GOVERNMENT COLLEGE OF TECHNOLOGY

ELECTRONICS AND COMMUNICATION ENGINEERING

VERTICALS

Vertical I- High speed Communications	**Vertical II-RF Technologies**	**Vertical III-Signal and Image processing**	**Vertical IV-VLSI Design**	**Vertical V - BioMedical Technologies**	**Vertical VI-Embedded Systems and IOT**
18LPE$17-AdHoc and Wireless Sensor networks	18LPE$18-Satellite Communication	18LPE$02-Speech Signal Processing	18LPE$13- Low Power VLSI	18LPE$51-Biosensors	18LPE$03-Introduction to MEMS
18LPE$27-Wireless Communication Techniques	18LPE$26 - Microwave Integrated Circuits	18LPE$12 - Advanced Digital Signal Processing	18LPE$45-Analog IC Design	18LPE$52-Medical Instrumentation	18LPE$07-Automotive Electronics
18LPE$28-High Speed Networks	18LPE$34-Advanced Radiation Systems	18LPE$15-Digital Image and Video Processing	18LPE$46-Programming FPGA using HDLs	18LPE$53-Medical imaging systems	18LPE$09-Embedded Systems
18LPE$29-Coding Theory and Secured Communication	18LPE$35-Electromagnetic Interference and Compatibility	18LPE$40-VLSI Signal Processing	18LPE$47-ASIC Design	18LPE$54-BioInformatics for BioMedical Engineers	18LPE$16-Control Systems
18LPE$30-Software Defined Networks (common to ECE& CSE)	18LPE$36-RF Transceivers	18LPE$41-Non linear Signal Processing	18LPE$48-System on Chip Design	18LPE$55-Biotelemetry and Telemedicine	18LPE$25-Internet of Things
18LPE$31-Massive MIMO and Millimeter wave systems	18LPE$37-RF System Design	18LPE$42-Radar Signal Processing	18LPE$49-VLSI Testing and Design for Testability	18LPE$56-Embedded systems in BioMedical Engineering	18LPE$59-Smart Sensors
18LPE$32-Optical Communication and Networks	18LPE$38-Smart Antennas	18LPE$43-Computer Vision Algorithms and Applications	18LPE$50-Design for Verification using UVM	18LPE$57-Wearable Technologies	18LPE$60-Industrial Internet of Things (Common To ECE &EIE)
18LPE$33-Evolution of 4G/5G Technologies	18LPE$39-Modern Antennas	18LPE$44-Digital Signal Processors		18LPE$58-Hospital safety and management	18LPE$61-Embedded Operating Systems

Vertical I: HIGH SPEED COMMUNICATIONS

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18LPE$17	AdHoc and Wireless Sensor networks	PE	40	60	100	3	0	0	3
2.	18LPE$27	Wireless Communication Techniques	PE	40	60	100	3	0	0	3
3.	18LPE$28	High Speed Networks	PE	40	60	100	3	0	0	3
4.	18LPE$29	Coding Theory and Secured Communication	PE	40	60	100	3	0	0	3
5.	18LPE$30	Software Defined Networks (common to ECE& CSE)	PE	40	60	100	3	0	0	3
6.	18LPE$31	Massive MIMO and Millimeter wave systems	PE	40	60	100	3	0	0	3
7.	18LPE$32	Optical Communication and Networks	PE	40	60	100	3	0	0	3
8.	18LPE$33	Evolution of 4G/5G Technologies	PE	40	60	100	3	0	0	3

Vertical II: RF TECHNOLOGIES

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18LPE$18	Satellite Communication	PE	40	60	100	3	0	0	3
2.	18LPE$26	Microwave Integrated Circuits	PE	40	60	100	3	0	0	3
3.	18LPE$34	Advanced Radiation Systems	PE	40	60	100	3	0	0	3
4.	18LPE$35	Electromagnetic Interference and Compatibility	PE	40	60	100	3	0	0	3
5.	18LPE$36	RF Transceivers	PE	40	60	100	3	0	0	3
6.	18LPE$37	RF System Design	PE	40	60	100	3	0	0	3
7.	18LPE$38	Smart Antennas	PE	40	60	100	3	0	0	3
8.	18LPE$39	Modern Antennas	PE	40	60	100	3	0	0	3

Vertical III: SIGNAL AND IMAGE PROCESSING

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18LPE$02	Speech Signal Processing	PE	40	60	100	3	0	0	3
2.	18LPE$12	Advanced Digital Signal Processing	PE	40	60	100	3	0	0	3
3.	18LPE$15	Digital Image and Video Processing	PE	40	60	100	3	0	0	3
4.	18LPE$40	VLSI Signal Processing	PE	40	60	100	3	0	0	3
5.	18LPE$41	Non linear Signal Processing	PE	40	60	100	3	0	0	3
6.	18LPE$42	Radar Signal Processing	PE	40	60	100	3	0	0	3
7.	18LPE$43	Computer Vision Algorithms and Applications	PE	40	60	100	3	0	0	3
8.	18LPE$44	Digital Signal Processors	PE	40	60	100	3	0	0	3

Vertical IV: VLSI DESIGN

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18LPE$13	Low Power VLSI	PE	40	60	100	3	0	0	3
2.	18LPE$45	Analog IC Design	PE	40	60	100	3	0	0	3
3.	18LPE$46	Programming FPGA using HDLs	PE	40	60	100	3	0	0	3
4.	18LPE$47	ASIC Design	PE	40	60	100	3	0	0	3
5.	18LPE$48	System on Chip Design	PE	40	60	100	3	0	0	3
6.	18LPE$49	VLSI Testing and Design for Testability	PE	40	60	100	3	0	0	3
7.	18LPE$50	Design for Verification using UVM	PE	40	60	100	3	0	0	3

Vertical V: BIOMEDICAL TECHNOLOGIES

Sl. No.	Course Code	Course Title	CAT	CA Marks	End SemMarks	Total Marks	Hours/Week			
							L	T	P	C
1.	18LPE$51	Biosensors	PE	40	60	100	3	0	0	3
2.	18LPE$52	Medical Instrumentation	PE	40	60	100	3	0	0	3
3.	18LPE$53	Medical imaging systems	PE	40	60	100	3	0	0	3
4.	18LPE$54	BioInformatics for BioMedical Engineers	PE	40	60	100	3	0	0	3
5.	18LPE$55	Biotelemetry and Telemedicine	PE	40	60	100	3	0	0	3
6.	18LPE$56	Embedded systems in BioMedical Engineering	PE	40	60	100	3	0	0	3
7.	18LPE$57	Wearable Technologies	PE	40	60	100	3	0	0	3
8.	18LPE$58	Hospital safety and management	PE	40	60	100	3	0	0	3

Vertical VI: EMBEDDED SYSTEMS AND IOT

Sl. No.	Course Code	Course Title	CAT	CA Marks	End SemMarks	Total Marks	Hours/Week			
							L	T	P	C
1.	18LPE$03	Introduction to MEMS	PE	40	60	100	3	0	0	3
2.	18LPE$07	Automotive Electronics	PE	40	60	100	3	0	0	3
3.	18LPE$09	Embedded Systems	PE	40	60	100	3	0	0	3
4.	18LPE$16	Control Systems	PE	40	60	100	3	0	0	3
5.	18LPE$25	Internet of Things	PE	40	60	100	3	0	0	3
6.	18LPE$59	Smart Sensors	PE	40	60	100	3	0	0	3
7.	18LPE$60	Industrial Internet of Things (Common To ECE &EIE)	PE	40	60	100	3	0	0	3
8.	18LPE$61	Embedded Operating Systems	PE	40	60	100	3	0	0	3

VERTICAL I
HIGH SPEED COMMUNICATON

18LPE$17	ADHOC AND WIRELESS SENSOR NETWORKS

PRE-REQUISITES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Learn Ad hoc network and Sensor Network fundamentals
- Understand the different routing protocols
- Have an in-depth knowledge on sensor network architecture and design issues
- Understand the transport layer and security issues possible in Ad hoc and Sensor networks
- Have an exposure to mote programming platforms and tools

UNIT I ADHOC NETWORKS – INTRODUCTION AND ROUTING	**(9 Periods)**
Elements of Adhoc Wireless Networks, Issues in Ad hoc wireless networks, Example commercial applications of Adhoc networking, Ad hoc wireless Internet, Issues in Designing a Routing Protocol for AdHoc Wireless Networks, Classifications of Routing Protocols, Table Driven Routing Protocols - Destination Sequenced Distance Vector (DSDV), On–Demand Routing protocols –Ad hoc On–Demand Distance Vector Routing (AODV).	
UNIT II SENSOR NETWORKS – INTRODUCTION & ARCHITECTURES	**(9 Periods)**
Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, WSN application examples, Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Network Architecture - Sensor Network Scenarios, Transceiver Design Considerations, Optimization Goals and Figures of Merit.	
UNIT III WSN NETWORKING CONCEPTS AND PROTOCOLS	**(9 Periods)**
MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols and Wakeup Concepts - S-MAC, The Mediation Device Protocol, Contention based protocols - PAMAS, Schedule based protocols – LEACH, IEEE 802.15.4 MAC protocol, Routing Protocols Energy Efficient Routing, Challenges and Issues in Transport layer protocol.	
UNIT IV SENSOR NETWORK SECURITY	**(9 Periods)**
Network Security Requirements, Issues and Challenges in Security Provisioning, Network Security Attacks, Layer wise attacks in wireless sensor networks, possible solutions for jamming, tampering, black hole attack, flooding attack. Key Distribution and Management, Secure Routing – SPINS, reliability requirements in sensor networks.	
UNIT V SENSOR NETWORK PLATFORMS AND TOOLS	**(9 Periods)**
Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms – TinyOS, nesC, CONTIKIOS, Node-level Simulators – NS2 and its extension to sensor networks, COOJA, TOSSIM, Programming beyond individual nodes – State centric programming.	

Contact Periods:
Lecture: 45 Periods **Tutorial:0 Periods** **Practical:0 Periods** **Total:45 Periods**

TEXT BOOKS:

*1. C. Siva Ram Murthy and B. S. Manoj, — "**Ad Hoc Wireless Networks Architectures and Protocols"**, Prentice Hall, PTR, 2004. (UNIT I)*

*2. Holger Karl , Andreas willig, — "**Protocol and Architecture for Wireless Sensor Networks"**, John wiley publication, Jan 2006.(UNIT II-V)*

REFERENCE BOOKS:

1. *Feng Zhao, Leonidas Guibas, — "**Wireless Sensor Networks: an information processing approach"**, Elsevier publication, 2004.*
2. *Charles E. Perkins, — "**Ad Hoc Networking"**, Addison Wesley, 2000.*
3. *I.F. Akyildiz, W. Su, Sankarasubramaniam, E. Cayirci, — "**Wireless sensor networks: a Survey"**, computer networks, Elsevier, 2002, 394 - 422.*

COURSE OUTCOMES:

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

CO1: Know the basics of Ad hoc networks and Wireless Sensor Networks.
CO2: Apply this knowledge to identify the suitable routing algorithm based on the network and user requirement.
CO3: Apply the knowledge to identify appropriate physical and MAC layer protocols.
CO4: Understand the transport layer and security issues possible in Ad hoc and sensor networks.
CO5: Be familiar with the OS used in Wireless Sensor Networks and build basic modules.

COURSE ARTICULATION MATRIX

CO	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	PSO 2	PSO 3
CO1	M	L	-	-	-	-	L	-	L	-	-	L	M	L	-
CO2	-	-	-	L	L	-	-	-	-	-	-	-	L	L	-
CO3	M	-	-	-	-	-	L	-	L	-	-	-	L	-	-
CO4	M	L	M	M	M	L	L	-	-	L	L	L	M	M	-
CO5	M	-	-	-	M	L	L	-	-	L	L	-	M	L	-
18LPE$17	M	L	L	M	M	L	L	-	L	L	L	L	M	L	-

L - Low, M - Moderate (Medium), H - High

18LPE$27	WIRELESS COMMUNICATION TECHNIQUES

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

* To study the characteristics of wireless channel, design of a cellular system, variousdigital signalling techniques, multipath mitigation techniques and understand the concepts of multiple antenna techniques

UNIT – I	WIRELESS CHANNELS	(9 Periods)
Electromagnetic Wave Propagation Mechanisms - Reflection, Diffraction, Scattering Models – Large scale path loss – Path loss models: Free Space and Two-Ray models -Link Budget design – Small scale fading- Parameters of mobile multipath channels – Time dispersion parameters-Coherence bandwidth – Doppler spread & Coherence time, Fading due to Multipath time delay spread – flat fading – frequency selective fading – Fading due to Doppler spread – fast fading – slow fading.		
UNIT – II	**CELLULAR ARCHITECTURE**	**(9 Periods)**
Multiple Access techniques - FDMA, TDMA, CDMA – Capacity calculations–Cellular concept-Frequency reuse - channel assignment- hand off- interference & system capacity- trunking and grade of service – Coverage and capacity improvement.		
UNIT – III	**DIGITAL SIGNALING FOR FADING CHANNELS**	**(9 Periods)**
Structure of a wireless communication link, Principles of Offset-QPSK, p/4-DQPSK, QAM Principle, Error performance in fading channels, OFDM principle – Cyclic prefix, Windowing, PAPR.		
UNIT – IV	**MULTIPATH MITIGATION TECHNIQUES**	**(9 Periods)**
Equalisation – Adaptive equalization, Linear and Non-Linear equalization, Zero forcing and LMS Algorithms, Diversity – Micro and Macro diversity, Diversity combining techniques, Error probability in fading channels with diversity reception, Rake receiver		
UNIT – V	**MULTIPLE ANTENNA TECHNIQUES**	**(9 Periods)**
MIMO systems – spatial multiplexing -System model -Pre-coding - transmitter diversity, receiver diversity- Channel state information-capacity in fading and non-fading channels.		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45Periods

TEXT BOOK:

1 *Rappaport,T.S.,* ***"Wireless communications",*** *Pearson Education, 3rd Edition, 2010.*
2 *Andreas.F. Molisch,* ***"Wireless Communications",*** *John Wiley – India, 2ndEdition 2012.*

REFERENCE BOOKS:

1 *David Tse and PramodViswanath,* ***"Fundamentals of Wireless Communication",*** *Cambridge University Press, 2005.*
2 *UpenaDalal,* ***"Wireless Communication",*** *Oxford University Press, 2009.*
3 *Van Nee, R. and Ramji Prasad,* ***"OFDM for wireless multimedia communications",****Artech House, 2000.*
4 *Simon Haykins& Michael Moher,* ***"Modern Wireless Communications",*** *Pearson Education, 2007.*
5 *Vijay. K. Garg,* ***"Wireless Communication and Networking",*** *Morgan Kaufmann Publishers, 2007.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Gain knowledge about the characteristics of a channel

CO2 Understand a cellular system based on resource availability and trafficdemands

CO3 Identify suitable signalling techniques for the wireless channel and system under consideration

CO4 Gain knowledge about suitable multipath mitigation techniques for thewireless channel and system under consideration

CO5 Understand multiple antenna techniques for capacity/performance gains.

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	M	M	M	-	-	M	-	-	-	M	M	L	M
CO2	M	M	M	-	-	-	-	-	-	-	-	-	M	-	M
CO3	M	H	M	-	-	-	-	-	-	M	-	-	M	L	M
CO4	M	H	M	-	-	-	-	-	-	M	-	-	M	L	M
CO5	M	M	M	-	M	-	-	-	-	-	-	M	M	-	M
18LPE$27	M	M	M	M	M	-	-	M	-	M	-	M	M	L	M

L - Low, M - Moderate (Medium), H - High

18LPE$28	HIGH SPEED NETWORKS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- To highlight the features of different technologies involved in High Speednetworking and their performance

UNIT – I	HIGH SPEED NETWORKS	(9 Periods)
Frame Relay Networks – Asynchronous transfer mode – ATM Protocol Architecture, ATM logical Connection, ATM Cell – ATM Service Categories – AAL, High Speed LANs: Fast Ethernet, Gigabit Ethernet, Fiber Channel – Wireless LANs: applications, requirements – Architecture of 802.11		
UNIT – II	**CONGESTION AND TRAFFIC MANAGEMENT**	**(9 Periods)**
Queuing Analysis- Queuing Models – Single Server Queues – Effects of Congestion – Congestion Control – Traffic Management – Congestion Control in Packet Switching Networks – Frame Relay Congestion		
UNIT – III	**TCP AND ATM CONGESTION CONTROL**	**(9 Periods)**
TCP Flow control – TCP Congestion Control – Retransmission – Timer Management – Exponential RTO backoff – KARN's Algorithm – Window management – Performance of TCP over ATM. Traffic and Congestion control in ATM – Requirements – Attributes – Traffic Management Frame work, Traffic Control – ABR traffic Management – ABR rate control, RM cell formats, ABR Capacity allocations – GFR traffic management.		
UNIT – IV	**INTEGRATED AND DIFFERENTIATED SERVICES**	**(9 Periods)**
Integrated Services Architecture – Approach, Components, Services- Queuing Discipline, FQ, PS, BRFQ, GPS, WFQ – Random Early Detection, Differentiated Services.		
UNIT – V	**PROTOCOLS FOR QOS SUPPORT**	**(9 Periods)**
RSVP – Goals and Characteristics, Data Flow, RSVP operations, Protocol Mechanisms –Multiprotocol Label Switching – Operations, Label Stacking, Protocol details – RTP –Protocol Architecture, Data Transfer Protocol, RTCP.		

Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**

TEXT BOOK:

1 *William Stallings,* ***"HIGH SPEED NETWORKS AND INTERNETS****", Pearson Education, Second Edition, 2002.*

2 *IrvanPepelnjk, Jim Guichard, Jeff Apcar,* ***"MPLS and VPN architecture",*** *Cisco Press, Volume 1 and 2, 2003.*

REFERENCE BOOKS:

1 *Jean warland and Pravin Wadaja,* ***"High Performance Communication Networks"****, 2nd Edition, Jean Harcourt Asia Pvt. Ltd.,2001.*

2 *Andrew S. Tanenbaum,* ***"Computer networks",*** *PHI Private limited, new Delhi*

Abhijit S. Pandya, Ercan Sea, ***"ATM Technology for Broad Band Telecommunication Networks",***
CRC Press, New York, 2004.

4 *Tere Parnell,* ***"Guide to Building High-speed Networks",*** *Osborne/McGraw-Hill, 1998, 0072119578, 9780072119572.*

5. *Sumit Kasera, Pankaj Sethi,* ***" ATM Networks",*** *Tata Mc Graw- Hill, New Delhi , 2000*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Familiarize about ATM and Frame relay
CO2 Identify techniques to support real-time traffic and congestion control
CO3 Identify techniques to support real-time traffic and congestion control
CO4 Describe the integrated and differentiated services
CO5 Interpret protocols for different levels of quality of service (QoS)

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	L	L	L	-	-	L	L	-	-	-	L	L	M	-	M
CO2	M	M	M	-	-	L	L	-	-	-	L	L	M	-	M
CO3	M	M	M	-	-	L	L	-	-	-	L	L	M	-	M
CO4	L	L	L	-	-	L	L	-	-	-	L	L	M	-	M
CO5	L	L	L	-	-	L	L	-	-	-	L	L	M	-	M
18LPE$28	M	M	M	-	-	L	L	-	-	-	L	L	M	-	M

L - Low, M - Moderate (Medium), H - High

18LPE$29	CODING THEORY AND SECURED COMMUNICATION

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

* To understand the basics of number theory and Galois field concepts, importance of modern coding techniques in the design of digital communication systems, authentication and key management techniques and importance of security for networks.

UNIT – I	NUMBER THEORETIC AND ALGEBRAIC ALGORITHMS	(9 Periods)
Significance of network and data security in todays communication scenario – Overall Classification - Integer Arithmetic Modular Arithmetic – matrices – Linear congruence- Substitution ciphers – Transposition ciphers – Stream cipher- Block ciphers – Algebraic structures – GF(2^n) fields.		
UNIT – II	**LDPC CODES**	**(9 Periods)**
LDPC Codes: Construction and Notation - Tanner Graph - Decoding of LDPC Codes - EXIT Chart for LDPC codes - Irregular LDPC codes - LDPC codes in 5G.		
UNIT – III	**TRELLIS CODES AND TURBO CODES**	**(9 Periods)**
Modulation codes. Trellis coded modulation. Lattice type Trellis codes. Geometrically uniform trellis codes. Decoding of modulation codes- Turbo codes. Turbo decoder. Interleaver. Turbo decoder. MAP and log MAP decoders. Iterative turbo decoding.		
UNIT – IV	**INTEGRITY AUTHENTICATION AND KEY MANAGEMENT**	**(9 Periods)**
Message integrity – random oracle model – message authentication – SHA-512 – WHIRL POOL- Digital signature schemes Entity authentication– password – challenge response – zero knowledge – Biometrics – Kerberos – symmetric key management – public key distribution – steganography, Application Examples.		
UNIT – V	**NETWORK SECURITY**	**(9 Periods)**
Security at the Application Layer: E-mail – PGP – S/MIME – Security at the transport layer: SSL and TLS – Security at the network layer: IPsec, Two Security Protocol – Security Association – Internet Key Exchange – ISAKMP, Application Examples.		

Contact Periods: **Lecture: 45 PeriodsTutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**

TEXT BOOKS:

1 *Behrouz A.Forouzan,* ***"Cryptography and Network Security",*** *Special Edition, Tata McGraw Hill, 2007.*

2 *Tood.K.Moon "****Error Correcting Codes****" A John Wiley &Sons, INC, Publication*

REFERENCE BOOKS:

1 *Charlie Kaufman, Radia Perlman, Mike Speciner,* ***"Network Security Private Communication in a Public World",*** *Pearson Education, Second Edition, 2003.*

2 *Douglas R.Stinson,* ***"Cryptography: Theory and Practice",*** *CRC Press Series on Discrete Mathematics and its Applications, 1995*

3 *W.Stallings,* ***"Cryptography & Network Security: Principles and Practice",*** *Prentice Hall, Third Edition, 2003.*
4 *William Stallings* ***"Network Security Essentials: Applications and Standards",*** *2nd Edition, Pearson Education, 2000.*
5. *S.Lin&D.J.Costello, "****Error Control Coding (2/e)****", Pearson, 2005.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Describe the use of number theory and Galois field concepts
CO2 Construct LDPC Codes
CO3 Construct Trellis codes and Turbo codes
CO4 Describe new authentication and key management techniques
CO5 Recognize the importance of security for networks

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	H	H	H	H	L	L	H	H	-	-	-	H	H	L	H
CO2	H	H	H	H	L	H	H	H	-	-	-	H	H	L	H
CO3	H	H	H	H	L	H	H	H	-	-	-	H	H	L	H
CO4	H	H	H	H	L	H	H	H	-	-	-	H	H	L	H
CO5	H	H	H	H	L	H	H	H	-	-	-	H	H	L	H
18LPE$29	H	H	H	H	L	H	H	H	-	-	-	H	H	L	H

L - Low, M - Moderate (Medium), H - High

18LPE$30	SOFTWARE DEFINED NETWORKS *(Common to ECE & CSE)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

* Advance and emerging networking technologies. Software defined networking and how it is changing the way communications networks are managed, maintained, and secured. The concepts of virtualization and virtual machines.

UNIT – I	SDN: BACKGROUND AND MOTIVATION	(9 Periods)
Evolving Network Requirements - The history of SDN -The SDN Approach - SDN architecture and its fundamental abstractions - SDN- and NFV-Related Standards -Why SDN? - How SDN Works? Open Flow Concept and Implementation – Open Flow Limitations. Mininet: A simulation environment for SDN.		
UNIT – II	**SDN DATA PLANE AND CONTROL PLANE**	**(9 Periods)**
SDN Data Plane and Open Flow : SDN Data Plane –Open Flow Logical Network Device –Open Flow Protocol SDN Control Plane: SDN Control Plane Architecture - ITU-T Model – Open Daylight - REST - Cooperation and Coordination Among Controllers. Programming SDNs - Frenetic, Procera.		
UNIT – III	**SDN APPLICATION PLANE**	**(9 Periods)**
SDN Application Plane Architecture - Network Services Abstraction Layer-Traffic Engineering - Measurement and Monitoring - Security - Data Center Networking - Mobility and Wireless - Information-Centric Networking.		
UNIT – IV	**NETWORK FUNCTIONS VIRTUALIZATION**	**(9 Periods)**
Concepts and Architecture - Background and Motivation for NFV -Virtual Machines -NFV Concepts - NFV Benefits and Requirements - NFV Reference Architecture - NFV Functionality : NFV Infrastructure - Virtualized Network Functions -SDN and NFV- Network Virtualization: Open FlowVLAN Support - Network Virtualization – Open Daylight's Virtual Tenant Network- Software Defined Infrastructure.		
UNIT – V	**QUALITY OF SERVICE AND SECURITY**	**(9 Periods)**
Quality of Service : QoS Architectural Framework - Integrated Services Architecture (ISA) - Differentiated Services - Service Level Agreements - IP Performance Metrics – Open Flow QoSSupport. **Quality of Experience**: Definition of QoE- QoE Strategies in Practice-Factors Influencing QoE Measurements of QoE -Application of QoE **SECURITY:** Security Requirements - SDN Security -NFV Security - Applying Programming Techniques to Networks, Security Applications.		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1 *William Stallings* ***"Foundations of Modern Networking : SDN, NFV, QoE, IoT, and Cloud"*** *1st edition, Pearson Education, Inc. 2016.*

REFERENCE BOOKS:

1 *Paul Goransson and Chuck Black, "**Software Defined Networks: A Comprehensive Approach**", edition, Morgan Kaufmann Publishers, Inc., 2014.*

2 *Thomas D. Nadeau; Ken Gray, "**SDN: Software Defined Networks**", O'Reilly Media, Inc. 2013.*

3 *Vivek Tiwari, "**SDN and Open Flow for beginners with hands on labs**", Amazon Digital Services, Inc. 2013.*

4 *Kreutz et al.: "**Software-Defined Networking: A Comprehensive Survey**", Proceedings of the IEEE, Vol. 103, No. 1, January 2015*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Differentiate between traditional networks and software defined networks. [Familiarity]

CO2 Explain and discuss the basic concepts and architecture of SDN. [Familiarity]

CO3 Compare the performance of various open flow versions. Analyse and apply implementation of SDN through Open Flow Switches [Assessment]

CO4 Identify various SDN applications and environments that benefits from its use. [Usage]

CO5 Explain and discuss the basic concepts and architecture of Network Functions Virtualization. [Familiarity]

CO6 Evaluate the security issues and Quality of Service related to SDN. [Usage]

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	H	H	H	H	H	-	-	L	-	-	-	M	H	M	H
CO2	H	H	H	H	H	-	-	L	-	-	-	M	H	M	H
CO3	H	H	H	H	H	-	-	L	-	-	-	M	H	M	H
CO4	H	H	H	H	H	-	-	L	-	-	-	M	H	M	H
CO5	H	H	H	H	H	-	-	L	-	-	-	M	H	M	H
CO6	H	H	H	H	H	-	-	L	-	-	-	M	H	M	H
18LPE$30	H	H	H	H	H	-	-	L	-	-	-	M	H	M	H

L - Low, M - Moderate (Medium), H - High

18LPE$31	MASSIVE MIMO AND MILLIMETER WAVE SYSTEMS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- To teach the importance of improving capacity of wireless channel using MIMO, understand the concepts of MIMO and Massive MIMO in Wireless Communication and the principle of millimeter waves, millimeter transceivers.

UNIT – I	INTRODUCTION	(9 Periods)
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	**MIMO DIVERSITY AND SPATIAL MULTIPLEXING**	**(9 Periods)**
Sources and types of diversity, Analysis under Rayleigh fading, Diversity and channel knowledge. Alamouti space time code. MIMO spatial multiplexing: Space time receivers, ML, ZF, MMSE and Sphere decoding, BLAST receivers and Diversity multiplexing trade - off.		
UNIT – III	**MASSIVE MIMO SYSTEM**	**(9 Periods)**
Introduction - MIMO for LTE, Capacity of massive MIMO, Pilot Design for massive MIMO, Resource allocation and transceivers design, Base band and RF implementation, Channel Models.		
UNIT – IV	**MILLIMETER WAVES**	**(9 Periods)**
Millimeter wave characteristics- Channel performance at 60 GHz – Gigabit wireless communication – Development of millimeter wave standards-coexistence with wireless backhaul – review of modulation for millimeter wave – OOK, PSK, FSK and QAM.		
UNIT – V	**TRANSCEIVERS FOR MILLIMETER WAVES**	**(9 Periods)**
Millimeter wave link budget – Transceiver architecture – Transceiver without mixer- Receiver without local oscillator – Millimeter wave calibration – Millimeter wave antennas – parameters – beam steering antenna- Millimeter wave design consideration.		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1 *.David Tse and Pramod Viswanath, "**Fundamentals of Wireless Communication**", Cambridge University Press 2005.*
2 *Kao-Cheng Huang, Zhaocheng Wang**," Millimeter Wave Communication Systems",** Wiley, 2011.*

REFERENCE BOOKS:

1 *Sergey M. Smolskiy Author, Leonid A. Belov and Victor N. Kochemasov, **"Handbook of RF, Microwave, and Millimeter-Wave Components"**, Artech House Microwave Library, 2012.*
2 *Hamid Jafarkhani, "**Space - Time Coding: Theory and Practices**", Cambridge University Press 2005.*
3 *Tolga M. Duman, Ali Ghrayeb, "**Coding for MIMO Communication Systems**" John Wiley & Sons, Ltd 2007.*
4 *Mohinder Jankiraman, **"Space-time codes and MIMO systems",** Artech House, Boston, London . www.artech house.com, ISBN 1-58053-865-7-2004.*

5. *Paulraj Rohit Nabar, Dhananjay Gore,* ***"Introduction of space time wireless communication systems"****, Cambridge University Press, 2003.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Understand the various methods for improving capacity of wireless channel using MIMO

CO2 Discuss various Diversity techniques and spatial multiplexing techniques in MIMO

CO3 Describe Massive MIMO concepts

CO4 Understand about the concepts and challenges of mmwave communication

CO5 Describe about transmitter and receiver types in mmwave communication

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	H	H	H	H		H	H	-	-	-	-	H	H	-	H
CO2	H	H	H	H		H	H	-	-	-	-	H	H	-	H
CO3	H	H	H	H		H	H	-	-	-	-	H	H	-	H
CO4	H	H	H	H		H	H	-	-	-	-	H	H	-	H
CO5	H	H	H	H		H	H	-	-	-	-	H	H	-	H
18LPE$31	H	H	H	H		H	H	-	-	-	-	H	H	-	H

L - Low, M - Moderate (Medium), H - High

18LPE$32	OPTICAL COMMUNICATION AND NETWORKS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- To provide an overview of the various Optical system components, physical layerdesign and networking issues related to optical networks

UNIT – I	INTRODUCTION TO OPTICAL NETWORKS AND COMPONENTS	(9 Periods)
Introduction to Optical Networks: Telecommunications Networks Architecture, Services, circuit switching and packet switching, Optical Networks - Optical Packet Switching, Transmission Basics - Network Evolution, Nonlinear Effects: Self-phase Modulation, Cross-phase Modulation, Four Wave mixing – Solitons - Components: Couplers, Isolators and Circulators, Multiplexers and Filters, Optical Amplifiers, Transmitters, Detectors, Switches, Wavelength Converters.		
UNIT – II	**TRANSMISSION SYSTEM ENGINEERING**	**(9 Periods)**
Transmission System Engineering: System Model, Power Penalty, Transmitter, Receiver, Optical Amplifiers, Crosstalk, Dispersion, Wavelength Stabilization, Overall Design Considerations.		
UNIT – III	**CLIENT LAYERS OF THE OPTICAL LAYER AND NETWORK SURVIVABILITY**	**(9 Periods)**
SONET/SDH - Optical Transport Network- Generic Framing Procedure – Ethernet – IP – Multiprotocol Label Switching – Resilient packet ring – Storage area networks. Basic Concepts - Protection in SONET/SDH.- Protection in the Client Layer – Service Classes Based on Protection- Optical Layer Protection Schemes - Interworking between Layers.		
UNIT – IV	**WDM NETWORK ELEMENTS AND WDM NETWORK DESIGN**	**(9 Periods)**
Optical Line Terminals – Optical Line Amplifiers – Optical Add/ Drop Multiplexers – Optical Cross connects.Cost Trade-Offs: A Detailed Ring Network Example – LTD and RWA Problems – Dimensioning Wavelength-Routing Networks – Statistical Dimensioning Models – Maximum Load Dimensioning Models.		
UNIT – V	**PHOTONIC PACKET SWITCHING AND ACCESS NETWORKS**	**(9 Periods)**
Optical Time Division Multiplexing – Synchronization - Header Processing – Buffering - Burst Switching Network Architecture Overview – Enhanced HFC - Fiber to the Curb (FTTC)		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1 *Rajiv Ramaswami and Kumar Sivarajan, Galen H. Sasaki,* ***"Optical Networks A Practical Perspective",*** *3rd Edition, , Morgan - Kaufmann Publishers.*

2 ***Optical Networks, Third Generation Transport Systems****, Uyless Black, Pearson, 2002.*

REFERENCE BOOKS:

1 *Max Ming-Kang Liu,* ***"Principles and Applications of Optical Communication",*** *Tata McGraw Hill Education Pvt., Ltd., New Delhi.*

2 *Thomas E. Stern, Georgios Ellinas, Krishna Bala,* ***"Multiwavelength Optical Networks – Architecture, Design and control"****, Cambridge University Press, 2nd Edition, 2009.*

3 *Rajiv Ramaswami and Kumar N. Sivarajan,* ***"Optical Networks : A Practical Perspective",*** *Harcourt Asia Pte Ltd., Second Edition 2006.*

4 *P.E. Green, Jr.,* ***"Fiber Optic Network",*** *Prentice Hall, NJ, 1993.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Identify the technology underlying optical networks and the different components needed to build an optical network

CO2 Understand transmission systems engineering

CO3 Describe Client layers of optical network and optical layer protection

CO4 Describe WDM network elements and WDM network design models.

