SRI CHANDRASEKHARENDRA SARASWATHI VISWA MAHAVIDYALAYA

(University established under section 3of UGC Act 1956)

(Accredited with 'A' Grade by NAAC)

CURRICULUM FOR FULL TIME

BE - ELECTRONICS AND COMMUNICATION ENGINEERING

HONS./MINOR DEGREE IN EMERGING AREAS(OPTIONAL)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

B.E /B.TECH-Hons./Minor Degrees in Emerging Areas (Optional)

Emerging Areas	Offered as Hons., for the following Major Disciplines*	Offered as Minor Degrees for the following Major Disciplines**
5G COMMUNICATION SYSTEMS	Electronics and Communication Engineering / Computer Science and Engineering / Information Technology/ Electrical and Electronics Engineering	Electronics and Instrumentation Engineering/ Mechatronics / Mechanical Engineering / Civil Engineering
VLSI DESIGN	Electronics and Communication Engineering / Computer Science and Engineering / Information Technology/ Electrical and Electronics Engineering	Electronics and Instrumentation Engineering/ Mechatronics / Mechanical Engineering / Civil Engineering
IMAGE PROCESSING AND COMPUTER VISION	Electronics and Communication Engineering / Computer Science and Engineering / Information Technology	Electrical and Electronics Engineering /Electronics and Instrumentation Engineering/ Mechatronics/ Mechanical Engineering / Civil Engineering
DRONE TECHNOLOGY	Electronics and Communication Engineering/ Electrical and Electronics Engineering/ Mechatronics/ Mechanical Engineering	Computer Science and Engineering / Information Technology/ Civil Engineering

Note: The “Minor Degree or Hons. will cumulatively require additional 18 to 20 credits in the specified area in addition to the credits essential for obtaining the Under Graduate Degree in Major Discipline.

* Under Graduate Degree Courses in EMERGING AREAS shall be allowed as specialization from the same Department. The minimum additional Credits for such Courses shall be in the range of 18-20 and the same shall be mentioned in the degree, as specialization in that particular area.

** Minor specialization in EMERGING AREAS in Under Graduate Degree Courses may be allowed where a student of another Department shall take the minimum additional Credits in the range of 18-20 and get a degree with minor from another Department.

ELECTRONICS AND COMMUNICATION ENGINEERING WITH HONS./MINOR DEGREES

5G COMMUNICATION SYSTEMS

CURRICULUM & SYLLABUS

For B.E. (Hons.) Electronics and Communication Engineering with Specialization in

5G COMMUNICATION SYSTEMS

S.No	Year	Sem	Course Code	Course Name	L	T	P	C	IA	EA	TM
1	II	IV		INTRODUCTION TO COMMUNICATION AND NETWORKING	3	0	0	3	40	60	100
2	III	V		ADVANCED WIRELESS COMMUNICATION	3	0	0	3	40	60	100
3	III	V		WIRELESS COMMUNICATION LAB	0	0	2	2	40	60	100
4	III	VI		WIRELESS BROADBAND NETWORKS	3	0	0	3	40	60	100
5	IV	VII		5G COMMUNICATIONS	3	0	0	3	40	60	100
6	IV	VII		5G COMMUNICATION LABORATORY	0	0	2	2	40	60	100
7	IV	VIII		SMART ANTENNAS FOR 5G COMMUNICATION	3	0	0	3	40	60	100
Total Credits					**19**						

Course Code		L	T	P	C	IA	EA	TM
Course Name	**INTRODUCTION TO COMMUNICATION AND NETWORKING**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Digital Communication							

Course Objectives:

The course should enable the students

1. To understand basic knowledge of networking.
2. To demonstrate knowledge of OSI and TCP Models.
3. To Evaluate and compare the performance of the various digital modulations schemes.
4. To understand the concept of Information Theory.
5. To Acquire the skills to generate and detect Wireless digital modulation schemes.

