ECEXXXX: PRINCIPLES OF SIGNAL ESTIMATION FOR WIRELESS COMMUNICATION

Department of Electronics and Communication Engineering — The LNMIIT, Jaipur

Programme: PhD | **Year:** 1st | **Semester:** Odd
Course: Program Elective | **Credits:** 3 or 4 | **Hours:** 40

Course Context and Overview (100 words):

Signal estimation theory provides a wide variety of tools and techniques, which form the fundamental basis for several key applications in modern wireless communications. The field of wireless communications has grown dramatically and witnessed revolutionary technology developments in the last decade. Data rate from a slow 10 Kbps to very fast 100 Mbps in wireless communication in last ten years is only possible with the support of signal estimation and signal processing approaches. These have subsequently led to the development of latest generation wireless technologies such as HSDPA (High Speed Downlink Packet Access), LTE (Long Term Evolution) and WiMAX (Worldwide Interoperability for Microwave Access). This course will present an elaborate introduction to the principles and performance of required fundamental for these wireless technologies.

Prerequisites Courses: Engineering Mathematics

Course outcomes (COs):

On completion of this course, the students will have the ability to:
CO1: understand basics of estimation theory for wireless communication.
CO2: know how to model Cramer Rao Bound (CRB) for Parameter Estimation while taking example of wireless sensor networks as well as wireless communication systems.
CO3: understand channel equalization and Orthogonal Frequency Division Multiplexing systems.
CO4: design, implement and simulate practical estimation algorithms to solve the various wireless communication problems.

Course Topics:

Topics	**Lecture Hours**	
UNIT-I: Fundamentals of Estimation Theory and Vector Estimation	10	10
Basics of Estimation, Maximum Likelihood (ML), Sensor Network and Noisy Observation Model, Likelihood Function and Maximum Likelihood Estimate. Properties of Maximum Likelihood Estimate: Mean and Unbiasedness, Variance and Spread Around Mean, Reliability of the Maximum Likelihood Estimate, Number of Samples Required.	5	
Estimation of Complex Parameters – Symmetric Zero Mean Complex Gaussian Noise, Wireless Fading Channel Estimation – Pilot Symbols and Likelihood Function, Wireless Fading Channel Estimation – Pilot Training based Maximum Likelihood ML Estimate, Wireless Fading Channel Estimation – Mean and Variance of Pilot Training Based Maximum Likelihood, Wireless Fading Channel Estimation for Downlink Mobile Communication.	5	
UNIT-II: Cramer Rao Bound and Least Square Principle	10	10

Cramer Rao Bound (CRB) for Parameter Estimation, Cramer Rao Bound Example – Wireless Sensor Network, Vector Parameter Estimation – System Model for Multi Antenna Downlink Channel Estimation, Likelihood Function and Least Squares Cost Function for Vector Parameter Estimation, Least Squares Cost Function for Vector Parameter Estimation Vector Derivative Gradient.	5	
Least Squares Solution Maximum Likelihood Estimate Pseudo Inverse, Properties of Least Squares Estimate – Mean Covariance and Distribution, Least Squares Multi Antenna Downlink Maximum Likelihood Channel Estimation, Multiple Input Multiple Output MIMO Channel Estimation – Least Squares Maximum Likelihood ML, Example – Least Squares Multiple Input Multiple Output MIMO Channel Estimation.	5	
UNIT-III: Channel Equalization and Introduction to OFDM	12	12
Channel Equalization and Inter Symbol Interference ISI Model, Least Squares based Zero Forcing Channel Equalizer, Example of ISI Channel and Least Squares based Zero Forcing, Equalization and Approximation Error for Zero Forcing Channel Equalizer, Example Equalization and Approximation Error for Zero Forcing Channel Equalizer.	5	
Introduction to Orthogonal Frequency Division Multiplexing (OFDM) – Cyclic Prefix CP and Circular Convolution, Introduction to Orthogonal Frequency Division Multiplexing OFDM – FFT at Receiver and Flat Fading, Channel Estimation Across Each Subcarrier in Orthogonal Frequency Division Multiplexing OFDM, Example Orthogonal Frequency Division Mulltiplexing OFDM – Transmission of Samples with Cyclic Prefix, Example Orthogonal Frequency Division Mulltiplexing OFDM – FFT at Receiver and Channel Estimation.	7	
UNIT-IV: OFDM Transmission and Its Application	8	8
Comb Type Pilot (CTP) Based Orthogonal Frequency Division Multiplexing OFDM Channel Estimation, CTP Based OFDM Channel Estimation Example, Frequency Domain Equalization (FDE) for Inter Symbol Interference (ISI) Removal in Wireless System.	4	
Introduction to Sequential Estimation – Application in Wireless Channel Estimation, Wireless Channel Coefficient – Estimate and Variance Update Equation.	4	

Text Books:

A. Jagannatham, Principles of Modern Wireless Communications Systems, McGraw Hill Education.

Reference books:

Young Soo Cho, MIMO OFDM Wireless Communication with MATLAB, Wiley.

https://nptel.ac.in/courses/117/104/117104118/

Evaluation Method:

Item	Units	Weightage (%)
Assignment	1 and 2	10
Term Paper	1 and 2	20
Assignment	3 and 4	10
Project Work	All	10
End Term	All	50

Updated By: Santosh Shah (09/09/2020)