CO5 Explain access networks architecture and photonic packet switching

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	L	M	L	-	-	-	-	-	-	M	M	-	M
CO2	M	M	L	L	L	-	-	-	-	-	-	L	M	-	M
CO3	M	M	L	L	-	-	-	-	-	-	-	M	M	-	M
CO4	H	H	L	L	-	-	-	-	-	-	-	M	M	-	L
CO5	H	H	M	M	L	-	-	-	-	-	-	M	M	-	M
18LPE$32	M	M	L	L	L	-	-	-	-	-	-	M	M	-	M

L - Low, M - Moderate (Medium), H - High

18LPE$33	EVOLUTION OF 4G /5G TECHNOLOGIES

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- To understand the challenges of 4G , 5G technology and explore the architecture of4G, understand the 5G Modulation Schemes and different types of multiple access techniques in 5G

UNIT – I	INTRODUCTION TO 4G	(9 Periods)
Introduction – 4G vision – 4G features and challenges - Applications of 4G – 4G Technologies, Multicarrier Modulation: OFDM principle- Modulation, Cyclic Prefix - Windowing, PAPR, OFDM in LTE, Timing and Frequency Synchronization, SC-FDE - Smart antenna techniques.		
UNIT – II	**SYSTEM ARCHITECTURE OF LTE**	**(9 Periods)**
OFDM with FDMA, TDMA, CDMA, OFDMA, SC-FDMA, OFDMA and SC-FDMA in LTE, IMS Architecture, LTE, Advanced Broadband Wireless Access and Services, MVNO.		
UNIT – III	**EVOLUTION OF 5G NETWORKS**	**(9 Periods)**
Introduction to 5G, vision and challenges, 5G NR – New Radio – air interface of 5G, radio access, Ultra-Dense Network Architecture and Technologies for 5G- Concept and Challenges of UDN, GPP HeNB Architecture, Key Technologies of UDN- Flexible Networking, Multi-RATs Coordination.		
UNIT – IV	**5G MODULATION SCHEMES**	**(9 Periods)**
Introduction to Equalization- types - Filter-bank based multi-carrier (FBMC), Universal filtered multi carrier (UFMC), Generalized frequency division multicarrier (GFDM) - Principles, Transceiver Block diagram, Frame structure, Resource structure, allocation, mapping, MIMO-GFDM.		
UNIT – V	**MULTIPLE ACCESS TECHNIQUES IN 5G**	**(9 Periods)**
NOMA – Principle- Superposition Coding, Successive Interference Cancellation, Power Domain NOMA, Sparse Code NOMA- types, Power Domain Sparse Code NOMA and IDMA Relaying: Cooperative NOMA- Benefits and Challenges, Half duplex relaying, Full duplex relaying, Amplify and forward relaying, Decode and forward relaying, Decode and forward relaying with PLNC, BER Analysis, Capacity Analysis.		

Contact Periods:
Lecture: 45 PeriodsTutorial: 0 Periods Practical: 0 Periods Total: 45Periods

TEXT BOOKS:

1 *Arunabha Ghosh, Jan Zhang, Jefferey Andrews, Riaz Mohammed,* ***"Fundamentals of LTE"*** *Pearson education (Formerly Prentice Hall, Communications Engg and Emerging Technologies), ISBN-13: 978-0-13-703311-9, 2011.*

2 *Afif Osseiran, Jose.F.Monserrat and Patrick Marsch,* ***"5G Mobile and Wireless Communications Technology"****, Cambridge University Press, 2016.*

REFERENCE BOOKS:

1 *Xiang, W; Zheng, K; Shen, X.S;* ***"5G Mobile Communications",*** *Springer, 2016.*

2 *'HarriHolma and Antti Toskala ,* ***"LTE for UMTS Evolution to LTE-Advanced",****Second Edition - 2011, John Wiley & Sons, Ltd. Print ISBN: 9780470660003.*

3 *UMTS' Pierre Lescuyer and Thierry Lucidarme* ***,"EVOLVED PACKET SYSTEM (EPS) ; THE LTE AND SAE EVOLUTION OF 3G",*** *2008, John Wiley & Sons, Ltd. Print ISBN:978-0-470-05976-0.*

4 *Stefania Sesia, IssamToufik, and Matthew Baker,* ***"LTE – The UMTS Long Term Evolution ; From Theory to Practice"****, 2009 John Wiley & Sons Ltd, ISBN 978-0-470-69716-0.*
5 *Saad Z Asif,* ***"5G Mobile Communication,Concepts and Challenges",*** *CRC Press.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Comprehend the 4G technology

CO2 Appreciate the significance of 4G technology and its architecture

CO3 Describe the evolution of 5G networks

CO4 characterize the different 5G potential Candidate Waveforms

CO5 explain the different 5G multiple access Schemes

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	M	-	-	L	-	-	-	-	-	M	M	-	M
CO2	M	M	M	-	-	L	-	-	-	-	-	M	M	-	M
CO3	M	M	M	-	-	L	-	-	-	-	-	M	M	-	M
CO4	M	M	M	-	-	L	-	-	-	-	-	M	M	-	M
CO5	M	M	M	-	-	L	-	-	-	-	-	M	M	-	M
18LPE$33	M	M	M	-	-	L	-	-	-	-	-	M	M	-	M

L - Low, M - Moderate (Medium), H - High

VERTICAL –II

RF TECHNOLOGIES

18LPE$18	SATELLITE COMMUNICATION

PRE-REQUISITES:

* **DIGITAL COMMUNICATION** **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To Learn Current state and advantages of Satellite Communication.
* To understand satellite orbits and trajectories.
* To Have Knowledge on different satellite subsystems and multiple access methods.
* To understand different aspects of communication link design.

UNIT I: SATELLITE ORBITS	**(9 Periods)**
Orbital Mechanics - Orbit Equations- Kepler's Laws - Orbital Period -Orbits and their types - Orbital Spacing- look angle calculation -Satellite Launch - Propagation Delay-System Performance.	
UNIT II: SATELLITE SUBSYSTEM	**(9 Periods)**
AOCS -TTC&M –Power – Transponders - Antennas -earth control-Effects of earth Perturbation-suntransit-moontransit-satellite power design -MTBF -Basic Equations -System Noise and G/T ratio –Uplink- Downlink and Design for a specified C/N ratio - GEO and LEO examples -Atmospheric and Rain effects on link performance.	
UNIT III: SATELLITE LINK DESIGN	**(9 Periods)**
Link design equation -noise temperature - atmospheric effects on link design -interference effects - earth station parameters -earth space propagation effects - frequency window - free space loss - Ionospheric scintillation- telemetry -tracking and command of satellites - Digital Modulation for satellite systems - Error control requirements for satellite.	
UNIT IV: SATELLITE MULTIPLE ACCESS SYSTEM	**(9 Periods)**
FDMA techniques -SCPC and CSSB systems - TDMA frame structure- burst structure- frame efficiency -super-frame - frame acquisition and synchronization -TDMA vs FDMA - burst time plan- beam hopping - satellite switched -Erlang call congestion formula - DA-FDMA -DA-TDMA	
UNIT V: SATELLITE SERVICES	**(9 Periods)**
Remote sensing- navigation - scientific and military application -VSAT -Network architecture – AccessControl protocols and techniques - VSAT Earth stations- Satellite Mobile Telephony - Global star - DBS/DTH Television – GPS - Weather satellites.	

Contact periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *T.Pratt, C. Bostian and J.Allnutt;* ***— "Satellite Communications",*** *John Wiley and Sons, Second Edition, 2003.*
2. *D.Rody,* ***— "Satellite Communications"****, McGraw-Hill Professional, Fourth Edition, 2006.*

REFERENCE BOOKS:

1. *W.L.Pritchard,H G Suyderhoud and R A Nelson,* ***— "Satellite Communication System Engineering",*** *Second edition, Prentice Hall, 1993.*
2. *Tri. T. Ha,* ***— "Digital Satellite Communications"****, McGraw Hill, Second Edition, 1990.*
3. *B.N.Agarwal,* ***— "Design of Geosynchronous Space craft",*** *Prentice Hall, 1986.*
4. *M. Richharia,* ***— "Satellite communication systems"****, McGraw-Hill Professional , 1999.*

COURSE OUTCOMES:

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

CO 1: Knowledge on basics of Satellite Communication.
CO 2: Ability to understand satellite orbits and trajectories.
CO 3: Have Knowledge on different satellite subsystems.
CO 4: Ability to understand different aspects of communication link design.
CO 5: Knowledge on multiple access methods.
CO 6: Knowledge on important applications of satellites

COURSE ARTICULATION MATRIX

CO/PO	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	PSO 2	PSO 3
CO1	M	L	-	-	-	-	L	-	L	-	-	L	M	L	-
CO2	-	-	-	L	L	-	-	-	-	-	-	-	L	L	-
CO3	M	-	-	-	-	-	L	-	L	-	-	-	L	-	-
CO4	M	L	M	M	M	L	L	-	-	L	L	L	M	M	-
CO5	M	-	-	-	M	L	L	-	-	L	L	-	M	L	-
CO6	L	-	-	-	L	L	L	-	-	-	L	-	L	L	-
18LPE$18	M	L	L	M	M	L	L	-	L	L	L	L	M	L	-

L - Low, M - Moderate (Medium), H - High

18LPE$26	MICROWAVE INTEGRATED CIRCUITS

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* The objective is to provide the basic concepts and techniques of Microwave Integrated Circuits.

UNIT I: INTRODUCTION	**(9 Periods)**
Introduction to Monolithic Microwave Integrated Circuits (MMICs) - their advantages over discrete circuits - materials - MMIC fabrication techniques - MOSFET fabrication - Thin film formation.	
UNIT II: MICROSTRIP LINES	**(9 Periods)**
Planar transmission lines for MICs – Method of conformal transformation for microchip analysis – Concept of effective dielectric constant – Effective dielectric constant for microstrip – Losses in microstrip.	
UNIT III: SLOT LINES	**(9 Periods)**
Slot Line Approximate analysis and field distribution – Transverse resonance method and evaluation of slot line impedance – Comparison with micro strip line.	
UNIT IV: LUMPED ELEMENTS FOR MICS	**(9 Periods)**
Use of Lumped elements – Capacitive elements – Inductive elements and Resistive elements.	
UNIT V: MICROWAVE SEMICONDUCTOR DEVICES & MICROWAVE PASSIVE COMPONENTS	**(9 Periods)**
Parametric amplifiers, tunnel diode, varactor diode, PIN diode, Gunn diode, their principle of operation, performance characteristics& applications, scattering parameter calculations of E plane-Tee, Magic Tee, Directional Coupler.	

Contact periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1.Gupta KC, and Amarjit Singh, ***Microwave Integrated circuits****, WileyEastern,1974.*
2.Leo Young, ***Advances in Microwaves****, Academic Press.*

REFERENCE BOOKS:

*1. Bharathi Bhat, and S.K. Koul "****stripline-like transmission lines for microwave integrated circuits****, New age international ,2007.*
*2. Samuel. Y. Liao, "****Microwave Circuit Analysis and Amplifier Design****", Prentice Hall. Inc.,1987.*
*3. T.C.Edwards, "****Foundations for Microstrip Circuit Design (2/e)****", Wiley, 1992.*
*4.Ravender Goyal, "****Monolithic MIC; Technology & Design****", Artech House, 1989.*

COURSE OUTCOMES:

Upon completion of this course, the students will be able to

CO1: Acquire knowledge about Microwave Integrated Circuits.
CO2: Gain knowledge of plannar transmission line for MIC.
CO3: Gain knowledge of slot lines for MIC.
CO4: Gain knowledge and understanding of lumped elements for MIC.
CO5: Develop understanding of the fundamentals required to design & implement Integrated Circuits operating at microwave frequencies.
CO6: Acquire knowledge about Microwave Semiconductor Devices.

COURSE ARTICULATION MATRIX

CO/PO	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	PSO 2	PSO 3
CO1	H	H	-	-	H	M	-	H	-	-	-	-	-	M	-
CO2	-	H	-	-	H	M	M	-	-	-	-	-	-	H	-
CO3	-	-	-	-	H	M	L	-	-	-	-	-	-	M	-
CO4	-	H	-	-	H	L	M	-	-	-	-	-	-	M	-
CO5	-	H	-	-	H	H	H	-	-	-	-	-	-	H	-
CO6	-	-	-	-	H	H	H	-	-	-	-	M	-	M	-
18LPE$26	L	H	-	-	H	M	H	L	-	-	-	L	-	M	-

L - Low, M - Moderate (Medium), H - High

18LPE$34	ADVANCED RADIATION SYSTEMS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- The students will have knowledge on the principles of radiating systems, analysis and design of antenna arrays, will gain knowledge on synthesis of antennas, analysis and design of special antennas and concepts of smart antennas

UNIT – I	FUNDAMENTALS OF RADIATION	(9 Periods)

Retarded vector potential- Heuristic approach and Maxwell's equation approach - Duality theorem - The Lorentz guage condition - Fields radiated by an alternating current element and half wave dipole - Total power radiated and radiation resistance of alternating current element and half wave dipole - Power radiated in the far field - Linear, elliptical and circular polarization- Development of the Poincare sphere.

UNIT – II	ANTENNA ARRAY	(9 Periods)

N element linear array - uniform amplitude and spacing - Phased arrays - Directivity of Broadside and End fire arrays - Three dimensional characteristics - Pattern multiplication - Binomial arrays and Dolph-T chebycheff arrays - Circular array - Planararray - array factor, beam width, directivity.

UNIT – III	ANTENNA SYNTHESIS	(9 Periods)

Synthesis problem - line source based beam synthesis methods, Fourier transform and Woodward - Lawson sampling methods - Linear array shaped beam synthesis method- Low side lobe, narrow main beam synthesis methods - discretization of continuous sources. Schelkunoff polynomial method.

UNIT – IV	SPECIAL ANTENNAS	(9 Periods)

Aperture antennas - Huygens Principle. Rectangular apertures - Circular apertures and their design considerations - Babinets principle, Fourier transform in aperture antenna theory. Micro strip antennas: feeding methods - Rectangular patch - transmission line model - circular patch - Micro strip array and feed networks.

UNIT – V	SMART ANTENNAS	(9 Periods)

Beam steering - degree of freedom - optimal antenna - adaptive antennas – smart antennas - key benefits of smart antennas technology - wide band smart antennas - Narrow band processing: signal model, conventional beam former, null steering beam former, optimal beam former, optimization using reference signal and beam space processing.

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Balanis.A,* ***"Antenna Theory -Analysis and Design****", John Wiley and Sons, New York, 4th Edition, 2016.*

2 *Lal Chand Godara*, **"Smart Antennas"**, *C.R.C Press, 2018.*

REFERENCE BOOKS :

1 *John D Kraus, Ronald J Marhefka, Ahmad S Khan,* ***"Antennas for all applications"****, 3rd Edition , John Wiley and Sons, New York, 2012.*

2 *Edward C. Jordan, Keith G. Balmain****"Electromagnetic Waves and Radiating Systems"****, 2nd Edition, Prentice Hall of India, 2015.*

3 *Warren L. Stutzman and Gary A. Thiele,****"Antenna Theory and Design",****3rd Edition,John Wiley and Sons, New York, 2012.*

4 *Theodore S. Rappaport,****"Smart Antennas: Adaptive Arrays, Algorithms, & Wireless Position Location"****, IEEE Press, 2011.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Explain the concept of radiation, analyze and design antenna arrays for given specifications

CO2 Synthesize antennas for known excitations and outputs

CO3 Explain the concepts of smart Antennas**.**

COURSE ARTICULATION MATRIX:

CO/PO	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	PSO 2	PSO 3
CO1	H	M	L	-	-	-	-	-	-	-	-	-	H	L	L
CO2	H	H	L	-	-	-	-	-	-	-	-	-	H	L	L
CO3	H	L	L	-	-	-	-	-	-	-	-	-	H	L	L
18LPE$34	H	M	L	-	-	-	-	-	-	-	-	-	H	L	L

L - Low, M - Moderate (Medium), H - High

18LPE$35	ELECTROMAGNETIC INTERFERENCE ANDCOMPATIBILITY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

- To acquire knowledge on the fundamentals of Electromagnetic Interference, its measurements, control techniques and design of EMC in PCBs.

UNIT – I	EMI ENVIRONMENT	(9 Periods)
EMI and EMC concepts and definitions-Sources of EMI-conducted and radiated EMI- Transient EMI- Time domain Vs Frequency domain EMI-Units of measurementparameters.		
UNIT – II	**EMI COUPLING PRINCIPLES AND STANDARDS**	**(9 Periods)**
Conducted-Radiated and Transient Coupling-Common Impedance Ground Coupling- Radiated Common Mode and Ground Loop Coupling-Radiated Differential Mode Coupling-NearField Cable to Cable Coupling-Power Mains and Power Supply coupling- Units of specifications-Civilian standards - FCC, CISPR, IEC, EN, Military standards - MILSTD 461D/462		
UNIT – III	**EMI MEASUREMENTS**	**(9 Periods)**
EMI Test Instruments and Systems-EMI Shielded Chamber-Open Area Test Site-TEMCell-Sensors andInjectors and Couplers-Test beds for ESD and EFT.		
UNIT – IV	**EMI CONTROL TECHNIQUES**	**(9 Periods)**
Shielding-Filtering-Grounding-Bonding-Isolation Transformer-Transient Suppressors-Cable Routing-Signal Control-Component Selection and Mounting		
UNIT – V	**EMC DESIGN OF PCBS**	**(9 Periods)**
PCB Traces Cross Talk-Impedance Control-Power Distribution Decoupling-Zoning-Motherboard Designs and Propagation Delay Performance Models.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *V.P.Kodali, **"Engineering Electromagnetic Compatibility: Principles, Measurements, Technologies, and Computer Models**", s.Chand& Co., New Delhi,2011.*

REFERENCES:

1 *Clayton R.Paul, **"Introduction to Electromagnetic compatibility"**, John Wiley & Sons, 2nd edition, 2006.*

2 *Henry W.Ott, **"Noise Reduction Techniques in Electronic Systems"**, John Wiley and Sons, New York, 2008.*

3 ***"Electromagnetic Interference and Compatibility"**, IIT-Delhi, IMPACT Series, Modules 1-9.*

4 *Bernhard Keiser, **"Principles of Electromagnetic Compatibility"**, Artech house, 3rd Ed, 2006..*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Explain EMI/EMC concepts, various coupling principles and standards

CO2 Discuss various EMI measurement methods and control techniques

CO3 Describe the Electromagnetic Complianceprocedure for PCB design

COURSE ARTICULATION MATRIX:

CO/PO	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	PSO 2	PSO 3
CO1	H	M	L	-	-	-	-	-	-	-	-	-	H	M	L
CO2	H	H	L	-	-	-	-	-	-	-	-	-	H	M	L
CO3	H	L	L	-	-	-	-	-	-	-	-	-	H	M	L
18LPE$35	H	M	L	-	-	-	-	-	-	-	-	-	H	M	L

L - Low, M - Moderate (Medium), H - High

18LPE$36	RF TRANSCEIVERS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

- The students will understand the working of various components of RFtransmitter and receiver systems.