Course Outcomes:

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

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Understanding of networking systems.	**K2**
CO2	Understanding the concept of different layers in the networks.	**K3**
CO3	Demonstrate proficiency in the generation and detection of digital modulated signals.	**K5**
CO4	Gain a comprehensive understanding of information theory and channel coding to improve communication reliability.	**K2**
CO5	Explore the practical applications of wireless digital modulation techniques.	**K5**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	M	M	L	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	-	-	L	L	-	-	-	-	-	-	-	-	L	L
CO4	M	-	L	-	-	-	-	-	-	-	-	-	L	-	-
CO5	S	M	M	L	M	-	-	-	-	-	-	-	-	M	L

UNIT-I	INTRODUCTION TO DATA COMMUNICATION	9 Hours
Data Communication, Networks – Distributed Processing, Network Criteria, Applications; Protocols and Standards, Standard Organization, Line Configuration – Point to Point, Multi Point; Topology – Mesh, Star, Tree, Bus, Ring, Hybrid; Transmission mode, Categories of Network – LAN, MAN, WAN, Inter Networks.		
UNIT-II	**OSI AND TCP/IP MODEL**	**9 Hours**
ISO organization, The model – Layered architecture, functions of the layers -Physical layer, Data Link layer, Network layer, Transport layer, session layer, Presentation layer, Application layer. The TCP/IP reference model, comparison of TCP/IP & OSI, Introduction to Internet – ARPANET, Architecture of Internet, Client server model, www, IP Address Classes, Protocols: IP, HTTP, TCP. FTP, ARP.		
UNIT-III	**DIGITAL MODULATION TECHNIQUES**	**9 Hours**
Phase shift Keying techniques using coherent detection: generation, detection and error probabilities of BPSK and QPSK. Mary PSK. M-ary QAM . Frequency shift keying techniques using Coherent detection: BFSK generation, detection and error probability. Spread Spectrum Communication Systems - Direct Sequence Spread Spectrum Systems, Frequency Hopped Spread Spectrum.		
UNIT-IV	**INFORMATION THEORY**	**9 Hours**
Information-theoretic limits and Channel Coding, The capacity of AWGN Channel: modelling and geometry, Shannon theory basics: entropy, mutual information, and divergence, channel coding theorem, the capacity of standard constellations, parallel Gaussian channels and water filling Channel codes: Binary convolutional codes, Turbo codes and iterative coding, LDPC codes, bandwidth-efficient coded modulation.		
UNIT-V	**WIRELESS DIGITAL MODULATION**	**9 Hours**
Wireless Digital Modulation Physical modelling for wireless channels, Fading and diversity, OFDM, CDMA, MIMO- linear array, Beam-steering, MIMO-OFDM, Spatial Multiplexing,Space-time coding.		
	Total Hours	**45 Hours**

Text Book(s)

1.	Behrouz A. Forouzan , Data Communications And Networking, Mc Graw Hill, 2017.
2.	Upamanyu Madhow, Fundamentals of Digital Communication, Cambridge University Press, 2012
3	Sanjay Sharma, Communication Systems (Analog and Digital), SK Kataria Sons, 2013.

Reference Book(s)

1.	B. P. Lathi, Modern Digital and Analog Communication Systems, Oxford.
2.	J. R. Barry, E. A. Lee, and D. G. Messerschmitt, Digital Communication, Kluwer Academic Publishers, 2004.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**ADVANCED WIRELESS COMMUNICATION**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	**Wireless Communication Techniques**							

Course Objectives:

The course should enable the students

1. To understanding of the capacity limitations of wireless channels.
2. To Explore the principles of MIMO systems.
3. To Analyse the capacity of MIMO systems under different channel conditions.
4. To Study radio wave propagation and its effects on wireless communication.
5. To Investigate different space-time coding techniques.

Course Outcomes:

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

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Analyze channel capacity of wireless channels.	**K3**
CO2	Analyse MIMO system.	**K3**
CO3	Apply the principles of MIMO systems to enhance the capacity and reliability of wireless communication.	**K4**
CO4	Understand the principles of radio wave propagation.	**K2**
CO5	Design and decoding of various space-time coding techniques.	**K5**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O 1	PS O2	PS O3
CO1	M	L	L	-	-	-	-	-	-	-	-	-	L	-	-
CO2	M	L	L	-	M	-	-	-	-	-	-	-	-	L	-
CO3	S	M	M	-	M	-	-	-	-	-	-	-	M	-	-
CO4	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	L	M	M	S	S	-	-	-	-	-	-	-	S	L	-

