Course Code	Course Title	L	T	P	C
1152EC132	STATISTICAL SIGNAL PROCESSING	2	2	0	3

a) Course Category

Program Elective

b) Preamble

This course provides an introduction to random variables, parameter estimation in presence of noise and the different types of optimum filtering algorithms based on the probabilistic and stochastic processes. It also covers signal modeling, adaptive filtering & its applications

c)Prerequisite

Discrete Time Signal Processing

d) Related Courses

Signal Processing Techniques for Speech Recognition

e) Course Outcomes

On successful completion of the course, the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain basic constituents of a random variables	K2
CO2	Describe the concepts related to Parameter Estimation techniques	K2
CO3	Apply the LMMSE and Wiener filtering techniques	K3
CO4	Explain the importance of lattice filters and linear prediction	K2
CO5	Explain the appropriate adaptive filtering techniques	K2

f) Correlation of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	H	M	-	-	-	-	-	-	L	-	-
CO2	H	H	-	M	M	-	-	-	-	-	-	L	-	-
CO3	H	H	M	L	M	-	-	-	-	-	-	L	L	-
CO4	H	M	L	L	M	-	-	-	-	-	-	L	-	-
CO5	H	H	H	L	H	-	-	-	L	-	-	L	L	-

g) Course Content

UNIT I REVIEW OF RANDOM VARIABLES 12

Basic introduction to random variables, Spectral representation of random signals, Wiener Khinchine theorem, Properties of power spectral density, Gaussian Process and White noise process, Linear System with random input, Spectral factorization theorem and its importance, Innovation process and Whitening filter, Random signal modelling: MA, AR, ARMA models.

UNIT II PARAMETER ESTIMATION THEORY 12

Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE), Cramer-Rao bound, Efficient estimators; Criteria of estimation: the methods of maximum likelihood and its properties; Bayesian estimation: Mean square error and MMSE, Mean Absolute error, Hit and Miss cost function and MAP estimation.

UNIT III GAUSSIAN NOISE SIGNAL ESTIMATION 12

Linear Minimum Mean-Square Error (LMMSE) Filtering: Wiener Hoff Equation, FIR Wiener filter – Filtering, Linear Prediction, Noise Cancellation, Lattice Representation for the FIR Wiener Filter, IIR Weiner Filter - Causal IIR Wiener filter, Non-causal IIR Wiener filter, Wiener Deconvolution, Causal Linear Prediction.

UNIT IV LEVINSON RECURSION AND LATTICE FILTERS 12

Linear Prediction of Signals, Forward and Backward Predictions, Levinson Durbin Algorithm, Levinson Recursion, FIR Lattice filter, Split Lattice filter, IIR Lattice filter, Lattice Methods for All-pole signal modelling, Stochastic modelling

UNIT V ADAPTIVE FILTERING ALGORITHMS12

Principle and Application, Steepest Descent Algorithm, Convergence characteristics: LMS algorithm, Convergence, Excess mean square error, Leaky LMS algorithm, Application of Adaptive filters, RLS algorithm, Derivation, Matrix inversion Lemma, Initialization, Tracking of non-stationarity

Total 60 Hrs

h) Learning Resources

Text Books

1. Monson H.Hayes, “Statistical Digital Signal Processing and Modeling,” John Wiley & Sons, 2008.
2. H. Stark and J. Woods, “Probability and Random Processes with Applications to SignalProcessing”, 3rd edition, Pearson Education, 2001.
3. S. M. Kay, “Fundamentals of Statistical Signal Processing”, 1st edition, Volume 1, Prentice Hall, 1993

Reference Books

1. John G. Proakis “Algorithms for Statistical Signal Processing”, Pearson Education Education, 2002.
2. DimitrisG.Manolakis “Statistical and Adaptive Signal Processing”, Tata McGraw Hill, 2000.
3. Papoulis and S. Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", Fourth Edition, McGraw Hill, 2002.

Online Resources

1. https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/video-lectures/
2. http://www.nptel.ac.in/syllabus/117103019