UNIT – I	FUNDAMENTAL CONCEPTS IN TRANSCEIVER DESIGN	(9 Periods)
Linear Systems and Transformations – Nonlinear systems – Noise – RF system design parameters – Modulation accuracy – Transmitter systems parameters – P1dB – IP3 – PAPR – Power back off – ACPR – EVM – Linearization of RF power amplifiers.		
UNIT – II	**TRANSMITTER DESIGN**	**(9 Periods)**
MIMO transmission schemes –MIMO transceiver architectures: Antenna selection architecture – Frequency division multiplexing architecture – Time division multiplexing architecture – Code division multiplexing architecture – Antenna crosstalk – Nonlinear crosstalk – Impairment and distortion compensation.		
UNIT – III	**RECEIVER DESIGN**	**(9 Periods)**
Receiver architectures – Smart antenna receiver architectures – MIMO receiver architectures – Capacity reduction of MIMO system due to frontend – RF interference on MIMO receivers – MIMO test bed design.		
UNIT – IV	**RF IMPAIRMENTS IN MIMO TRANSCEIVERS**	**(9 Periods)**
Phase noise in MIMO transceivers – DC offset in MIMO transceivers – I/Q imbalance inMIMO transceivers - BER analysis		
UNIT – V	**SINGLE RF FRONT END MIMO TRANSCEIVERS**	**(9 Periods)**
RF front end MIMO using antenna selection – Single RF front end MIMO using FDM, TDMand CDM – Single RF front end MIMO using a parasitic antenna		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Abbas Mohammadi and Fadhel M. Ghannouchi, "**RF Transceiver Design for MIMOWireless Communications**", Springer, 2012.*

REFERENCE BOOK

1 *Harvey Lehpamer,* ***"Transmission System Design Handbook for Wireless Networks"****, Artech House, 2012*

2 *David Pozar,* ***"Microwave and RF Wireless Systems",*** *Wiley, 2010.*

3 Stephan A Mass, ***"Non-Linear Microwave and RF circuits",***Artech House, SecondEdition, 2013.

4 *George D. Vendelin, Anthony M. Pavio, Ulrich L. Rohde****, "Microwave Circuit DesignUsing Linear and Nonlinear Techniques",*** *John Wiley, 2015.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Explain the fundamental concepts used in RF transceivers design

CO2 Discuss the design procedure of RF transmitter and RF receiver

CO3 Recall RF impairments and design single RF front end for MIMO transceivers

COURSE ARTICULATION MATRIX:

CO/PO	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	PSO 2	PSO 3
CO1	H	M	L	-	-	-	-	-	-	-	-	-	H	L	L
CO2	H	H	L	-	-	-	-	-	-	-	-	-	H	L	L
CO3	H	H	L	-	-	-	-	-	-	-	-	-	H	L	L
18LPE$36	H	H	L	-	-	-	-	-	-	-	-	-	H	L	L

L - Low, M - Moderate (Medium), H - High

18LPE$37	RF SYSTEM DESIGN

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- The students will have an idea to analyse, design and realization of RF transmission & micro-strip lines, passive microwave filters, impedance matching networks, RF amplifier and oscillators and will understand the operating principles of oscillators, mixers and various sub-systems of RF Section of a Receiver and gain knowledge on link availability, fading and link budget design for a terrestrial Microwave link.

UNIT – I	RF ISSUES, TRANSMISSION LINE ANALYSIS AND DESIGN	(9 Periods)
Issues in RF design - Electromagnetic Spectrum - RF behavior of passive components - Transmission line analysis - open ended, short circuited - Sourced and Loaded Transmission line - Smith Chart and applications - Micro strip Transmission line design - Scattering Parameters - Impedance Matching using Lumped Elements.		
UNIT – II	**RF FILTER DESIGN**	**(9 Periods)**
Overview - Basic RLC Series and Parallel resonators – RF Filter design using Insertion Loss method: Butterworth, Chebyshev and Linear Phase: LPF, HPF, BPF, BSF-Normalisation for Frequency and Type – Impedance Normalisation- Filter implementations: Richard's transform, Kuroda's identities, Series to Parallel Element conversion.		
UNIT – III	**RF AMPLIFIER DESIGN, EFFECTS OF NON-LINEARITY**	**(9 Periods)**
Two Port Power Gains - Stability considerations - Input and Output Stability circles – Unconditional Stability – Design for Maximum Gain and Specified Gain – LNA Design Issues in High power Amplifier design - Gain compression – Inter-Modulation products – Third order Intercept point – Dynamic Range – Intercept Point for cascaded systems.		
UNIT – IV	**OSCILLATORS, MIXERS & RF FRONT END DESIGN**	**(9 Periods)**
General Analysis of Oscillator– Oscillators using BJT and FET – Colpitts and Hartley Oscillator design – Crystal Oscillator – Microwave Oscillators - RF Front End and Tuner building blocks – Mixers - RF directional couplers and hybrid couplers - Complete RF Tuner design considerations.		
UNIT – V	**WIRELESS LINK AND NETWORK DESIGN**	**(9 Periods)**
Microwave transmission – Point-to-Point link design – theoretical and practical aspects – Fade margin – Rain effects – protected and non-protected microwave systems – link design and path calculations – design guidelines – MW lookup tables – Point to Multi-Point wireless networks - Cell site selection – Microwave Repeater site selection.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK :

1 *David M. Pozar, **"Microwave Engineering",** Wiley India (P) Ltd, New Delhi, 4th edition, 2013.*

2 *Reinhold Ludwig and Gene Bogdanov, **"RF Circuit Design: Theory andApplications**", Pearson Education Inc., 2nd edition, 2011.*

REFERENCE BOOKS :

1 *Harvey Lehpamer, **"Transmission System Design Handbook for Wireless Networks"**, Artech House, 2012*

2 *David Pozar, **"Microwave and RF Wireless Systems",** Wiley, 2010.*

3 Stephan A Mass, ***"Non-Linear Microwave and RF circuits",***Artech House, SecondEdition, 2013.

4 *George D. Vendelin, Anthony M. Pavio, Ulrich L. Rohde**, "Microwave Circuit Design Using Linear and Nonlinear Techniques",** John Wiley, 2015.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Formulate, analyze and solve design problems in RF transmission lines, micro-strip lines, passive RF filters and impedance matching networks.

CO2 Comprehend and explain operating principles and design concepts of RFamplifiers, oscillators and mixers

CO3 Analyze and solve problems on microwave link availability, fade margin and link budget.

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	H	M	L	-	-	-	-	-	-	-	-	-	H	L	L
CO2	H	H	L	-	-	-	-	-	-	-	-	-	H	L	L
CO3	H	H	L	-	-	-	-	-	-	-	-	-	H	L	L
18LPE$37	H	H	L	-	-	-	-	-	-	-	-	-	H	L	L

L - Low, M - Moderate (Medium), H - High

18LPE$38	SMART ANTENNAS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

- The students will acquire knowledge on basics of smart antennas, understand spatial temporal characteristics for different channel models and gain knowledge on DOA estimation techniques.

UNIT – I	INTRODUCTION TO SMART ANTENNAS	(9 Periods)
Antenna gain-Phased array antenna-power pattern-beam steering-degree of freedom- optimal antenna- adaptive antennas-smart antenna: key benefits of smart antenna technology-wide band smart antennas		
UNIT – II	**SPATIAL PROCESSING FOR WIRELESS SYSTEMS**	**(9 Periods)**
Spatial processing for wireless systems. Adaptive antennas. Beam forming networks,Digital radio receiver techniques and software radios.		
UNIT – III	**SPATIAL PROCESSING FOR CDMA SYSTEMS**	**(9 Periods)**
Coherent and non-coherent CDMA spatial processors. Dynamic re-sectoring, Range and capacity extension – multi-cell systems.		
UNIT – IV	**SPATIO – TEMPORAL CHANNEL MODELS**	**(9 Periods)**
Environment and signal parameters. Geometrically based single bounce elliptical model. Optimal spatial filtering – adaptive algorithms for CDMA. Multi-target decision – directed algorithm.		
UNIT – V	**DIRECTION OF ARRIVAL ESTIMATION METHODS**	**(9 Periods)**
DOA estimation – conventional and subspace methods. ML estimation techniques. Estimation of the number of sources using eigen decomposition. Direction finding and true ranging PL systems. Elliptic and hyperbolic PL systems. TDOA estimation techniques.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *J.C.Libertiand T.S.Rappaport,* ***Smart Antennas for Wireless Communication****,Prentice Hall (PTR),2012.*

2 *Lal Chand Godara,"****Smart Antennas",****C.R.C Press, 2018.*

REFERENCE BOOKS:

1 *Warren L Stutzman, Gary A.Thiele,* ***" Antenna Theory and Design"****McGraw Hill, 3rd edition, ", John Wiley & Sons, 2013*

2 *Balanis.A,* ***"Antenna Theory Analysis and Design",*** *John Wiley and Sons, New York, 4th Edition, 2016.*

3 *R.Janaswamy,* ***Radio Wave Propagation and Smart Antennas for Wireless Communication****, Kluwer, 2008.*

4 *John.L.Volakis,* ***"Antenna Engineering Handbook"****, 5thEdition, McGraw Hill, 2018.*

5 *Constantine A.Balanis,* ***"Modern Antenna Handbook"****, John Wiley and Sons, 2008.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Explain smart antenna concepts and perform signal processing for wireless systems

CO2 Discuss thespatio-temporal processing concepts for wireless channels

CO3 Perform signal processing for CDMA systems and Estimate Direction of Arrival.

COURSE ARTICULATION MATRIX:

CO/PO	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	PSO 2	PSO 3
CO1	H	M	L	-	-	-	-	-	-	-	-	-	H	L	L
CO2	H	H	L	-	-	-	-	-	-	-	-	-	H	L	L
CO3	H	L	L	-	-	-	-	-	-	-	-	-	H	L	L
18LPE$38	H	M	L	-	-	-	-	-	-	-	-	-	H	L	L

L - Low, M - Moderate (Medium), H - High

18LPE$39	MODERN ANTENNAS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- The students will acquire knowledge on microstrip patch antennas, active integrated antennas, reconfigurable array antennas and their designrequirements.

UNIT – I	MICROSTRIP ANTENNAS	(9 Periods)
Advantages and trade-off-material consideration-Methods of analysis and design-Excitation methods-Dual polarization & circular polarization techniques-Broadband and dual band techniques-Antenna miniaturization techniques		
UNIT – II	**FRACTAL ANTENNAS**	**(9 Periods)**
Fractal antenna geometries-Iterated function systems-Fractal antenna elements-Fractal antenna arrays-Antenna arrays based on fractal and aperiodic tilings		
UNIT – III	**MOBILE HANDESET ANTENNAS**	**(9 Periods)**
Impact on antenna design-Cellular handset antenna design issues-Helical wire antennas and variants-Evolution of the PIFA-Ceramic chip and Resonator antennas-SAR measurement and minimization-Provision for GPS and Bluetooth-Measurement of handset antennas-Future trends		
UNIT – IV	**BROADBAND PLANAR ANTENNA**	**(9 Periods)**
Introduction-Suspended plate antennas-Techniques for broad impedance bandwidth-Techniques for enhanced radiation performance-Applications in high speed wireless communication-Planar monopole antennas - Applications in high speed UWB wireless communication		
UNIT – V	**ANTENNAS FOR MEDICAL APPLICATIONS**	**(9 Periods)**
Environment-Antennas for medical imaging-Heating-Bio-Telemetry-Pulsed Electromagnetic Fields-sensing-Future directions		

Contact Periods:

Lecture 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK :

1 *John.L.Volakis,* ***"Antenna Engineering Handbook",*** *5th Edition, McGraw Hill, 2018.*

2 *Constantine A.Balanis,* ***"Modern Antenna Handbook",*** *John Wiley and Sons, 2008.*

REFERENCE BOOKS :

1 *DebatoshGuha, Yahia M.M. Antar,* ***"Microstrip and Printed Antennas",*** *1st Edition,John Wiley & Sons, 2011..*

2 *S.Drabowitch, A.Papiernik ,et.al,* ***"Modern Antennas",*** *Springer, Second edition,2015*

3 *ZhiNing Chen,* ***"Antennas for Portable Devices",*** *John Wiley & Sons, 2017.*

4 *A.R.Harish and M.Scahidananda,"* ***Antennas and Wave Propagation",*** *OxfordUniversity Press,*
Chennai, 2017.

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Design and analyze the characteristics of microstrip and fractal antennas

CO2 Discuss the design of antennas for personal communication.

CO3 Recallantenna characteristicssuitable for broadband and medical applications.

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	H	M	L	-	-	-	-	-	-	-	-	-	H	M	L
CO2	H	H	L	-	-	-	-	-	-	-	-	-	H	M	L
CO3	H	L	L	-	-	-	-	-	-	-	-	-	H	M	L
18LPE$39	H	M	L	-	-	-	-	-	-	-	-	-	H	M	L

L - Low, M - Moderate (Medium), H - High

VERTICAL III

SIGNAL AND IMAGE PROCESSING

18LPE$02	SPEECH SIGNAL PROCESSING

PRE-REQUISITES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To have in-depth knowledge on basic concepts and speech Analysis.
* To analyze the quality and properties of speech signal.
* To model speech signals
* To have in-depth knowledge on speech recognition and speech synthesis

UNIT I: SPEECH FUNDAMENTALS	**(9 Periods)**
Basic Concepts: Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics – acoustics of speech production; Review of Digital Signal Processing concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods.	
UNIT II: SPEECH ANALYSIS	**(9 Periods)**
Speech Analysis: Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures – mathematical and perceptual – Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths.	
UNIT III: SPEECH MODELING	**(9 Periods)**
Speech Modeling: Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues.	
UNIT IV: SPEECH RECOGNITION	**(9 Periods)**
Speech Recognition: Architecture of a large vocabulary continuous speech recognition system – acoustics and language models – ngrams, context dependent sub-word units; Applications and present status.	
UNIT-V: SPEECH SYNTHESIS	**(9 Periods)**
Speech Synthesis: Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, subword units for TTS, intelligibility and naturalness – role of prosody, Applications and present status. Speech Coding Standards-An overview of ITU-T G.726, G.728 and G.729standards.	

Contact periods:

Lecture:45 Periods **Tutorial:0 Periods** **Practical:0 Periods** **Total:45 Periods**

TEXT BOOKS:

1. *Lawrence Rabiner and Biing-Hwang Juang, "**Fundamentals of Speech Recognition**", Pearson Education, 2003.*
2. *Daniel Jurafsky and James H Martin, "**Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition**", Pearson Education.*

REFERENCE BOOKS:

1. *Steven W. Smith, "**The Scientist and Engineer's Guide to Digital Signal Processing**", California Technical Publishing.*
2. *Thomas F Quatieri, "**Discrete-Time Speech Signal Processing – Principles and Practice**", Pearson Education.*
3. *Claudio Becchetti and Lucio Prina Ricotti, "**Speech Recognition**", John Wiley and Sons, 1999.*
4. *Ben gold and Nelson Morgan, "**Speech and audio signal processing**", processing and perception of speech and music, Wiley- India Edition, 2006 Edition.*
5. *Frederick Jelinek, "**Statistical Methods of Speech Recognition**", MIT Press.*

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1: To in-depth knowledge on basic concepts and speech Analysis.

CO2: To analyze the quality and properties of speech signal.

CO3: To model speech signals

CO4: To have in-depth knowledge on speech recognition and speech synthesis

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	M	M	H	M	-	-	H	-	-	-	-	H	H	M	-
CO2	L	M	L	M	-	-	L	-	-	-	-	H	H	M	-
CO3	L	L	H	M	-	-	H	-	-	-	-	H	M	H	-
CO4	M	M	L	M	-	-	M	-	-	-	-	H	H	M	-
18LPE$02	M	M	H	M	-	-	H	-	-	-	-	H	H	M	-

L - Low, M - Moderate (Medium), H - High

18LPE$12	ADVANCED DIGITAL SIGNAL PROCESSING

Category: PE

PRE-REQUISITES:

- **Digital Signal Processing**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To have in-depth knowledge on random signal and its spectrum estimation.
- To design adaptive filters.
- To have in-depth knowledge on multirate DSP systems.

UNIT I DISCRETE RANDOM SIGNAL PROCESSING	**(9 Periods)**
Weiner Khitchine relation - Power spectral density – filtering random process, Spectral Factorization Theorem, special types of random process – Signal modeling-Least Squares method, Pade approximation, Prony's method, iterative Prefiltering, Finite Data records, Stochastic Models.	
UNIT II SPECTRUM ESTIMATION	**(9 Periods)**
Non-Parametric methods - Correlation method - Co-variance estimator - Performance analysis of estimators – Unbiased consistent estimators - Periodogram estimator - Barlett spectrum estimation - Welch estimation - Model based approach - AR, MA, ARMA Signal modeling - Parameter estimation using Yule-Walker method.	
UNIT III LINEAR ESTIMATION AND PREDICTION	**(9 Periods)**
Maximum likelihood criterion - Efficiency of estimator - Least mean squared error criterion - Wiener filter - Discrete Wiener Hoff equations - Recursive estimators - Kalman filter - Linear prediction, Prediction error - Whitening filter, Inverse filter - Levinson recursion, Lattice realization, Levinson recursion algorithm for solving Toeplitz system of equations.	
UNIT IV ADAPTIVE FILTERS	**(9 Periods)**
FIR Adaptive filters - Newton's steepest descent method - Adaptive filters based on steepest descent method - Widrow Hoff LMS Adaptive algorithm - Adaptive channel equalization - Adaptive echo canceller - Adaptive noise cancellation - RLS Adaptive filters - Exponentially weighted RLS - Sliding window RLS - Simplified IIR LMS Adaptive filter.	
UNIT V MULTIRATE DIGITAL SIGNAL PROCESSING	**(9 Periods)**
Mathematical description of change of sampling rate - Interpolation and Decimation - Continuous time model - Direct digital domain approach - Decimation by integer factor - Interpolation by an integer factor - Single and multistage realization - Poly phase realization - Applications to sub band coding - Wavelet transform and filter bank implementation of wavelet expansion of signals.	