UNIT-I	**CAPACITY OF WIRELESS CHANNELS**	**9 Hours**
The crowded spectrum, need for high data rate, MIMO systems – Array Gain, Diversity Gain, Data Pipes, Spatial MUX, MIMO System Model. MIMO System Capacity – channel known at the TX, Channel unknown to the TX – capacity of deterministic channels, Random channels and frequency selective channels.		
UNIT-II	**RADIO WAVE PROPAGATION**	**9 Hours**
Radio wave propagation – Macroscopic fading- free space and out door, small scale fading Fading measurements – Direct pulse measurements, spread spectrum correlation channel sounding frequency domain channel sounding, Antenna Diversity – Diversity combining methods.		
UNIT-III	**SPACE TIME BLOCK CODES**	**9 Hours**
Delay Diversity scheme, Alamoti space time code – Maximum likelihood decoding maximum ratio combining. Transmit diversity space time block codes for real signal constellation and complex signal constellation - decoding of STBC.		
UNIT-IV	**SPACE TIME TRELLIS CODES**	**9 Hours**
Space time coded systems, space time code word design criteria, design of space time T C on slow fading channels, design of STTC on Fast Fading channels, performance analysis in slow and fast fading channels, effect of imperfect channel estimation and Antenna correlation on performance, comparison of STBC & STTC.		
UNIT-V	**LAYERED SPACE TIME CODES**	**9 Hours**
LST transmitter – Horizontal and Vertical LST receiver – ML Rx, Zero forcing Rx; MMSE Rx, SIC Rx, ZF V-blast Rx- MMSE V-blast Rx, Iterative Rx - capacity of MIMO – OFDM systems – capacity of MIMO multi user systems.		
	Total Hours	**45 Hours**

Text Book(s)

1.	Mohinder Jankiraman, "Space Time Codes and MIMO Systems", Artech House, Boston", London. www.artechhouse.com, 2004.
2.	Paulraj Rohit Nabar, Dhananjay Gore, "Introduction of Space Time Wireless Communication Systems", Cambridge University Press, 2003.

Reference Book(s)

1.	David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.
2.	Sergio Verdu "Multi User Detection", Cambridge University Press, 1998.
3.	Andre Viterbi, "Principles of Spread Spectrum Techniques", Addison Wesley 1995.
4.	Volker Kuhn, "Wireless communication over MIMO channels", John Wiley and Sons Ltd., 2006.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**WIRELESS COMMUNICATION LABORATORY**	0	0	2	2	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Digital Communication							

Course Objectives:

1. To study & measure the performance of digital communication systems.
2. To study the practical aspects of baseband system design.
3. To provide a complete knowledge of Wireless Communication.
4. To design and conduct experiments, for digital communication.

Course Outcomes:

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

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Generate and detect digital communication signals	**K4**
CO2	Evaluate cellular mobile communication technology and propagation mode.	**K4**
CO3	Apply mathematical formulation to analyse spectrum estimation of a signal.	**K3**
CO4	Analyse the performance of optimization algorithms for equalizing the channel or noise/echo cancellation.	**K5**
CO5	Design synchronization algorithm for Digital Communication systems.	**K5**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S	-	-	S	-	-	-	S	S	M	M	L	L	-
CO2	S	S	L	M	S	-	-	-	S	S	M	M	-	L	-
CO3	S	S	M	M	S	-	-	-	S	S	M	M	L	-	-
CO4	S	S	M	M	S	M	M	L	S	S	M	M	-	L	M
CO5	S	S	L	M	S	L	M	L	S	S	M	M	M	M	M

	LIST OF EXPERIMENTS
1.	Communication link simulation
2.	Pseudo random binary sequence generation Baseband DSSS
3.	Performance analysis of simulated CDMA system
4.	OFDM design
5.	Channel equalizer design
6.	Design and Analysis of Spectrum Estimators
7.	BER performance Analysis of M-ary digital Modulation Techniques
8.	Noise / Echo cancellation
9.	Study of synchronization
10.	Wireless channel characterization.
Tools : MATLAB, LABVIEW	

Course Code		L	T	P	C	IA	EA	TM
Course Name	**WIRELESS BROADBAND NETWORKS**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Computer Networks, Wireless Communication							

Course Objectives:

The course should enable the students

1. To learn the basic architecture of a next generation network (NGN) with reference.
2. To understand next generation network services.
3. To learn the role of P Multimedia Sub-System (IMS), network attachment and admission control functions.
4. To learn and compare the various methods of providing connection-oriented services over NGN.

