GUJARAT TECHNOLOGICAL UNIVERSITY

Programme Name: Master of Engineering
Level: PG
Subject Code : ME02000041
Subject Name : MIMO System

WEF Academic Year :	**2024-25**
Semester :	2
Category of the Course :	PEC-4

Prerequisite :	Digital Communications, Signals and Systems, Wireless communications
Rationale :	To learn about MIMO communication systems, capacity of MIMO, space time coding scheme and MIMO in 4G/5G wireless communications with available technology and schemes

Course Outcome :

After Completion of the Course, Student will able to :

No	Course Outcomes	RBT Level*
01	Understand the basic concept of antenna diversity schemes.	UN
02	Analyse the signal processing of MIMO in 4G LTE Communication	AN
03	Compare the channel capacity of MIMO system under different channel conditions.	EL
04	Understand the problems related to Alamouti coding and BLAST structure of MIMO system.	UN
05	Analyze the Massive MIMO environment in 5G systems.	AN
06	Understand the cooperative communication along with cognitive radio.	RM

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

Teaching and Examination Scheme :

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Course Content :

Sr. No.	Course Content	No. of Hours	% of Weightage
1	Introduction to Multi-antenna Systems, Motivation, Diversity, Types of Diversity, Types of multi-antenna systems, MIMO vs. multi-antenna systems	4	10
2	Transmit diversity, Receive diversity, MIMO system, Space-time codes, the Alamouti scheme, Delay diversity, Cyclic delay diversity, The rake receiver, Combining techniques, Spatial Multiplexing, Layered Architecture, Spectral efficiency and capacity, Transmitting independent streams in parallel, Mathematical notation	7	15
3	The generic MIMO problem, Singular Value Decomposition, Eigen values and eigenvectors, Equalizing, MIMO systems, Disadvantages of equalizing MIMO systems, Predistortion in MIMO systems, Disadvantages of pre-distortion in MIMO systems, Precoding and combining in MIMO systems, Advantages of pre-coding and combining, Disadvantages of precoding and combining, Channel state information	7	15
4	Codebooks for MIMO, Beamforming, Beamforming principles, Increased spectrum efficiency, Interference cancellation, Switched beamformer, Adaptive beamformer, Narrowband beamformer, Wideband beamformer	5	10
5	Case study: MIMO in LTE, Code words to layers mapping, Pre-coding for spatial multiplexing, Pre-coding for transmit diversity, Beamforming in LTE, Cyclic delay diversity based pre-coding, Pre-coding codebooks, Propagation Channels, Time & frequency channel dispersion, AWGN and multipath propagation channels, Delay spread values and time variations, Fast and slow fading environments, Complex baseband multipath channels, Narrowband and wideband channels, MIMO channel models	8	20
6	Channel Estimation, Channel estimation techniques, Estimation and tracking, Training based channel estimation, Blind channel estimation, Channel estimation architectures, Iterative channel estimation, MMSE channel estimation, Correlative channel sounding, Channel estimation in single carrier systems, Channel estimation for CDMA, Channel estimation for OFDM.	8	20

7	Latest technologies with the application of MIMO, Concept of Massive MIMO, Application of Massive MIMO in 5th Generation Mobile telephony, IoT systems with MIMO, Massive MIMO with F-OFDM,MIMO based Cooperative Communication,MIMO Cognitive Radios	**4**	**10**
	Total	**43**	**100**

Reference Book :

1. Claude Oestges, Bruno Clerckx, "MIMO Wireless Communications : From Real-world Propagation to Space-time Code Design",Academic Press, 1st edition, 2010.
2. MohinderJanakiraman, “Space - Time Codes and MIMO Systems”, Artech House Publishers, 2004.
3. EzioBiglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, ArogyaswamiPaulraj, H. Vincent Poor, “MIMO Wireless Communications, Cambridge.
4. Rakhesh Singh Kshetrimayum, “Fundamentals of MIMO Wireless Communications”,Cambridge University Press 2017
5. ArogyaswamiPaulraj, RohitNabar, and DhananjayGore.“Introduction to Space-Time Wireless Communications” (Cambridge University Press, New York, NY, USA)
6. Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung G. Kang, “MIMO-OFDM WIRELESS COMMUNICATIONS WITH MATLAB” Wiley
7. Aditya K. Jagannatham, “Principles of Modern Wireless Communication Systems” McGrawHillEducation
8. Tolga M. Duman and Ali Ghrayeb, “Coding for MIMO Communication systems”, John Wiley & Sons, West Sussex, England, 2007.
9. A.B. Gershman and N.D. Sidiropoulus, “Space-time processing for MIMO communications”, Wiley, Hoboken, NJ, USA, 2005.
10. H. Jafarkhani, “Space-time coding: Theory & Practice”, Cambridge University Press, 2005
11. Larsson, Erik G. and PetreStoica, “Space-Time Block Coding for Wireless Communications”, Cambridge University Press (2008)

Suggested Course Practical List :

MATLAB exercise problems may be given based on

1. Understand the different wireless channel Models.
2. Performance comparison of SISO, SIMO, MISO and MIMO.
3. Channel capacity of MIMO system.
4. The Alamouti scheme
5. Space time coding in MIMO Communications.

List of Laboratory/Learning Resources Required :

Scilab

NPTEL

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