Contact periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Monson H. Hayes, "**Statistical Digital Signal Processing and Modeling**", John Wiley and Sons Inc., New York, 2006.*
2. *Simon Haykin, "**Adaptive Filter Theory**", Prentice Hall, Englehood Cliffs, NJ1986.*

REFERENCE BOOKS:

1. *Sophoncles J. Orfanidis, "**Optimum Signal Processing** ", McGraw-Hill, 2000.*
2. *John G. Proakis, Dimitris G. Manolakis, "**Digital Signal Processing**", Prentice Hall of India,New Delhi, 2005.*
3. *S. Kay," **Modern Spectrum Estimation Theory And Application**", Prentice Hall, Englehood Cliffs, Nj1988.*
4. *P. P. Vaidyanathan, "**Multirate Systems And Filter Banks**", Prentice Hall, 1992.*

COURSE OUTCOMES:

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

CO1: Have in-depth knowledge on random signal and its spectrum estimation.

CO2: Design adaptive filters.

CO3: Design multirate DSP systems

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	H	M	L	-	-	-	-	-	-	-	-	-	H	M	L
CO2	H	H	L	-	-	-	-	-	-	-	-	-	H	M	L
CO3	H	L	L	-	-	-	-	-	-	-	-	-	H	M	L
18LPE$12	H	M	L	-	-	-	-	-	-	-	-	-	H	M	L

L - Low, M - Moderate (Medium), H - High

18LPE$15	DIGITAL IMAGE AND VIDEO PROCESSING

Category: PE

PRE-REQUISITES:

* **DIGITAL SIGNAL PROCESSING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* This course enables the students to understand image and video processing fundamentals and algorithms for real time applications.

UNIT- I : DIGITAL IMAGE FUNDAMENTALS	**(9 Periods)**
Digital image fundamentals - Elements of Visual perception, Image Sensing and Acquisition - Image Sampling and Quantization - Pixels Relationships - Basics of Color image processing - Color Models – RGB, YUV, HSI – Color transformations – formulation, color components, color slicing, tone and color corrections.	
UNIT- II : IMAGE ENHANCEMENT	**(9 Periods)**
2D transforms-Discrete Fourier Transform and its inverse - Properties and applications. Gray level transformations - Histogram Equalization and Specification techniques – Pixel domain smoothing filters – linear and order-statistics - Pixel domain sharpening filters – first and second order derivatives – Frequency Domain filtering – Low pass and High pass – Homomorphic filtering.	
UNIT- III : IMAGE COMPRESSION	**(9 Periods)**
Image compression – Redundancy – interpixel and psycho visual – Lossless Compression – predictive and entropy – Lossy Compression – Predictive and transform coding – Discrete Cosine Transform – Compression standards – JPEG and JPEG 2000. Discrete Wavelet transform and its properties.	
UNIT- IV : VIDEO FUNDAMENTALS	**(9 Periods)**
Fundamentals of video coding – Inter-frame redundancy – Motion Estimation techniques – Full Search and Fast Search Strategies – Forward and Backward motion prediction – Frame Classification – I, P and B. Video Sequence Hierarchy – Group of pictures, frames, slices, macro blocks and blocks. Elements of video encoder and decoder – Video coding standards – MPEG and H.26X.	
UNIT- V : IMAGE AND VIDEO SEGMENTATION	**(9 Periods)**
Detection of Discontinuities - Edge linking and boundary detection – Thresholding – global and adaptive – Region based segmentation. Video Segmentation – Temporal segmentation – Shot boundary detection – Hard-cuts and Soft-cuts - spatial segmentation – Motion based – Video object detection and tracking.	

Contact periods:

Lecture: 45 Periods **Tutorial:0 Periods** **Practical:0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. Rafael C. Gonzales, Richard E. Woods, ***"Digital Image Processing"****, Third Edition, Pearson Education, 2010.*

2. Murat Tekalp, ***"Digital Video Processing"****, Prentice Hall, 2nd Edition, 2015.*

REFERENCE BOOKS:

1. *Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins,* ***"Digital Image Processing Using MATLAB"****, Third Edition Tata McGraw Hill Pvt. Ltd., 2011.*
2. *Anil Jain K.* ***"Fundamentals of Digital Image Processing"****, PHI Learning Pvt. Ltd., 2011.*
3. *Willliam K Pratt,* ***"Digital Image Processing"****, John Willey, 2002.*
4. *Malay K. Pakhira,* ***"Digital Image Processing and Pattern Recognition"****, First Edition, PHI Learning Pvt. Ltd., 2011.*

COURSE OUTCOMES:

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

CO1: Understanding of Digital Image fundamentals
CO2: Ability to develop efficient Image enhancement algorithms
CO3: Knowledge on basic image coding schemes and image compression standards
CO4: Understanding of video fundamentals and video standards
CO5: Knowledge on Image and Video segmentation and representation schemes

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	M	L	-	H	L	-	-	-	-	-	-	-	L	-	-
CO2	L	M	-	H	L	M	-	-	-	-	-	-	M	-	-
CO3	M	M	-	M	L	-	-	-	-	-	-	-	M	-	-
CO4	M	L	-	H	L	-	-	-	-	-	-	-	L	-	-
CO5	L	M	-	M	L	-	-	-	-	-	-	-	M	-	-
18LPE$15	M	M	-	H	L	M	-	-	-	-	-	-	M	-	-

L - Low, M - Moderate (Medium), H - High

18LPE$40	VLSI SIGNAL PROCESSING

PREREQUISITES	CATEGORY	L	T	P	C
Nil	PE	3	0	0	3

COURSE OBJECTIVES

- To understand DSP systems, Pipelining and Parallel Processing
- To implement the algorithmic strength reduction techniques in filterstructures
- To understand the pipelining and parallel processing concepts in IIR filters
- To understand Bit level Arithmetic Architectures
- To understand the clocking styles, synchronous and Asynchronousprotocols suitable for VLSI Architectures

UNIT – I	INTRODUCTION TO DSP SYSTEMS, PIPELINING AND PARALLEL PROCESSING OF FIR FILTERS.	(9 Periods)
Introduction to DSP systems – Typical DSP algorithms, Data flow and Dependence graphs - critical path, Loop bound, iteration bound, Longest path matrix algorithm, Pipelining and Parallelprocessing of FIR filters, Pipelining and Parallel processing for low power		
UNIT – II	**RETIMING, ALGORITHMIC STRENGTH REDUCTION**	**(9 Periods)**
Retiming – definitions and properties, Unfolding – an algorithm for unfolding, properties of unfolding, sample period reduction and parallel processing application, Algorithmic strength reduction in filters and transforms – 2-parallel FIR filter, 2-parallel fast FIR filter, DCT architecture, rank-order filters, OddEven merge-sort architecture, parallel rank-order filters.		
UNIT – III	**FAST CONVOLUTION, PIPELINING AND PARALLEL PROCESSING OF IIR FILTERS**	**(9 Periods)**
Fast convolution – Cook-Toom algorithm, modified Cook-Toom algorithm, Pipelined and parallel recursive filters – Look-Ahead pipelining in first-order IIR filters, Look-Ahead pipelining with power-of- 2 decomposition, Clustered look-ahead pipelining, Parallel processing of IIR filters, combined pipelining and parallel processing of IIR filters.		
UNIT – IV	**BIT-LEVEL ARITHMETIC ARCHITECTURES**	**(9 Periods)**
Bit-level arithmetic architectures – parallel multipliers with sign extension, parallel carry-ripple and carry-save multipliers, Design of Lyon's bit-serial multipliers using Horner's rule, bit-serial FIRfilter, CSD representation, CSD multiplication using Horner's rule for precision improvement, Distributed Arithmetic fundamentals and FIR filters.		
UNIT – V	**NUMERICAL STRENGTH REDUCTION, SYNCHRONOUS, WAVE AND ASYNCHRONOUS PIPELINING**	**(9 Periods)**
Numerical strength reduction – subexpression elimination, multiple constant multiplication, iterative matching, synchronous pipelining and clocking styles, clock skew in edge-triggered singlephase clocking, two-phase clocking, wave pipelining, Asynchronous pipelining, bundled data versus dual rail protocol.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Keshab K. Parhi, "**VLSI Digital Signal Processing Systems, Design and implementation**", Wiley, Interscience, 2007.*
2 *U. Meyer – Baese, "**Digital Signal Processing with Field Programmable Gate Arrays",** Springer, Second Edition, 2004*

REFERENCE BOOKS:

1 *Kung S. Y, H. J. While House, T. Kailath, "**VLSI and Modern Signal Processing"**, Prentice Hall,1985.*
2 *Jose E. France, YannisTsividis, "**Design of Analog – Digital VLSI Circuits for Telecommunications and Signal Processing"**, Prentice Hall, 1994.*
3 *Samir Palnitkar, "**Verilog HDL-A guide to Digital Design and synthesis second edition Pearson**", Education in South Asia 2013.*
4 J.G. Proakis, Manolakis, "**Digital Signal Processing"**, Prentice-Hall, 4th Edition, 2006.
5 *Medisetti V. K, "**VLSI Digital Signal Processing**", IEEE Press (NY), USA, 1995.*

COURSE OUTCOMES:
Upon completion of the course, students will be able to/have:

CO1 Understand DSP algorithms, Pipelining and Parallel Processing in FIR

CO2 Implement the algorithmic strength reduction techniques in filterstructures

CO3 Understand the pipelining and parallel processing concepts in IIR filters

CO4 Understand Bit level Arithmetic Architectures

CO5 Understand the clocking styles, synchronous and Asynchronous protocols suitable for VLSI Architectures

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	H	M	M	L	L	L	-	-	-	-	-	M	H	M	H
CO2	H	M	M	L	L	L	-	-	-	-	-	M	H	M	H
CO3	H	M	M	L	L	L	-	-	-	-	-	M	H	M	H
CO4	H	M	M	L	L	L	-	-	-	-	-	M	H	M	H
CO5	H	M	M	L	L	L	-	-	-	-	-	M	H	M	H
18LPE$40	H	M	M	L	L	L	-	-	-	-	-	M	H	M	H

L - Low, M - Moderate (Medium), H - High

18LPE$41	NON LINEAR SIGNAL PROCESSING

PREREQUISITES	CATEGORY	L	T	P	C
Nil	PE	3	0	0	3

COURSE OBJECTIVES

- To understand Maximum Likelihood estimation, point and scale estimation.
- To familiarize with binary and colour image processing basics.
- The student can handle median based operations.
- The student has knowledge about sorting operations.
- The student can explain various implementation technologies.

UNIT – I	LINEAR SIGNAL PROCESSING AND STATISTICAL PRELIMINARIES	(9 Periods)
Random Variables and Distributions – Estimation – Point Estimation – Maximum likelihood Estimators – M-Estimators – L-Estimators – R-Estimators – Scale Estimation - Noise Models.		
UNIT – II	**BINARY IMAGE AND COLOUR IMAGE PROCESSING**	**(9 Periods)**
Introduction – Morphological Image Processing –Standard Binary morphological operations –Dilation and Erosion based operations. Introduction to colour image processing – Light and colour – Colour formation – Human perception of colour – Colour Model – the Chromaticity Diagram – Colour image Quantization – Histogram of a Colour image – Colour image Filtering – Pseudo-Colouring – Colour image segmentation.		
UNIT – III	**INTRODUCTION TO NON LINEAR FILTERS**	**(9 Periods)**
Nonlinear filters – Measures of robustness – Order Statistics Filters – Median filters and their characteristics – Impulse noise filtering by median filters – Recursive and weighted median filters –Decision based filters – Switched Median filters.		
UNIT – IV	**ALGORITHMS**	**(9 Periods)**
Sorting and Selection Algorithm – Running Median Algorithm – Bitonic sort – Bubble sort and its variant – Shellsort – Quick sort – Bucket and Sample sort – Enumeration sort and Radix sort.		
UNIT – V	**ARCHITECTURE AND APPLICATIONS OF NONLINEAR FILTERS**	**(9 Periods)**
Basic structure for order statistics filtering – Systolic array implementation – Wave front array Implementation – General nonlinear filter structure – Signal dependent noise filtering – Computational complexity of general nonlinear filter model – Nonlinear Edge Detection – Implementation of decision logics.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Gonzalo R. Arce,"**Nonlinear Signal Processing: A Statistical Approach**", Wiley Interscience, 2004.*

2 *Loannis Pitas, Anastasios N. Venetsanopoulos,"**Nonlinear digital filters: principles and applications**", Springer, 1990 – Technology & Engineering.*

REFERENCE BOOKS:

1 *S. K Mitra, "**Nonlinear Image Processing** ", Academic Press, 2000.*

2 *Jianwu Xu, "**Nonlinear Signal Processing Based on Reproducing"** Kernel Hilbert Space ,Lambert Academic Publications ,2010*

3 *Kenneth E. Barner, Gonzalo R. Arce," **Nonlinear Signal and Image Processing**" , WileyInterscience, 1st edition 2003.*

4 *W. J. Fitzgerald, R. L. Smith, A. T. Walden,"**Nonlinear and Nonstationary Signal Processing**", Cambridge University Press,2001*

5 *Vijay Madisetti , "**Digital Signal Processing Handbook: Wireless Networking Radar Sensor Array Processing And Nonlinear Signal Processing**", 2nd Edition, CRC Press*

COURSE OUTCOMES:

Upon completion of the course, students will be able to/have:

CO1 Understand Maximum Likelihood estimation, point and scale estimation.

CO2 Define rules and standards for binary and colour image processing.

CO3 Design simple median based filters.

CO4 Describe different sorting algorithms.

CO5 Develop different architecture schemes for nonlinear filters.

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	M	M	M	-	-	-	-	-	-	-	-	M	M	L	M
CO2	M	M	M	-	-	-	-	-	-	-	-	M	M	L	M
CO3	M	M	M	-	-	-	-	-	-	-	-	M	M	L	M
CO4	M	M	M	-	-	-	-	-	-	-	-	M	M	L	M
CO5	M	M	M	-	-	-	-	-	-	-	-	M	M	L	M
18LPE$41	M	M	M	-	-	-	-	-	-	-	-	M	M	L	M

L - Low, M - Moderate (Medium), H - High

18LPE$42	RADAR SIGNAL PROCESSING

PREREQUISITES	CATEGORY	L	T	P	C
Nil	PE	3	0	0	3

COURSE OBJECTIVES

- To understand the Radar Signal acquisition and sampling in multiple domains
- To provide clear instruction in radar DSP basics
- To equip the skills needed in both design and analysis of common radaralgorithms
- To understand the basics of synthetic aperture imaging and adaptive arrayprocessing
- To illustrate how theoretical results are derived and applied in practice

UNIT – I	INTRODUCTION TO RADAR SYSTEMS	(9 Periods)
History and application of radar, basic radar function, elements of pulsed radar, review of signal processing concepts and operations, a preview of basic radar signal processing, radar systemcomponents, advanced radar signal processing		
UNIT – II	**SIGNAL MODELS**	**(9 Periods)**
Components of a radar signal, amplitude models, types of clutters, noise model and signal-tonoise ratio, jamming, frequency models: the doppler shift, spatial models, spectral model		
UNIT – III	**SAMPLING AND QUANTIZATION OF PULSED RADAR SIGNALS**	**(9 Periods)**
Domains and criteria for sampling radar signals, Sampling in the fast time dimension, Sampling in slow time: selecting the pulse repetition interval, sampling the Doppler spectrum, Sampling in the spatial and angle dimension, Quantization, I/Q Imbalance and Digital I/Q.		
UNIT – IV	**RADAR WAVEFORMS**	**(9 Periods)**
Introduction, The waveform matched filter, Matched filtering of moving targets, The ambiguity function, The pulse burst waveform, frequency-modulated pulse compression waveforms, Range sidelobe control for FM waveforms, the stepped frequency waveform, Phase-modulated pulsecompression waveforms, COSTAS Frequency Codes.		
UNIT – V	**DOPPLER PROCESSING**	**(9 Periods)**
Alternate forms of the Doppler spectrum, Moving target indication (MTI), Pulse Doppler processing, dwell-to-dwell stagger, Pulse pair processing, additional Doppler processing issues, clutter mapping and the moving target detector, MTI for moving platforms: adaptive displaced phase center antenna processing		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 Francois Le Chevalier, "**Principles of Radar and Sonar Signal Processing**", ArtechHouse , 2002

2 Mark A. Richards, **"Fundamentals of Radar Signal Processing"**, McGraw-Hill, New York, 2005

REFERENCE BOOKS:

1 *Michael O Kolawole**, "Radar systems, Peak Detection and Tracking"**, ElseveirIntroduction To Radar Systems 3/E, Skolnik, McGraw Hill. 2010*

2 *Peyton Z. Peebles, **"Radar Principles"**, Wiley India 2009.*

3 *Fred E. Nathanson**, "Radar Design Principles-Signal Processing and the environment"** PHI ,1999*

4 *Antonio De Maio and Marina Sabrina Greco, **"Modern Radar Detection Theory",** SciTech Publishing, 2016.*

5 *Fabrizio, Giuseppe Aureliano. **"High Frequency Over-the-Horizon Radar: Fundamental Principles, Signal Processing, and Practical Applications"**. 1st ed. New York: McGraw-Hill Education 2013.*

COURSE OUTCOMES:

Upon completion of the course, students will be able to/have:

CO1 Understand the basic concepts and operations of radar signalprocessing
CO2 Understand various radar signal models
CO3 In depth knowledge on radar signal acquisition and sampling
CO4 Understand various radar waveforms
CO5 Knowledge on Doppler Processing