Course Outcomes:

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

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Understand the evolution of wireless networks.	**K2**
CO2	Analyze the protocols used in wireless networks.	**K3**
CO3	Evaluate the features and components of 4G and beyond wireless networks.	**K4**
CO4	Analyze the LTE-A technology and network architecture.	**K3**
CO5	Analyze layer-level functions in wireless networks.	**K3**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	-	L	M	-	-	-	-	-	-	-	-	M	-
CO3	S	-	M	L	-	-	-	-	-	-	-	-	L	M	-
CO4	S	-	M	-	M	-	-	-	-	-	-	-	-	-	-
CO5	S	-	M	M	-	-	-	-	-	-	-	-	-	-	-

UNIT-I	EVOLUTION OF WIRELESS NETWORKS	9 Hours
Review of cellular standards, migration and advancement of GSM architecture and CDMA architecture, WLAN – IEEE 802.11and HIPERLAN, Bluetooth.		
UNIT-II	**WIRELESS PROTOCOLS**	**9 Hours**
Mobile network layer- Fundamentals of Mobile IP, data forwarding procedures in mobile IP, IPv4, IPv6, IP mobility management, IP addressing - DHCP, Mobile transport layer-Traditional TCP, congestion control, slow start, fast recovery/fast retransmission, classical TCP improvements- Indirect TCP, snooping TCP, Mobile TCP.		
UNIT-III	**3G EVOLUTIONS**	**9 Hours**
IMT-2000 - W-CDMA, CDMA 2000 – radio & network components, network structure, packet-data transport process flow, Channel Allocation, core network, interference-mitigation techniques, UMTS-services, air interface, network architecture of 3GPP, UTRAN – architecture, High Speed Packet Data-HSDPA, HSUPA.		
UNIT-IV	**4G AND BEYOND**	**9 Hours**
Introduction to LTE-A – Requirements and Challenges, network architectures – EPC, E- UTRAN architecture - mobility management, resource management, services, channel -logical and transport channel mapping, downlink/uplink data transfer, MAC control element, PDU packet formats, scheduling services, random access procedure.		
UNIT-V	**LAYER-LEVEL FUNCTIONS**	**9 Hours**
Characteristics of wireless channels - downlink physical layer, uplink physical layer, MAC scheme - frame structure, resource structure, mapping, synchronization, reference signals and channel estimation, SC-FDMA, interference cancellation –CoMP, Carrier aggregation, Services - multimedia broadcast/multicast, location-based services.		
	Total Hours	**45 Hours**

Text Book(s)

1.	KavehPahlavan, "Principles of wireless networks", Prentice-Hall of India, 2008.
2.	Vijay K.Garg, "Wireless Network Evolution- 2G & 3G" Pearson, 2013.

Reference Book(s)

1.	Clint Smith,P.E, Dannel Collins, "3G Wireless Networks" 2nd edition, Tata McGraw-Hill, 2008.
2.	JochenH.Schiller, "Mobile Communications", 2/e, Pearson, 2014.
3.	Sassan Ahmadi, "LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies", Elsevier, 2014.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**5G COMMUNICATIONS**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Digital communications, Mobile Communication Systems, Wireless Networks							

Course Objectives:

The course should enable the students

1. To understand the requirements and regulations for 5G networks.
2. To Familiarize functional architecture of 5G networks.
3. To Understand the design principles 5G radio technology.
4. To analyse different network deployment types in 5G.

Course Outcomes:

