

# Fundamentals of MIMO Systems

(Core Subject)

<b>Course Code:</b>	12M1WEC432	<b>Semester:</b>	4 <sup>th</sup> Sem. M. Tech (ECE)/DD
<b>Credits:</b>	3	<b>Contact Hours:</b>	L-3, T-0, P-0

## Course Objectives

The main objective of the course is to

1. To make students familiar with fundamentals of wireless communication systems.
2. To understand the diversity and spatial multiplexing phenomenon in MIMO system.
3. To understand the receiver system design for MIMO.
4. To become familiar with OFDM and MIMO-OFDM systems.

## Course Outcomes

After studying this course the students would gain enough knowledge of

1. Emerging issues for implementing MIMO wireless channels.
2. Different fading channel distributions in multipath wireless channel.
3. OSTBC design for multiple antenna system.
4. Computation of performance parameters of MIMO wireless system.

## Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	Overview of Probability and Stochastic Processes: Probability distributions, Statistical averages and Random variables, Binomial distribution, Chi-square distribution, Rayleigh distribution, Rice distribution, Nakagami m-distribution, Central limit theorem, etc.	Haykin: Chapter 8	2
2.	Overview of Wireless Channel and Fading: Multi-path and Time-varying channel impulse response, Inter-Symbol-Interference, Narrowband fading, Envelope and power distribution, Level-crossing Rate and Average fading duration, Wideband fading, slow and fast-fading, Delay Spread and Coherence Bandwidth, Doppler Spread and Channel Coherence Time, Rayleigh fading, Rician fading, m-Nakagami fading	Goldsmith: Chapter 3	5
3	MIMO-I: Diversity: Temporal diversity, Frequency diversity, Spatial diversity, Multiplexing gain, Diversity gain, Analysis of receiver diversity, Combining schemes :	Goldsmith: Chapter 7, Kshetrimayum: Chapter 1	8

	Selection, Threshold, Maximal ratio, Equal gain, Transmitter diversity: with and without channel state information, Alamouti scheme, Diversity Analysis		
4	MIMO-II: Principles: Multi-antenna system and its advantages, MIMO channel and signal model, MIMO channel capacity, MIMO system model, Analysis of BER of multiple antenna system with diversity, Zero-forcing receiver; drawbacks, MIMO-MMSE receiver; properties and advantages	Goldsmith: Chapter 7, 10, Kshetrimayum: Chapter 3,5	8
5	MIMO-III: Multiplexing Architectures: Decomposition of MIMO channel; Singular value decomposition (SVD), Optimal MIMO power allocation, MIMO system capacity, Transmit beamforming, Orthogonal space-time code (OSTBC), Alamouti code, Non-linear MIMO receiver; V-BLAST; SIC, MIMO beamforming; maximal ratio transmission.	Kshetrimayum: Chapter 7,8, 9, 10	9
6	Orthogonal Frequency Division Multiplexing (OFDM): Multicarrier modulation (MCM); schematic; detection, Comparison of single carrier and multicarrier transmission, bottleneck in MCM, OFDM schematic and cyclic prefix, Loss in efficiency, Frequency offset in OFDM; ICI, Peak to average power ratio (PAPR) in OFDM, Single-carrier (SC)- FDMA; schematic, subcarrier mapping, BER performance of OFDM. MIMO-OFDM; schematic.	Goldsmith: Chapter 12	5
7	Applications of MIMO and OFDM: Long term evolution (LTE) and WiMAX; features, OFDMA, Channel dependent scheduling, Resource allocation, Puncturing, H-ARQ, Frequency shift transmit diversity, Network architecture, frame structure, Protocol stack	Kshetrimayum: Chapter 4, 12	5
<b>Total Number of Lectures</b>			42

## Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks

- 10 Marks : Class performance, Tutorials & Assignments
- 10 Marks : Quizzes
- 5 marks : Attendance

## **Text Books**

1. Goldsmith, Andrea, “Wireless Communications”, Cambridge University press (2005).
2. Rakesh. S. Kshetrimayum: “Fundamentals of MIMO Wireless Communications”, Cambridge University press, 2017
3. Haykin, Simon, “An introduction to analog and digital communications” John Wiley & Sons.

## **Reference Books**

1. Space-Time coding: theory and Practice, Hamid Jafarkhani, Cambridge University Press, 2005.
2. MIMO: From Theory to Implementation, Alain Sibille, Claude Oestges, and Alberto Zanella, Academic Press, 2013.
3. Fundamentals of Wireless Communication, David Tse and Pramod Viswanath, Cambridge University Press, 2005.
4. MIMO Wireless Communications, Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, and H. Vincent Poor, Cambridge University Press, 2007.

## **Web resources**

1. nptel lecture on MIMO, OFDM and wireless.