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	H	M	M	L	L	-	-	-	-	-	-	M	M	L	L
CO2	H	M	M	L	L	-	-	-	-	-	-	M	M	L	L
CO3	H	M	M	L	L	-	-	-	-	-	-	M	M	L	L
CO4	H	M	M	L	L	-	-	-	-	-	-	M	M	L	L
CO5	H	M	M	L	L	-	-	-	-	-	-	M	M	L	L
18LPE$42	H	M	M	L	L	-	-	-	-	-	-	M	M	L	L

L - Low, M - Moderate (Medium), H - High

18LPE$43	COMPUTER VISION ALGORITHMS AND APPLICATIONS

PREREQUISITES	CATEGORY	L	T	P	C
Nil	PE	3	0	0	3

COURSE OBJECTIVES

- To understand fundamentals of Digital Image Processing
- To extract features from Images
- To gain knowledge on image Registration
- To understand image fusion techniques
- To gain knowledge on 3D Visualization

UNIT – I	FUNDAMENTALS OF DIGITAL IMAGE PROCESSING	(9 Periods)
Review- Elements of visual perception, brightness, contrast, hue, saturation, mach band effect. 2D image transforms-DFT, DCT, KLT, and SVD. Review of morphological image processing		
UNIT – II	**FEATURE EXTRACTION**	**(9 Periods)**
First and second order edge detection operators, Phase congruency, Localized feature extraction detecting image curvature, shape features Hough transform, shape skeletonization, Boundary descriptors, Moments, Texture descriptors- Autocorrelation, Co occurrence features, Run length features, Fractal model based features, Gabor filter, wavelet features		
UNIT – III	**IMAGE REGISTRATION**	**(9 Periods)**
Preprocessing, Feature selection-points, lines, regions and templates Feature correspondence- Point pattern matching, Line matching, region matching Template matching .Transformation functions-Similarity transformation and Affine Transformation. Resampling Nearest Neighbour and Cubic Splines		
UNIT – IV	**IMAGE FUSION**	**(9 Periods)**
Image Fusion-Overview of image fusion, pixel fusion, Multi resolution based fusion discrete wavelet transform, Curvelet transform. Region based fusion		
UNIT – V	**3D IMAGE VISUALIZATION**	**(9 Periods)**
Sources of 3D Data sets, Slicing the Data set, Arbitrary section planes, The use of color, Volumetric display, Stereo Viewing, Ray tracing, Reflection, Surfaces, Multiply connected surfaces, Image processing in 3D, Measurements on 3D images.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins,* ***"Digital Image Processing Using MATLAB"****, Third Edition Tata McGraw Hill Pvt. Ltd., 2011.*

2 *Anil Jain K.* ***"Fundamentals of Digital Image Processing"****, PHI Learning Pvt. Ltd., 2011.*

REFERENCE BOOKS:

1 ArdeshirGoshtasby, " **2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications**",John Wiley and Sons,2005.

2 John C.Russ, "**The Image Processing Handbook**", CRC Press,2007

3 Mark Nixon, Alberto Aguado, "**Feature Extraction and Image Processing**", Academic Press, 2008.

4 Rick S.Blum, Zheng Liu," **Multisensor image fusion and its Applications**",Taylor& Francis,2006

5 *Willliam K Pratt, **"Digital Image Processing"**, John Willey, 2002.*

6 *Malay K. Pakhira, **"Digital Image Processing and Pattern Recognition"**, First Edition, PHI Learning Pvt. Ltd., 2011.*

COURSE OUTCOMES:

Upon completion of the course, students will be able to/have:

CO1 Understand fundamentals of Digital Image Processing.

CO2 Ability to extract features from Images.

CO3 Knowledge on image Registration

CO4 Understand various image Fusion techniques

CO5 Knowledge on 3D Image Visualization

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	H	M	M	M	M	-	-	-	-	-	-	H	H	M	-
CO2	H	M	M	M	M	-	-	-	-	-	-	H	H	M	-
CO3	H	M	M	M	M	-	-	-	-	-	-	H	H	M	-
CO4	H	M	M	M	M	-	-	-	-	-	-	H	H	M	-
CO5	H	M	M	M	M	-	-	-	-	-	-	H	H	M	-
18LE$43	H	M	M	M	M	-	-	-	-	-	-	H	H	M	-

L - Low, M - Moderate (Medium), H - High

18LPE$44	DIGITAL SIGNAL PROCESSORS

PREREQUISITES	CATEGORY	L	T	P	C
Nil	PE	3	0	0	3

COURSE OBJECTIVES

- To Understand the Fundamentals of Programmable DSPs
- To Understand various components of DSP Architecture
- To have In depth knowledge on CPU Data Paths and Control
- To Understand various concepts Pipeline and Interrupts
- To Implement various DSP Algorithms

UNIT – I	FUNDAMENTALS OF PROGRAMMABLE DSPs	(9 Periods)
Von Neumann ,Harvard Architecture,Modified Havard and VLIW Architecture - Modified Bus Structures and Memory access in P-DSPs- Multiple access memory , Multi-ported memory , Pipelining -Special Addressing modes in P- DSPs - On chip Peripherals- Computational accuracy in DSP processor- MAC		
UNIT – II	**TMS320C67x DSP ARCHITECTURE**	**(9 Periods)**
TMS320 DSP Family Overview- TMS320C6000 DSP Family Overview- TMS320C67xDSPFeatures- TMS320C67x DSP Architecture - Central Processing Unit (CPU) ,Internal Memory ,Memory and Peripheral		
UNIT – III	**TMS320C67x CPU DATA PATHS AND CONTROL**	**(9 Periods)**
General-Purpose Register Files -Functional Units - Register File Cross -Memory, Load, and Store Paths- Data Address Paths -Control Register File- Instruction Operation and Execution- Parallel Operations- Conditional Operations- Resource Constraints- Addressing Modes- Instruction Compatibility		
UNIT – IV	**TMS320C67x PIPELINE AND INTERRUPTS**	**(9 Periods)**
Pipeline Operation- Pipeline Execution of Instruction Types- Functional Unit Constraints- Performance Considerations- **Interrupts** -Overview- Globally Enabling and Disabling Interrupts- Individual Interrupt Control- Interrupt Detection and Processing- Performance Considerations- Programming Considerations		
UNIT – V	**IMPLEMENTATION OF BASIC DSP ALGORITHMS**	**(9 Periods)**
Study of time complexity of DFT and FFT algorithm, Use of FFT for filtering long data sequence,IIR and FIR Filters,Interpolation, Decimation , wavelet filter		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Avtar Singh and S. Srinivasan* ***"Digital Signal Processing",*** *Thomson Publications, 2004.*

2 *Lapsley et al. S. Chand & Co* ***"DSP Processor Fundamentals, Architectures & Features "****,2000.*

REFERENCE BOOKS:

1 ***"Digital Signal Processors, Architecture, Programming and Applications"*** *– B. Venkata Ramani and M. Bhaskar, TMH, 2004.*

2 ***"Digital Signal Processing*** *"– Jonatham Stein, John Wiley, 2005*

3 *Avtar Singh and S. Srinivasan, "**Digital Signal Processing – Implementations using DSPMicroprocessors**", cengage Learning India PrivateLimited, Delhi 2012*

4 *" **Programming and Applications**" – Tata McGraw – Hill Publishing Company Limited. NewDelhi, 2003.*

5 *RulphChassaing, "**Digital Signal Processing and Applications with the C6713 andC6416DSK**", A John Wiley & Sons, Inc., Publication, 2005*

COURSE OUTCOMES:

Upon completion of the course, students will be able to/have:

CO1 Understand the Fundamentals of Programmable DSPs
CO2 Understand various components of DSP Architecture
CO3 In depth knowledge on CPU Data Paths and Control
CO4 Understand various concepts Pipeline and Interrupts
CO5 Implement various DSP Algorithms

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	H	H	M	L	L	L	-	-	-	-	-	M	H	M	-
CO2	H	H	M	L	L	L	-	-	-	-	-	M	H	M	-
CO3	H	H	M	L	L	L	-	-	-	-	-	M	H	M	-
CO4	H	H	M	L	L	L	-	-	-	-	-	M	H	M	-
CO5	H	H	M	L	L	L	-	-	-	-	-	M	H	M	-
18LPE$44	H	H	M	L	L	L	-	-	-	-	-	M	H	M	-

L - Low, M - Moderate (Medium), H - High

VERTICAL – IV

VLSI DESIGN

18LPE$13	LOW POWER VLSI

Category: PE

PRE-REQUISITES:

* **VLSI DESIGN**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To expose the students to Low voltage and Low power VLSI CMOS circuit design.

UNIT I: BASICS OF MOS CIRCUITS	**(9 Periods)**
MOS Transistor structure and device modeling - MOS Inverters - MOS Combinational Circuits - Different Logic Families.	
UNIT II: POWER DISSIPATION & SCALING APPROACHES	**(9 Periods)**
Dynamic Power Dissipation: Short Circuit Power - Switching Power - Gliching Power, Static Power Dissipation, Degrees of Freedom. Supply Voltage Scaling Approaches: Device feature size scaling - Multi-Vdd Circuits - Architectural level approaches: Parallelism, Pipelining -Voltage scaling using high-level transformations- Dynamic voltage scaling- Power Management.	
UNIT III: SWITCHED CAPACITANCE MINIMIZATION APPROACHES	**(9 Periods)**
Hardware Software Tradeoff –Memory bus encoding - Two's complement Vs Sign Magnitude - Architectural optimization - Clock Gating.	
UNIT IV: LEAKAGE POWER MINIMIZATION & SPECIAL CIRCUITS	**(9 Periods)**
Logic styles leakage power minimization approaches: Variable-threshold-voltage CMOS (VTCMOS) approach - Multi-threshold-voltage CMOS (MTCMOS) approach - Power gating - Transistor stacking - Dual-Vt assignment approach (DTCMOS). Special circuits: Adiabatic Switching Circuits - Battery-aware Synthesis - Variation tolerant design.	
UNIT V: SYNTHESIS AND SOFTWARE DESIGN FOR LOW POWER	**(9 Periods)**
Synthesis for Low power, Behavioural level transforms, Software design for Low power.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Sung Mo Kang, Yusuf Leblebici, "**CMOS Digital Integrated Circuits**", Tata Mcgraw Hill, 2003.*
2. *Neil H. E. Weste and K. Eshraghian, "**Principles of CMOS VLSI Design**", 2nd Edition, Addison Wesley (Indian reprint), 2011.*
3. *Anantha P. Chandrakasan and Robert W. Brodersen, "**Low Power Digital CMOS Design**", Kluwer Academic Publishers, 1995.*

REFERENCE BOOKS:

1. *Kaushik Roy and Sharat C. Prasad, "**Low-Power CMOS VLSI Design**", Wiley-Interscience, 2000.*
2. *A. Bellamour, and M. I. Elmasri, "**Low Power VLSI CMOS Circuit Design**", Kluwer Academic Press, 1995.*

COURSE OUTCOMES:

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

CO1: An exposure on MOS Circuits and Supply Voltage Scaling Approaches.

CO2: Acquire knowledge on switched capacitance minimization approaches and leakage power minimization.

CO3: Analyze the synthesis and software design for Low power.

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	H	L	L	M	-	H	H	-	-	L	-	H	H	L	H
CO2	L	L	L	M	-	H	H	-	-	L	-	H	H	L	H
CO3	M	L	L	M	-	H	H	-	-	L	-	H	H	L	H
18LPE$13	L	L	L	M	-	H	H	-	-	L	-	H	H	L	H

L - Low, M - Moderate (Medium), H - High

18LPE$45	ANALOG IC DESIGN

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- To develop MOS based Analog VLSI circuits and analyse their performance.

UNIT – I	MOS DEVICE MODELS	(9 Periods)
Basic MOS Device Physics – General Considerations, MOS I/V Characteristics, Second Order effects, MOS Device models. Short Channel Effects and Device Models. Single Stage Amplifiers –Basic Concepts, Common Source Stage, Source Follower, Common Gate Stage, Cascode Stage.		
UNIT – II	**MOS AMPLIFIERS**	**(9 Periods)**
Differential Amplifiers – Single Ended and Differential Operation, Basic Differential Pair, Common-Mode Response, Differential Pair with MOS loads, Gilbert Cell. Frequency Response of Amplifiers – General Considerations, Common Source Stage, Source Followers, Common Gate Stage, Cascode Stage.		
UNIT – III	**CMOS OPERATIONAL AMPLIFIERS**	**(9 Periods)**
Feedback Amplifiers – General Considerations, Feedback Topologies, Effect of Loading. Operational Amplifiers – General Considerations, One Stage Op Amps, Two Stage Op Amps, Gain Boosting, Common-Mode Feedback, Input Range limitations, Slew Rate, Power Supply Rejection, Noise in Op Amps. Stability and Frequency Compensation		
UNIT – IV	**CURRENT MIRRORS AND NOISE**	**(9 Periods)**
Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors, Differential Pair Passive and Active Current Mirrors. Noise – Types of Noise, Representation of Noise in circuits, Noise in single stage amplifiers, Noise in Differential Pairs.		
UNIT – V	**D/A - A/D CONVERTERS AND SWITCHED CAPACITORS**	**(9 Periods)**
Ideal A/D and D/A converters, Quantization noise, Signed codes, Performance limitations. D/A converter: Current scaling, Voltage scaling and Charge scaling D/A converters - Serial D/A converters - Serial A/D converters, Parallel - High performance A/D converters. Band gap References, Introduction to Switched Capacitor Circuits, PLL, Nonlinearity		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *B.Razavi, "**Design of Analog CMOS Integrated Circuits**", McGraw Hill Edition 2006, 33rd reprint 2016..*
2 *Paul. R.Gray, Robert G. Meyer, "**Analysis and Design of Analog Integrated Circuits**", Wiley, (4/e), 2001.*

REFERENCE BOOKS:

1 *D. A. Johns and K. Martin, "**Analog Integrated Circuit Design**", Wiley,1997.*
2 *R. Jacob Baker, "**CMOS Circuit Design, Layout, and Simulation**", Wiley, (3/e),2010.*
3 *P.E.Allen, D.R. Holberg, "**CMOS Analog Circuit Design**", Oxford University Press,2012.*
4 *Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, "**Analysis and Design of Analog Integrated Circuits**", 5th Edition, Wiley, 2009*
5 *Grebene, "**Bipolar and MOS Analog Integrated circuit design**", John Wiley & sons, Inc., 2003*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Characterize and model MOS transistors

CO2 Operate MOS transistors in amplifiers with different characteristics

CO3 Design and analyze operational amplifier circuits based on MOS transistors

CO4 Explain the different current mirrors and the noise involved in amplifiers

CO5 Explain the D/A and A/D converters suitable for analog design

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	H	M	M	-	-	M	-	-	-	M	-	H	H	L	M
CO2	H	M	M	-	-	M	-	-	-	M	-	H	H	L	M
CO3	H	M	L	-	-	M	-	-	-	M	-	H	M	L	M
CO4	M	L	M	-	-	M	-	-	-	M	-	H	M	L	M
CO5	M	L	M	-	-	M	-	-	-	M	-	H	M	L	M
18LPE$45	H	M	M	-	-	M	-	-	-	M	-	H	H	L	M

L - Low, M - Moderate (Medium), H - High

18LPE$46	PROGRAMMING FPGA USING HDLs

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- To code digital function in Verilog HDL and Systemverilog as synthesizable andnon-synthesizable

UNIT – I	INTRODUCTION TO VERILOG, GATE AND DATAFLOW MODELING	(9 Periods)
Hierarchical Modeling – Basic concepts – Modules and ports - Gate Level Modeling - Dataflow Modeling.		
UNIT – II	**BEHAVIORAL MODELING AND TASKS**	**(9 Periods)**
Behavioral Modeling, Switch Level Modeling, Tasks and Functions: Difference between tasks and functions, declaration, invocation, Useful Modeling Techniques.		
UNIT – III	**SYSTEMVERILOG**	**(9 Periods)**
Introduction, SystemVerilog declaration spaces, SystemVerilog Literal Values and Built-in Data Types, SystemVerilog User-Defined and Enumerated Types, system Verilog Arrays, Structures and Unions.		
UNIT – IV	**SYSTEMVERILOG MODELING**	**(9 Periods)**
Systemverilog Procedural Blocks, Tasks and Functions, SystemVerilog Procedural Statements, Modeling Finite State Machines with SystemVerilog.		
UNIT – V	**INTERFACES AND DESIGN MODEL**	**(9 Periods)**
SystemVerilog Interfaces, A Complete Design Modeled with SystemVerilog, Behavioral and Transaction Level Modeling.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Samir Palnitkar, "**Verilog HDL**", 2nd Edition, Pearson Education, 2009.*

2 *Stuart Sutherland, Simon Davidmann, Peter Flake, Foreword by Phil Moorby, "**SystemVerilog For Design Second Edition A Guide to Using SystemVerilog for Hardware Design and Modelling**", Springer 2006.*

REFERNECES BOOKS:

1 *T.R. Padmanabhan, B Bala Tripura Sundari, "**Design through Verilog HDL"**, Wiley 2009.*

2 *ZainalabdienNavabi, "**Verilog Digital System Design"**, TMH, 2nd Edition, 2005.*

3 *"**System Verilog 3.1a**", Language Reference Manual, Accellera, 2004*

4 *Dr. S Ramachandran, "**Digital VLSI Systems Design A Design Manual for Implementation of Projects on FPGAs and ASICs using Verilog**", Springer, 2014.*

5 *Chris Spear, "**Systemverilog for verification a guide to learning the testbench Language Features**", Springer 2006.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1	Explain the verilog coding and simulate any digital function using Verilog HDL
CO2	Develop modeling based on tasks and function using Verilog HDL code
CO3	Explain the systemverilog modeling
CO4	Differentiate the synthesizable and non-synthesizable code
CO5	Apply good coding techniques on systemverilog interfaces and complete design model

COURSE ARTICULATION MATRIX :