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

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Understand and explain the channel models of 5G and the use cases for 5G.	**K2**
CO2	Analyze use of MIMO in 5G and its techniques.	**K3**
CO3	Understand device to device (D2D) communication and standardization.	**K2**
CO4	Study the in-depth functioning of 5G radio access technologies.	**K3**
CO5	Understand interference management, mobility management and security issues in 5G.	**K2**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	L	L	-	-	-	-	-	-	-	-	-	L	-	-
CO3	M	-	-	-	-	-	-	-	-	-	-	-	-	L	-
CO4	M	L		-	-	-	-	-	-	-	-	-	-	-	-
CO5	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT-I	5G BROADBAND WIRELESS COMMUNICATIONS	9 Hours
. An Overview of 5G requirements, Regulations for 5G, Spectrum Analysis and Sharing for 5G. Channel modeling requirements, propagation scenarios and challenges in the 5G modeling, Channel Models for mmWave MIMO Systems.		
UNIT-II	**THE 5G ARCHITECTURE**	**9 Hours**
Introduction, NFV and SDN, Basics about RAN architecture, High-level requirements for the 5G architecture, Functional architecture and 5G flexibility, Functional split criteria, Functional split alternatives, Functional optimization for specific applications, Integration of LTE and new air interface to fulfill 5G Requirements, Enhanced Multi-RAT coordination features, Physical architecture and 5G deployment.		
UNIT-III	**DEVICE-TO-DEVICE (D2D) COMMUNICATIONS**	**9 Hours**
D2D: from 4G to 5G, D2D standardization: 4G LTE D2D, D2D in 5G: research challenges, Radio resource management for mobile broadband D2D, RRM techniques for mobile broadband D2D, RRM and system design for D2D, 5G D2D RRM concept: an example, Multi- hop D2D communications for proximity and emergency, services, National security and public safety requirements in 3GPP and METIS, Device discovery without and with network assistance.		
UNIT-IV	**5G RADIO-ACCESS TECHNOLOGIES**	**9 Hours**
Access design principles for multi-user communications, Orthogonal multiple-access systems, Spread spectrum multiple-access systems, Capacity limits of multiple-access methods, Sparse code multiple access (SCMA), Interleave division multiple access (IDMA), Radio access for dense deployments, OFDM numerology for small-cell deployments, Small-cell sub-frame structure, Radio access for V2X communication, Medium access control for nodes on the move, Radio access for massive machine-type communication.		
UNIT-V	**INTERFERENCE MANAGEMENT, MOBILITY MANAGEMENT, AND SECURITY FOR 5G**	**9 Hours**
Network deployment types, Ultra-dense network or densification, Moving networks, Heterogeneous networks, Interference management in 5G, Interference management in UDN, Interference management for moving relay nodes, Interference cancelation, mobility management in 5G, User equipment-controlled versus network-controlled handover, Mobility management in heterogeneous 5G networks.		
	Total Hours	**45 Hours**

Text Book(s)

1.	5G Mobile and Wireless Communications Technology, AfifOsseiran, Jose F. Monserrat, Patrick Marsch, Second Edition, 2011.
2.	5G NR: The Next Generation Wireless Access Technology, Erik Dahlman, Stefan Parkvall, Johan Sko Ï d, Elsevier, First Edition, 2016.

3.	Fundamentals of 5G Mobile Networks, Jonathan Rodriguez, Wiley, First Edition, 2010
Reference Book(s)	
1.	Theodore S.Rappaport, Robert W.Heath, Robert C.Danials, James N.Murdock "Millimeter Wave Wireless Communications", Prentice Hall Communications.
2.	Athanasios G.Kanatos, Konstantina S.Nikita, Panagiotis Mathiopoulos, "New Directions in Wireless Communication Systems from Mobile to 5G", CRC Press.
3.	Amitabha Ghosh and RapeepatRatasuk "Essentials of LTE and LTE-A", Cambridge University Press.

Course Code		**L**	**T**	**P**	**C**	**IA**	**EA**	**TM**
Course Name	**5G COMMUNICATION LABORATORY**	0	0	2	2	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	5G Communication							

Course Objectives:

The course should enable the students

1. To Understand the working of cellular networks.
2. To analyse the performance of LTE network.
3. To analyse the performance of 5G communication.
4. To design and analyse 5G waveform generation.

Course Outcomes:

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

Course Outcomes	**Description**	**Highest Bloom's Taxonomy**
CO1	Design and analysis of cellular network.	**K4**
CO2	Design and analyse the 5G network.	**K4**
CO3	Understand the fundamentals of ray tracing as a simulation technique for analysing communication links in 5G networks.	**K3**
CO4	Evaluate the performance and capabilities of WLAN technologies in the context of 5G.	**K5**
CO5	Design and optimize beamforming algorithms and configurations for 5G systems.	**K5**

Z

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	S	-	-	S	-	-	-	S	S	M	M	-	L	-
CO2	S	S	L	M	S	-	-	-	S	S	M	M	-	L	-
CO3	S	S	M	M	S	-	-	-	S	S	M	M	L	-	-
CO4	S	S	M	M	S	L	M	-	S	S	M	M	-	L	-
CO5	S	S	L	M	S	L	M	-	S	S	M	M	M	M	M

LIST OF EXPERIMENTS

1. Call establishment in cellular network.
2. Handover in cellular network.
3. Throughput performance for various terrain models, transmission modes, loading, conditions, traffic profiles in LTE network.
4. 5G Communications Link Analysis with Ray Tracing.
5. Wireless Connectivity in the 5G Era for WLAN.
6. MIMO Wireless System Design for 5G.
7. 5G Waveforms generation.
8. 5G Beamforming Design.
9. Frame Structure of 5G technology.

