SPECTRAL ANALYSIS FOR SIGNAL PROCESSING

(Elective Subject)

Course Code:	**16B1WEC832**	**Semester:**	**8th Semester, B. 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 the spectral methods for signal processing

Course Outcomes

After the study of this course students will be able to:

1. Understand the spectral analysis of the signals.
2. Understand the basics difference between parametric and non-parametric methods of spectral analysis.
3. Familiar with the basics concept of filter bank method for spectral analysis.
4. Understand the basic concept of the spatial methods for spectral analysis of signals.

Course Contents :

Unit	Topics	Text book	Lectures
1	**Basic Concepts** Introduction, Energy Spectral Density of Deterministic Signals, Power Spectral Density of Random Signals, First Definition of Power Spectral Density, Second Definition of Power Spectral Density, Properties of Power Spectral Densities, The Spectral Estimation Problem	[1]&[2]	**06**
2	**Nonparametric Methods** Introduction ,Periodogram and Correlogram Methods, Periodogram ,Correlogram , Periodogram Computation via FFT Radix–2 FFT , Zero Padding , Properties of the Periodogram Method, Bias Analysis of the Periodogram ,Variance Analysis of the Periodogram ,The Blackman–Tukey Method ,The Blackman–Tukey Spectral Estimate, Non negativeness of the Blackman–Tukey Spectral Estimate, Window Design Considerations, Time–Bandwidth Product and Resolution–Variance Tradeoffs in Window Design, Some Common Lag Windows, Window Design Example,Temporal Windows and Lag Windows ,Other Refined Periodogram Methods ,Bartlett Method, Welch Method, Daniell Method,Sample Covariance Computation via FFT, FFT–Based Computation of Windowed Blackman–Tukey Periodograms,Data and Frequency Dependent Temporal Windows: The Apodization Approach	[1] & [3]	**08**

3	**Parametric Methods** Introduction, Signals with Rational Spectra ,Covariance Structure of ARMA Processes ,AR Signals,Yule–Walker Method ,Least Squares Method,Order–Recursive Solutions to the Yule–Walker Equations,Levinson–Durbin Algorithm,Delsarte–Genin Algorithm MA Signals ,ARMA Signals ,Modified Yule–Walker Method ,Two–Stage Least Squares Method ,Multivariate ARMA Signals ,ARMA State–Space Equations ,Subspace Parameter Estimation — Theoretical Aspects ,Subspace Parameter Estimation — Implementation Aspects ,Some Properties of Covariance ,The Burg Method for AR Parameter Estimation , Models of Sinusoidal Signals in Noise, Nonlinear Regression Model ARMA Model, Covariance Matrix Model , Nonlinear Least Squares Method , High–Order Yule–Walker Method, Pisarenko and MUSIC Methods Min–Norm Method, ESPRIT Method , Forward–Backward Approach , Mean Square Convergence of Sample Covariance's for Line Spectral Processes, The Carath´eodory Parameterization of a Covariance Matrix , Using the Unwindowed Periodogram for Sine Wave Detection in White Noise , NLS Frequency Estimation for a Sinusoidal Signal with Time Varying Amplitude, Monotonically Descending Techniques for Function Minimization, Frequency-selective ESPRIT-based Method , A Useful Result for Two-dimensional (2D) Sinusoidal Signals	[1],& [3]	**12**
4	**Filter Bank Methods** Introduction, Filter Bank Interpretation of the Periodogram , Refined Filter Bank Method, Slepian Baseband Filters , RFB Method for High–Resolution Spectral Analysis , RFB Method for Statistically Stable Spectral Analysis , Capon Method , Derivation of the Capon Method , Relationship between Capon and AR Methods , Filter Bank Reinterpretation of the Periodogram , Another Relationship between the Capon and AR Methods, Multiwindow Interpretation of Daniell and Blackman–Tukey Periodograms, Capon Method for Exponentially Damped Sinusoidal Signals, Amplitude and Phase Estimation Method (APES), Amplitude and Phase Estimation Method for Gapped Data (GAPES), Extensions of Filter Bank Approaches to Two–Dimensional Signals	[3], & [1]	**08**
5	**Spatial Methods** Introduction, Array Model, The Modulation–Transmission–Demodulation Process, Derivation of the Model Equation, Nonparametric Methods, Beam forming , Capon Method, Nonlinear Least Squares Method, Yule–Walker Method, Pisarenko and MUSIC Methods, Min–Norm Method, ESPRIT Method , On the Minimum Norm Constraint, NLS Direction-of-Arrival Estimation for a Constant-Modulus Signal ,Capon Method: Further Insights and Derivations, Capon Method for Uncertain Direction Vectors , Capon Method with Noise Gain Constraint , Spatial Amplitude and Phase Estimation (APES), The CLEAN Algorithm, Unstructured and Persymmetric ML Estimates of the Covariance Matrix	[3]	**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.
4. M. Vetterli, J. Kovacevic, and V. K. Goyal, Fourier and Wavelet Signal rocessing. Booksite: **http://fourierandwavelets.org/terms.php**