COs/POs	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	PSO 2	PSO 3
CO1	H	M	H	L	L	M	-	-	-	M	-	H	H	M	M
CO2	H	M	H	L	L	M	-	-	-	M	-	H	H	M	M
CO3	H	M	H	L	L	M	-	-	-	M	-	H	H	M	M
CO4	H	M	H	L	L	M	-	-	-	M	-	H	H	M	M
CO5	H	M	H	L	L	M	-	-	-	M	-	H	H	M	M
18LPE$46	H	M	H	L	L	M	-	-	-	M	-	H	H	M	M

L - Low, M - Moderate (Medium), H - High

18LPE$47	ASIC DESIGN

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- To gain knowledge on the fundamentals of ASIC design, programmable ASIC's,logical synthesis, simulation and testing of ASIC

UNIT – I	OVERVIEW OF ASIC AND PLD	(9 Periods)
Types of ASICs - Design flow - CAD tools used in ASIC Design - Programming Technologies: Antifuse - Static RAM - EPROM and EEPROM technology, Programmable Logic Devices: ROMs and EPROMs - PLA - PAL. Gate Arrays -CPLDs and FPGA.		
UNIT – II	**PROGRAMMABLE ASICs**	**(9 Periods)**
Programmable ASIC logic cells for ACTEL and XILNX - DC & AC inputs and outputs- Clock and Power inputs – I/O blocks, Programmable ASIC architecture - -Xilinx 4000- ACTEL's ACT-1,2,3 and their speed performance, Altera MAX 9000 –Altera Flex 8000/1000 - Spartan II and Virtex II FPGAs - Apex and Cyclone FPGAs.		
UNIT – III	**ASIC PHYSICAL DESIGN**	**(9 Periods)**
System Partitioning - Partitioning methods – Interconnect delay models and measurement of delay - Floor planning - Placement – Routing: Global routing - Detailed routing - Special routing - Circuit extraction – DRC		
UNIT – IV	**LOGIC SYNTHESIS, SIMULATION AND TESTING**	**(9 Periods)**
Design systems - Logic Synthesis - Verilog and VHDL synthesis - Types of simulation - Boundary scan test - Fault simulation - Automatic test pattern generation.		
UNIT – V	**HIGH PERFORMANCE ALGORITHMS FOR ASICS/ SoCS.**	**(9 Periods)**
High performance algorithms for ASICS/ SoCs as case studies – Canonic Signed Digit Arithmetic, KCM, Distributed Arithmetic, High performance digital filters for sigma-delta ADC, USB controllers, OMAP.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *M.J.S.Smith , "**Application - Specific Integrated Circuits"**, Pearson,2014.*

2 *Steve Kilts, "**Advanced FPGA Design"**, Wiley Inter-Science, 2007.*

REFERENCE BOOKS:

1 *Roger Woods, John McAllister, Dr. Ying Yi, Gaye Lightbod, "**FPGA-based Implementation of Signal Processing Systems"**, Wiley, 2008.*

2 *S.H. Gerez, "**Algorithms for VLSI Design Automation"**, John Wiley & Sons, 2008.*

3 *Douglas J. Smith, "**HDL Chip Design"**, Madison, AL, USA: Doone Publications, 1996.*

4 *Jose E. France, YannisTsividis, "**Design of Analog - Digital VLSI Circuits for Telecommunication and Signal Processing"**, Prentice Hall,1994.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Explain the ASIC design flow and programming technologies

CO2 Discuss the programmable ASIC's

CO3 Analyze the design trade off in various partitioning, placement and floorplanning.

CO4 Illustrate the logical synthesis , simulation and testing aspects of ASIC

CO5 Apply the high performance algorithm in ASIC and its applications.

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	H	M	L	-	-	M	-	-	-	M	-	H	M	L	M
CO2	H	1	L	-	-	M	-	-	-	M	-	H	M	L	M
CO3	H	M	L	-	-	M	-	-	-	M	-	H	M	L	M
CO4	H	1	L	-	-	M	-	-	-	M	-	H	M	L	M
CO5	H	M	M	-	L	M	-	-	-	M	-	H	H	L	M
18LPE$47	H	M	L	-	L	M	-	-	-	M	-	H	M	L	M

L - Low, M - Moderate (Medium), H - High

18LPE$48	SYSTEM ON CHIP DESIGN

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- To understand the challenges of SoC design and the implementation of SoCdesign flow.

UNIT – I	INTRODUCTION TO SoC AND PROCESSORS	(9 Periods)
Introduction: Driving Forces for SoC - Components of SoC - Design flow of SoC Hardware/Software nature of SoC - Design Trade-offs - SoC Applications System-level Design: Processor selection-Concepts in Processor Architecture: Instruction set architecture (ISA), elements in Instruction Handing-Robust processors: Vector processor, VLIW, Superscalar, CISC, RISC—Processor evolution: Soft and Firm processors, Custom Designed processors- on-chip memory		
UNIT – II	**INTERCONNECT CUSTOMIZATION AND CONFIGURATION**	**(9 Periods)**
Interconnection: On-chip Buses: basic architecture, topologies, arbitration and protocols, Bus standards: AMBA, Core Connect, Wishbone, Avalon - Network-on chip: Architecture topologies-switching strategies - routing algorithms flow control, Quality-of-Service-Reconfigurability in communication architectures.		
UNIT – III	**MODERN IP BASED VLSI DESIGN**	**(9 Periods)**
IP based system design: Introduction to IP Based design, Types of IP, IP across design hierarchy, IP life cycle, Creating and using IP - Technical concerns on IP reuse – IP integration - IP evaluation on FPGA prototypes.		
UNIT – IV	**IMPLEMENTATION OF SoC**	**(9 Periods)**
SOC implementation: Study of processor IP, Memory IP, wrapper Design - Real-time operating system (RTOS), Peripheral interface and components, High-density FPGAs - EDA tools used for SOC design.		
UNIT – V	**SoC TESTING**	**(9 Periods)**
SOC testing: Manufacturing test of SoC: Core layer, system layer, application layer-P1500 Wrapper Standardization-SoC Test Automation (STAT).		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Michael J.Flynn, Wayne Luk, "**Computer system Design: System-on-Chip**", Wiley-India, 2012*

2 *Youn-Long Steve Lin, "**Essential Issues in SoC Design: Designing complex systems-on-chip"**,Springer, 2006*

REFERENCE BOOK:

1 *Wayne Wolf, "**Modern VLSI Design – IP based Design",** Prentice Hall, 4th Edition, 2008.*

2 *W.H.Wolf, "**Computers as Components: Principles of Embedded Computing System Design**", Elsevier, 2008.*

3 *Patrick Schaumont "**A Practical Introduction to Hardware/Software Co-design**", 2nd Edition, Springer, 2012.*

4 *Sudeep Pasricha, Nikil Dutt, "**On Chip Communication Architectures: System on Chip Interconnect**", Morgan Kaufmann Publishers, 2008.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Explain the overall System on Chip (SoC) design flow and system level design selection of processor.

CO2 Analyze the system level design interconnections and customization architectures of all the modules.

CO3 Explain and evaluate the IP based system design in order to reduce the design cost and time

CO4 Implement and apply the IP based design for SoC.

CO5 Apply the testing knowledge on SoC.

COURSE ARTICULATION MATRIX :

COs/POs	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	PSO 2	PSO 3
CO1	H	L	L	-	-	M	-	-	-	M	-	H	M	L	M
CO2	H	M	L	-	-	M	-	-	-	M	-	H	M	L	M
CO3	H	M	M	-	-	M	-	-	-	M	-	H	H	L	M
CO4	H	L	M	-	-	M	-	-	-	M	-	H	H	L	M
CO5	H	M	M	-	L	M	-	-	-	M	-	H	H	L	M
18LPE$48	H	M	M	-	L	M	-	-	-	M	-	H	H	L	M

L - Low, M - Moderate (Medium), H - High

18LPE$49	VLSI TESTING AND DESIGN FOR TESTABILITY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- To gain the basic knowledge on fault modeling and to get exposure to testabilityapproaches and test vector generation algorithms for memory and logic circuits

UNIT – I	BASICS OF TESTING AND FAULT MODELING	(9 Periods)
Role of testing in VLSI Design flow, Testing at different levels of abstraction, Fault, error, defect, diagnosis, yield, Types of testing, Rule of Ten, Defects in VLSI chip. Modeling basic concepts, Functional modeling at logic level and register level, structure models, logic simulation, delay models. Various types of faults, Fault equivalence and Fault dominance in combinational sequential circuits		
UNIT – II	**FAULT DIAGNOSIS**	**(9 Periods)**
Fault simulation applications, General fault simulation algorithms- Serial, and parallel, Deductive fault simulation algorithms.		
UNIT – III	**TEST GENERATION FOR COMBINATIONAL AND SEQUENTIAL CIRCUITS**	**(9 Periods)**
Combinational circuit test generation, Structural Vs Functional test, ATPG, Fault table method-Path sensitization method – Boolean difference method – Tolerance techniques –Fault in PLA – Test generation - Difference between combinational and sequential circuit testing.		
UNIT – IV	**TESTABILITY**	**(9 Periods)**
D-algorithm procedure, Problems, PODEM Algorithm. Problems on PODEM Algorithm. FAN Algorithm. Problems on FAN algorithm, Comparison of D, FAN and PODEM Algorithms. Design for Testability, Ad-hoc design, Generic scan based design.		
UNIT – V	**SELF-TEST AND TEST ALGORITHMS**	**(9 Periods)**
Classical scan based design, System level DFT approaches Test pattern generation for BIST, Circular BIST. BIST Architectures. Testable memory design-Test algorithms-Test generation for Embedded RAMs. .		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *M.L.Bushnell and V.D.Agrawal, "**Essentials of Electronic Testing for Digital, Memory and Mixed- Signal VLSI Circuits**", Springer,2014.*

2 *M.Abramovici, M.A.Breuer and A.D.Friedman, "**Digital Systems and Testable Design**", JaicoPublishingHouse, 11th edition, 2011.*

REFERENCES BOOKS:

1 *A.L.Crouch,"**Design Test for Digital IC's and Embedded Core Systems**", Beijing China Electric Power Press,2010.*
2 *P.K.Lala,"**Digital Circuit Testing and Testability**", Academic Press, 2002.*
3 Stroud, "**A Designer's Guide to Built-in Self-Test**", Kluwer Academic Publishers, 2002
4 *Parag K.Lala, "**Fault Tolerant and Fault Testable Hardware Design",** BS Publications, 2002.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Identify the significance of testable design

CO2 Explain the concept of yield and identify the constraints influencing the faults.

CO3 Generate the test vectors for combinational and sequential circuits

CO4 Test the combinational and sequential circuit using test generation algorithms

CO5 Identify techniques to detect faults

COURSE ARTICULATION MATRIX:

COs/POs	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	PSO 2	PSO 3
CO1	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
CO2	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
CO3	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
CO4	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
CO5	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
18LPE$49	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M

L - Low, M - Moderate (Medium), H - High

18LPE$50	DESIGN FOR VERIFICATION USING UVM

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

* To provide the complete understanding on UVM testing, UVM verification and an experience on self checking UVM testbenches

UNIT – I	INTRODUCTION	(9 Periods)
Overview- The Typical UVM Testbench Architecture- The UVM Class Library-Transaction-Level Modeling (TLM) -Overview- TLM, TLM-1, and TLM-2.0 -TLM-1 Implementation- TLM-2.0 Implementation		
UNIT – II	**DEVELOPING REUSABLE VERIFICATION COMPONENTS**	**(9 Periods)**
Modeling Data Items for Generation - Transaction-Level Components - Creating the Driver - Creating the Sequencer - Connecting the Driver and Sequencer -Creating the Monitor - Instantiating Components- Creating the Agent - Creating the Environment -Enabling Scenario Creation -Managing of Test-Implementing Checks and Coverage		
UNIT – III	**UVM USING VERIFICATION COMPONENTS**	**(9 Periods)**
Creating a Top-Level Environment- Instantiating Verification Components - Creating Test Classes - Verification Component Configuration - Creating and Selecting a User-Defined Test – Creating Meaningful Tests- Virtual Sequences- Checking for DUT Correctness- Scoreboards- Implementing a Coverage Model		
UNIT – IV	**UVM USING THE REGISTER LAYER CLASSES**	**(9 Periods)**
Using The Register Layer Classes - Back-Door Access -Special Registers -Integrating a Register-Model in a Verification Environment- Integrating a Register Model- Randomizing Field Values- Pre-Defined Sequences		
UNIT – V	**ASSIGNMENT IN TESTBENCHES**	**(9 Periods)**
Assignment, APB: Protocol, Test bench Architecture, Driver and Sequencer, Monitor, Agent and Env; Creating Sequences, Building Test, Design and Testing of Top Module.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Kathleen A Meade & Sharon Rosenberg, "A **Practical Guide to Adopting the Universal Verification Methodology (UVM)**", Lulu Press, Second Edition, 2013.*

2 *Ray Salemi, **"The UVM Primer- A Step-By-Step Introduction to the Universal Verification Methodology"**, Boston Light Press, 2013.*

REFERENCES BOOKS:

1 *https://www.udemy.com/learn-ovm-UVM/ 2.*

2 *http://www.testbench.in/ut_00_index.html 3.*

3 *http://www.testbench.in/ot_00_index.html*

4 *https://www.accellera.org/images/downloads/standards/UVM/UVM_users_guide_1.2.pdf*

5 *Chris Spear & Greg Tumbush, **"System Verilog for Verification"**, Springer, Third Edition, 2012.*

6 *http://www.verificationguide.com*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Explain the basic concepts of UVM

CO2 Develop the actual and reusable verification components.

CO3 Create and instantiate verification components for UVM

CO4 Generate the register layer classes.

CO5 Code test benches using UVM and explain advanced peripheral bus test benches.

COURSE ARTICULATION MATRIX :

COs/POs	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	PSO 2	PSO 3
CO1	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
CO2	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
CO3	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
CO4	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
CO5	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M
18LPE$50	H	M	M	L	L	M	-	-	-	M	-	H	H	M	M

L - Low, M - Moderate (Medium), H - High

VERTICAL V
BIO MEDICAL TECHNOLOGIES

18LPE$51	BIOSENSORS

PREREQUISITES :	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

* The course focuses on biosensors and transducers associated with measurement of physiological phenomena, like pressure, displacement, flow, volume and biochemistry.

UNIT - I	TRANSDUCERS IN MEDICINE	(9 Periods)

Classification of transducers -characteristic of transducers-Temperature transducers: Resistance temperature detector (RTD), Thermistor, strain gauge transducers, semiconductor transducers, catheter tip transducers, Piezoelectric transducer-Photoelectric transducers -photovoltaic cell, photoconductive cell, photodiodes, Ultrasonic Flow transducers.

UNIT – II	ELECTRODES	(9 Periods)

Bio potential Electrodes - Electrode electrolyte interface, polarization, polarizable and non polarizable electrodes-Electrode Behaviour and Circuit Models-Electrode-skin Interface and Motion Artifact-Body-Surface Recording Electrodes-Internal Electrodes: Needle & wire electrodes, Electrode Arrays, Microelectrodes: Metal supported metal micropipette , microelectronic, properties of microelectrodes.

UNIT – III	CHEMICAL BIOSENSORS	(9 Periods)

Chemical Biosensors - Blood gas and Acid-Base Physiology, Electrochemical sensors, reference electrode, pH, pO2, pCO2 electrodes, Ion-Selective Field-Effect Transistor (ISFET), Noninvasive Blood-Gas Monitoring, Blood Glucose Sensors -Transcutaneous arterial oxygen tension & carbon dioxide tension monitoring enzyme electrode.

UNIT – IV	OPTICAL SENSOR AND RADIATION DETECTORS	(9 Periods)

Principles of optical sensors-optical fiber sensor- indicator mediated transducers-optical fiber temperature sensors-Proportional counter-Gas-ionization chamber-Geiger counters-Scintillation detectors.

UNIT – V	BIOLOGICAL SENSORS	(9 Periods)

Sensors / receptors in the human body-Basic organization of nervous system-Neural mechanism-Chemoreceptor: Hot and cold receptors, barro receptors, sensors for smell, sound, vision, Ion exchange membrane electrodes, enzyme electrode, glucose sensors, immune sensors-Basic principles of MOSFET biosensors and BIOMEMS-Smart sensors.

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS

1 *R. S. Khandpur, "**Handbook of Biomedical Instrumentation**", Tata McGraw Hill 2010*
2 *S.C. Cobbold, "**Transducers for Biomedical Instruments**", Prentice Hall,2012*

REFERENCE BOOKS

1 *Carr& Brown, "**Introduction to Biomedical Equipment Technology"**Pearson Edn, Asia. 2000*
2 *Rao &Guha,"**Principles of Medical Electronics & Biomedical Instrumentation**", University Press, India,2010*
3 *Iberall& Guyton, "**Regulation & Control in Physiological System**, "Instruments Soc.USA,2009*
4 *A.V.S. De Renck , "**Touch Heat & Pain**", Churchill Ltd. London., 2000*
5 *Brown & Gann, "**NIL**", Academic Press2009*

COURSE OUTCOMES:

On completion of the course, the students will have the ability to :

CO1 Have a broad understanding of the applications of various sensors and transducers available for physiological and cellular measurements.

CO2 Understand fundamental principles of electrodes.

CO3 Get the clear domain knowledge about various measurement various physiological parameters using chemical Biosensors.

CO4 Understand the operation of various optical sensors and radiation detectors.

CO5 Be capable of presenting the operation of Biological sensors.

