LMS), Recursive least square, and others adaptive filtering methods.

Course Contents :

Unit	Topics	Text book	Lectures
1	**DISCRETE-TIME RANDOM PROCESSES** **Random Variables**: Ensemble Averages , Jointly Distributed Random Variables, Joint Moments, Independent, Uncorrelated and Orthogonal Random Variables, Linear Mean Square Estimation, Gaussian Random Variables, Parameter Estimation: Bias and Consistency, **Random Processes:** Ensemble Averages, Gaussian Processes, Stationary Processes, The Autocovariance and Autocorrelation Matrices, Ergodicity White Noise, The Power Spectrum **Filtering Random Processes**: Spectral Factorization, Special Types of Random Processes , Autoregressive Moving Average Processes ,Autoregressive Processes, Moving Average Processes, sHarmonic Processes	[1]	**10**
2	**SIGNAL MODELING** The Least Squares (Direct) Method, The Pade Approximation, **Prony's Method:** Pole-Zero Modeling , Shanks' Method, All-Pole Modeling, Linear Prediction, Application: FIR Least Squares	[1]	**06**

	Inverse Filters Iterative Prefiltering, **Finite Data Records**: The Autocorrelation Method,The Covariance Method, **Stochastic Models:** Autoregressive Moving Average Models, Autoregressive Models, Moving Average Models, Application : Power Spectrum Estimation		
3	**WIENER FILTERING** The FIR Wiener Filter: Filtering, Linear Prediction, Noise Cancellation, Lattice Representation for the FIR Wiener Filter The IIR Wiener Filter: Noncausal IIR Wiener Filter , The Causal IIR Wiener Filter, Causal Wiener Filtering , Causal Linear Prediction, Wiener Deconvolution , Discrete Kalman Filter	[1] & [2]	**08**
4	**SPECTRUM ESTIMATION** **Nonparametric Methods:** The Periodogram, Performance of the Periodogram, The Modified Periodogram, Bartlett's Method Welch's Method, Blackman-Tukey Approach Performance Comparisons **Minimum Variance Spectrum Estimation**, **The Maximum Entropy Method,** **Parametric Methods**: Autoregressive Spectrum Estimation, Moving Average Spectrum Estimation, Autoregressive Moving Average Spectrum Estimation: **Frequency Estimation**: Eigendecomposition of the Autocorrelation Matrix, Pisarenko Harmonic Decomposition MUSIC, Other Eigenvector Methods **Principal Components Spectrum Estimation**: Bartlett Frequency Estimation, Minimum Variance Frequency Estimation, Autoregressive Frequency Estimation	[1],& [2]	**10**
5.	**ADAPTIVE FILTERING** **FIR Adaptive Filters** :The Steepest Descent Adaptive Filter, The LMS Algorithm, Convergence of the LMS Algorithm , Normalized LMS, Application : Noise Cancellation, Other LMS-Based Adaptive Filters, Gradient Adaptive Lattice Filter, Joint Process Estimator, Application : Channel Equalization , **Adaptive Recursive Filters** ,**Recursive Least Squares**: Exponentially Weighted RLS, Sliding Window RLS ,	[2], & [1]	**08**
	Total Lecture Hours		**42**

Evaluation Scheme

1. Test 1 : 15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
    1. 10 Marks : Class performance, Tutorials & Assignments
    2. 10 Marks : Quizzes
    3. 5 marks : Attendance

Text Books

1. Hayes, M.H.,"Statistical digital signal processing and modeling" Willey publishers
2. Proakis, John G. Digital signal processing: principles algorithms and

applications. Pearson Education India.
3. P.Stoica,and Randolph Moses "Spectral analysis of signals " PHI, Publishers

Reference Book

1. Oppenheim, Alan V., Ronald W. Schafer, and John R. Buck. Discrete-time signal processing, 2nd edition, Pearson Education.
2. Mitra, Sanjit Kumar, and Yonghong Kuo. Digital signal processing: a computer- based approach, 2nd edition, Tata McGraw-Hill.
3. Mitra, Sanjit Kumar, and Yonghong Kuo. Digital signal processing, 3rd edition, Tata McGraw-Hill.