Tools : MATLAB

Course Code		L	T	P	C	IA	EA	TM
Course Name	**SMART ANTENNAS FOR 5G COMMUNICATION**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	Syllabus Revision					V.1.0	
Pre-requisite	Electromagnetic Field Theory, Antenna and Wave Propagation							

Course Objectives:

The course should enable the students

1. To Understand the fundamentals of smart antennas and their architecture.
2. To study the different smart antenna configurations.
3. To analyse various Angle of arrival estimation methods.
4. To analyse the MIMO and mmWave antenna design requirements for 5G communication.

Course Outcomes:

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

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	To Familiarize with smart and adaptive antennas.	K2
CO2	Apply different adaptive algorithms for 5G antenna.	K3
CO3	Understanding the concept of direction of arrival and angle of arrival.	K2
CO4	Design of antenna array architectures to meet 5G requirement.	K4
CO5	Discuss millimeter wave communication.	K3

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	L	L	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	M	L	M	-	-	-	-	-	-	-	-	-	-
CO3	M	L	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	S	S	M	M	-	-	-	-	-	-	-	-	M	-
CO5	M	L	L	-	L	-	-	-	-	-	-	-	-	M	L

UNIT-I	INTRODUCTION TO SMART ANTENNA	9 Hours
Introduction to Smart Antennas, Architecture of a Smart Antenna System: Transmitter and Receiver, Types of Smart Antennas, Benefits and Drawbacks of Smart Antennas, Applications of Smart Antennas.		
UNIT-II	**SMART ANTENNA CONFIGURATIONS**	**9 Hours**
Fixed Sidelobe Cancelling, Retrodirective Arrays, Beamforming, Adaptive Arrays, Butler Matrix, Spatial Filtering with Beamformers, Switched Beam Systems, Multiple Fixed Beam System. Uplink Processing, Diversity Techniques, Angle Diversity, Maximum Ratio Combining, Adaptive Beamforming, Fixed Multiple Beams versus Adaptive Beamforming, Downlink Processing.		
UNIT-III	**ANGLE-OF-ARRIVAL ESTIMATION**	**9 Hours**
Fundamentals of Matrix Algebra, Array Correlation Matrix, AOA Estimation Methods: Bartlett AOA Estimate, Capon AOA Estimate, Linear Prediction AOA Estimate, Maximum Entropy AOA Estimate, Pisarenko Harmonic Decomposition AOA Estimate, Min-Norm AOA Estimate, MUSIC AOA Estimate, ESPRIT AOA Estimate.		
UNIT-IV	**MIMO ANTENNAS**	**9 Hours**
Introduction, Multiple-Antenna MS Design, RAKE Receiver Size, Mutual Coupling Effects, Dual-Antenna Performance Improvements, Downlink Capacity Gains, Principles of MIMO systems: SISO, SIMO, MISO, MIMO, Hybrid antenna array for mm Wave massive MIMO: Massive Hybrid Array Architectures, Hardware Design for Analog Subarray.		
UNIT-V	**mm WAVES**	**9 Hours**
Millimeter-wave Communications – spectrum regulations, deployment scenarios, beam- forming, physical layer techniques, interference and mobility management, Massive MIMO propagation channel models, Channel Estimation in Massive MIMO, Massive MIMO with Imperfect CSI, Multi-Cell Massive MIMO, Pilot Contamination, Spatial Modulation (SM).		
	Total Hours	**45 Hours**

Text Book(s)	
1.	Ahmed El Zooghby, „Smart Antenna Engineering‟, ARTECH HOUSE, INC, 2005.
2.	Frank B. Gross, „Smart antenna with MATLAB‟, 2nd Edition, McGraw-Hill, 2015.
3.	Lal Chand Godara , “SMART ANTENNAS” , CRC PR ESS, 2004.
Reference Book(s)	
1.	ShahidMumtaz, Jonathan Rodriguez, Linglong Dai mmWave Massive MIMO: A Paradigm for 5G.