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	L	M	L	M	-	M	-	-	-	M	M	L	L
CO2	M	M	L	L	L	M	-	M	-	-	-	M	M	L	L
CO3	M	M	L	L	L	M	-	M	-	-	-	M	M	L	L
CO4	H	H	L	L	L	M	-	M	-	-	-	M	M	L	L
CO5	H	H	M	M	L	M	-	M	-	-	-	M	M	L	L
18LPE$51	M	M	L	L	L	M	-	M	-	-	-	M	M	L	L

L - Low, M - Moderate (Medium), H - High

18LPE$52	MEDICAL INSTRUMENTATION

PREREQUISITES :	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

* This course provides an understanding about the design Bio potential amplifiers for acquisition of bio signals and to study the various non-electrical physiological parameter measurement and bio chemical measurements.

UNIT - I	BIOPOTENTIAL ELECTRODES	(9 Periods)
Origin of bio potential and its propagation. Electrode-electrolyte interface, electrode– skin interface, half-cell potential, impedance, polarization effects of electrode – non polarizable electrodes. Types of electrodes - surface, needle and micro electrodes and their equivalent circuits. Recording problems - measurement with two electrodes.		
UNIT – II	**BIOPOTENTIAL MEASUREMENT**	**(9 Periods)**
Bio signal characteristics– frequency and amplitude ranges. ECG – Einthoven's triangle, standard 12 lead system, block diagram. Measurements of heart sounds - PCG. EEG – 10-20 electrode system, unipolar, bipolar and average mode, Functional block diagram. EMG – unipolar and bipolar mode, block diagram, EOG and ERG.		
UNIT – III	**BIOPOTENTIAL AMPLIFIER**	**(9 Periods)**
Need for bio-amplifier - single ended bio-amplifier, differential bio-amplifier – right leg driven ECG amplifier. Band pass filtering, isolation amplifiers – transformer and optical isolation - isolated DC amplifier and AC carrier amplifier. Artifacts and removal.		
UNIT – IV	**NON ELECTRICAL PHYSIOLOGICAL PARAMETER MEASUREMENT**	**(9 Periods)**
Temperature, respiration rate and pulse rate measurements, Plethysmography, Pulse oximetry, Blood Pressure: direct methods - Pressure amplifiers - systolic, diastolic, mean detector circuit, indirect methods - auscultatory method, oscillometric method, ultrasonic method. Blood flow - Electromagnetic and ultrasound blood flow measurement. Cardiac output measurement- Indicator dilution, dye dilution and thermo dilution method.		
UNIT – V	**BIOCHEMICAL MEASUREMENT**	**(9 Periods)**
Biochemical sensors - pH, pO2 and pCO2, Ion selective Field Effect Transistor (ISFET), immunologically sensitive FET (IMFET), Blood glucose sensors - Blood gas analyzers, colorimeter, flame photometer, spectrophotometer, blood cell counter, auto analyzer.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1 *Joseph J. Carr and John M. Brown, "**Introduction to Biomedical equipment technology**", Pearson Education, 4th Edition, 2014.*

2 *John G.Webster, "**Medical Instrumentation Application and Design**", John Wiley and Sons, New York, 4 th Edition, 2009.*

REFERENCE BOOKS

1 *Khandpur R.S, "**Handbook of Biomedical Instrumentation**", Tata McGraw Hill, New Delhi, 3 rd Edition, 2014.*

2 *L.A Geddes and L.E.Baker, "**Principles of Applied Biomedical Instrumentation**", John Wiley and Sons, 3 rd Edition, Reprint 2008.*

3 *Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, "**Biomedical Instrumentation and Measurements**," Pearson Education India, 2 nd Edition, 2015.*

4 *Myer Kutz, **"Standard Handbook of Biomedical Engineering & Design",** McGraw-Hill Publisher, 2003.*

COURSE OUTCOMES:

On completion of the course, the students will have the ability to :

CO1 To describe the electrode behavior and circuit models.

CO2 To describe the fundamentals of Bio potential recording.

CO3 To design various bio amplifiers.

CO4 To Measure and analyse various nonelectrical physiological parameters.

CO5 To Measure and analyse various biochemical parameters.

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	L	M	L	M	L	M	-	-	-	M	M	L	M
CO2	M	M	L	M	L	M	L	M	-	-	-	L	M	L	M
CO3	M	M	L	M	H	M	L	M	-	-	-	M	M	L	M
CO4	H	H	L	M	M	M	L	M	-	-	-	M	M	L	M
CO5	H	H	M	L	L	M	L	M	-	-	-	M	M	L	M
18LPE$52	L	L	L	L	L	M	L	M	-	-	-	M	M	L	M

L - Low, M - Moderate (Medium), H - High

18LPE$53	MEDICAL IMAGING SYSTEMS

PREREQUISITES :	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

* This course aims to provide an insight to the Medical imaging modalities and reconstruction techniques.

UNIT - I	IMAGE CHARACTERISTICS AND QUALITY METRICS	(9 Periods)
Real and mental images -Reflected, transmitted and emitted light images-noise-Signal to Noise Ratio-Contrast Optimum contrast-Sharpness-Transfer functions-Resolution-line pairs and MTF.Image quality metrics for digital systems-Global parameter assessment, Spatial frequency assessment,Image processing assessment,Observer assessment.		
UNIT – II	**RADIOGRAPHIC IMAGE**	**(9 Periods)**
Unsharpness -Geomentric,photographic,motional-identifying the causes of unsharpness-Over and under penetration-Radiographic contrast -fogging-Graininess-mottle-Image artefacts-Distortion-foreshortening-elongation- Double images Image subtraction techniques-Digital subtraction.		
UNIT – III	**TOMOGRAPHIC IMAGING**	**(9 Periods)**
Over view of Computerized tomography as an image device-Scanner design-Reconstruction techniques-Reconstruction techniques-CT image quality-Other artefacts in CT-Multislice CT-CT Scanner Performance.		
UNIT – IV	**MAGNETIC RESONANCE IMAGING**	**(9 Periods)**
Basic principles of Magnetic Resonance Imaging-Block diagram of MR Scanner components-Common artefacts-image reconstruction-imaging equations-image quality-Resolution-Noise-Signal to Noise Ratio-Artefacts-Functional MRI.		
UNIT – V	**3D ULTRASOUND IMAGING**	**(9 Periods)**
Limitations of 3D Ultrasound imaging-3D Ultrasound scanning techniques-Reconstruction od 3D Ultrasound images-effects of errors in 3D image reconstruction-Viewing of 3D Ultrasound images-3-D Ultrasound system performance.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS

1 *Richard L. Van Metter, Jacob Beutel, Harold L. Kundel, "**Handbook of Medical Imaging**," Volume 1. Physics and Psychophysics, SPIE, 2000.*

2 *Chesney D. N., Chesney "**M. O. Radio graphic imaging**," CBS Publications, New Delhi, 2004.*

REFERENCE BOOKS

1 *Donald W. McRobbice, Elizabeth A. Moore, Martin J. Grave and Martin R. Prince "**MRI from Picture to proton**," Cambridge University press, second edition, New York 2007.*

2 *Frederick W Kremkau, "**Diagnostic Ultrasound Principles & Instruments**, "Saunders Elsevier,2005.*

3 *Jerry L. Prince, Jnathan M. Links,"**Medical Imaging Signals and Systems"**- Pearson Education Inc. 2014.*

4 *Peggy, W., Roger D. Ferimarch, "**MRI for Technologists"**, McGraw Hill, New York, second edition, 2000.*

COURSE OUTCOMES:

On completion of the course, the students will have the ability to :

CO1 Assess the characteristics and quality of the image.

CO2 Demonstrate Principles of Radiography.

CO3 Explain the image acquisition using CT.

CO4 Demonstrate the applications of magnetic field in the field of medicine.

CO5 Explain the principles of 3D Ultrasound imaging.

COURSE ARTICULATION MATRIX :

COs/POs	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	PSO 2	PSO 3
CO1	H	H	M	H	L	L	L	M	-	-	-	M	L	L	L
CO2	M	H	M	H	L	L	L	M	-	-	-	M	L	L	L
CO3	M	H	M	H	L	L	L	M	-	-	-	M	L	L	L
CO4	M	H	M	H	L	L	L	M	-	-	-	M	L	L	L
CO5	M	H	M	H	L	L	L	M	-	-	-	M	L	L	L
18LPE$53	M	H	M	H	L	L	L	L	-	-	-	M	L	L	L

L - Low, M - Moderate (Medium), H - High

18LPE$54	BIO INFORMATICS FOR BIOMEDICAL ENGINEERS

PREREQUISITES :	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

* This course Exposes to the need for Bioinformatics tools, be familiar with the modeling techniques

UNIT - I	INTRODUCTION	(9 Periods)
Need for Bioinformatics technologies – Overview of Bioinformatics technologies Structural bioinformatics – Data format and processing – Secondary resources and applications – Role of Structural bioinformatics - Biological Data Integration System.		
UNIT – II	**DATAWAREHOUSING AND DATAMINING IN BIOINFORMATICS**	**(9 Periods)**
Bioinformatics data – Data warehousing architecture – data quality – Biomedical data analysis – DNA data analysis – Protein data analysis – Machine learning – Neural network architecture and applications in bioinformatics.		
UNIT – III	**MODELING FOR BIOINFORMATICS**	**(9 Periods)**
Hidden markovmodeling for biological data analysis – Sequence identification –Sequence classification – multiple alignment generation – Comparative modeling –Protein modeling – genomic modeling – Probabilistic modeling – Bayesian networks – Boolean networks - Molecular modeling – Computer programs for molecular modeling.		
UNIT – IV	**PATTERN MATCHING AND VISUALIZATION**	**(9 Periods)**
Gene regulation – motif recognition – motif detection – strategies for motif detection – Visualization – Fractal analysis – DNA walk models – one dimension – two dimension – higher dimension – Game representation of Biological sequences – DNA, Protein, Amino acid sequences.		
UNIT – V	**MICROARRAY ANALYSIS**	**(9 Periods)**
Microarray technology for genome expression study – image analysis for data extraction – preprocessing – segmentation – gridding – spot extraction – normalization, filtering – cluster analysis – gene network analysis – Compared Evaluation of Scientific Data Management Systems – Cost Matrix – Evaluation model - Benchmark – Tradeoffs		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS

1 *Yi-Ping Phoebe Chen Edition, "**BioInformatics Technologies**", First Indian Reprint, Springer Verlag, 2007.*

2 *Bryan Bergeron, "**Bio Informatics Computing**", Second Edition, Pearson Education, 2003.*

REFERENCES:

*1 Arthur M Lesk, "**Introduction to Bioinformatics**", Second Edition, Oxford University Press, 2004*

*2 S. Balamurugan, Anand T. Krishnan , Dinesh Goyal "**Computation in BioInformatics: Multidisciplinary Applications**" 1st Edition, Wiley publishers,2021.*

COURSE OUTCOMES:

On completion of the course, the students will have the ability to :

CO1 Understand the basic concepts of Bio informatics

CO2 Understand the Various techniques used in Data mining

CO3 Model the Bio informatics system.

CO4 Understand pattern matching and visualization

CO5 Understand about Micro array analysis

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	L	M	L	L	L	L	-	-	-	M	M	L	M
CO2	M	M	L	L	L	L	L	L	-	-	-	L	M	L	M
CO3	M	M	L	L	L	L	L	L	-	-	-	M	M	L	M
CO4	H	H	L	L	L	L	L	L	-	-	-	M	M	L	L
CO5	H	H	M	M	L	L	L	L	-	-	-	M	M	M	M
18LPE$54	M	M	L	L	L	L	L	L	-	-	-	M	M	M	M

L - Low, M - Moderate (Medium), H - High

18LPE$55	BIOTELEMETRY AND TELEMEDICINE

PREREQUISITES :	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

* This course familiarize students with basic concepts of Biotelemetry and Telemedicine and its applications.

UNIT - I	BASICS OF TELEMETRY	(9 Periods)
Introduction, fundamental of RF telemetry, basic telemetry, system components of coding resolution, pulse code modulation, PCM multiplexing and conversion, PCM data transmission, PCM PSD system. Theoretical comparison of telemetry systems, sub modulation methods, power efficiency of combined systems, Practical constraint of telemetry methods optimized power efficiency.		
UNIT – II	**BIOTELEMETRY**	**(9 Periods)**
Measurement of Blood pressure – Direct Methods and Indirect Methods -Temperature - Respiration rate - Heart rate measurement - Apnea detectors -Oximetry -Pulse oximeter, Ear oximeter - Computerized patient monitoring system– Bedside, Central Monitoring system – Biotelemetry: Basics components, and its different types.		
UNIT – III	**TELEMEDICINE AND HEALTH**	**(9 Periods)**
History and Evolution of telemedicine, Functional diagram of telemedicine system, Telemedicine, Telehealth, Tele care, Organs of telemedicine, Global and Indian scenario, Ethical and legal aspects of Telemedicine - Confidentiality, Social and legal issues, Safety and regulatory issues, Advances in Telemedicine.		
UNIT – IV	**TELEMEDICAL TECHNOLOGY**	**(9 Periods)**
Principles of Multimedia - Text, Audio, Video, data, Data communications and networks, PSTN,POTS, ANT, ISDN, Internet, Air/ wireless communications: GSM satellite, and Micro wave, Modulation techniques, Types of Antenna, Integration and operational issues, Communication infrastructure for telemedicine – LAN and WAN technology. Satellite communication. Mobile hand held devices and mobile communication. Internet technology and telemedicine using world wide web (www). Video and audio conferencing. Clinical data – local and centralized.		
UNIT – V	**TELEMEDICAL APPLICATIONS**	**(9 Periods)**
Telemedicine access to health care services – health education and self care. · Introduction to robotics surgery, telesurgery. Telecardiology, Teleoncology, Telemedicine in neurosciences, Electronic Documentation, e-health services security and interoperability., Telemedicine access to health care services – health education and self care, Business aspects - Project planning and costing, Usage of telemedicine.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1 ***"Fundamentals of Remote Sensing – by George Joseph,"*** *second Edition, Universities press, 2005*
2 *Khandpur R.S, "**Hand-book of Biomedical Instrumentation**", Tata McGraw Hill, 2nd Edition, 2003.*

REFERENCE BOOKS:

1 *Wootton, R., Craig, J., Patterson, V. (Eds.), "**Introduction to Telemedicine. Royal Society of Medicine"** Press Ltd, Taylor & Francis 2006*
2 *Rao &Guha,"**Principles of Medical Electronics & Biomedical Instrumentation**", University Press, India. O'Carroll, P.W., Yasnoff, W.A., Ward, E., Ripp, L.H., Martin, E.L. (Eds), "Public Health Informatics and Information Systems", Springer, 2003.*
3 *Ferrer-Roca, O., Sosa - Iudicissa, M. (Eds.), "**Handbook of Telemedicine. IOS Press (Studies in Health Technology and Informatics**," Volume 54, 2002.*
4 *Simpson, W. Video over IP."**A practical guide to technology and applications**" Focal Press Elsevier, 2006.*
5 *Bemmel, J.H. van, Musen, M.A. (Eds.) "**Handbook of Medical Informatics**". Heidelberg, Germany: Springer, 1997.*
6 *Mohan Bansal, "**Medical Informatics**", Tata McGraw-Hill, 2004ond*

COURSE OUTCOMES:

On completion of the course, the students will have the ability to :

CO1 Describe basic Telemetry, Biotelemetry and Telemedicine systems.
CO2 Explain the application of Biotelemetry & Telemedicine in modern healthcare technology
CO3 Understand and explain the modern Tele medical technologies
CO4 Understand the concepts of Tele medicine Technology
CO5 Explain about the application of Tele medicine.

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	L	M	L	L	L	L	-	-	-	M	M	L	M
CO2	M	M	L	L	L	L	L	L	-	-	-	L	M	L	M
CO3	M	M	L	L	L	L	L	L	-	-	-	M	M	L	M
CO4	H	H	L	L	L	L	L	L	-	-	-	M	M	L	L
CO5	H	H	M	M	L	L	L	L	-	-	-	M	M	L	M
18LPE$55	M	M	L	L	L	L	L	L	-	-	-	M	M	L	M

L - Low, M - Moderate (Medium), H - High

18LPE$56	EMBEDDED SYSTEMS IN BIOMEDICAL ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	9	0	0	9

COURSE OBJECTIVES

- This course introduces the applications Embedded systems in Biomedical Engineering.

UNIT – I	INTRODUCTION TO BIOMEDICAL ENGINEERING	(9 Periods)
Origin of bio potential and its propagation- Resting and Action Potential – Bio signals characteristics-Types of electrodes - Types of transducers and applications-Bio-amplifiers- Types of recorderscomponentsof a biomedical system.		
UNIT – II	**WEARABLE HEALTH DEVICES**	**(9 Periods)**
Concepts of wearable technology in health care-Components of wearable devices- Biosensors-Blood glucose sensors - Head worn- Hand worn- Body worn-pulse oxymeter- Cardiac pacemakers – Hearing aids and its recent advancements-wearable artificial kidney.		
UNIT – III	**EMBEDDED SYSTEM FOR MEDICAL IMAGE PROCESSING**	**(9 Periods)**
Introduction to embedded image processing . ASIC vs FPGA - memory requirement-, power consumption- parallelism - Design issues in VLSI implementation of Image processing algorithms - interfacing. Hardware implementation of image processing algorithms: Segmentation and compression.		
UNIT – IV	**EMBEDDED SYSTEM FOR DIAGNOSTIC APPLICATIONS**	**(9 Periods)**
ICCU patient monitoring system – ECG-EEG-EMG acquisition system-MRI scanner-Basic components of MRI unit- CT scanner- Principle of operation –Sonography- Different modes of operation.		
UNIT – V	**CASE STUDY**	**(9 Periods)**
Respiratory measurement using spirometer- IPPB unit for monitoring respiratory parameters - ventilators- Defibrillator- Basic principle of a defibrillator- Glucometer- Block diagram of a Heart-Lung machine-Applications.		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *KhandpurR.S,"**Handbook of Biomedical Instrumentation**," Tata McGraw Hill, New Delhi, 3rd Edition, 2014.*

2 *L.A Geddes and L.E.Baker, "**Principles of Applied Biomedical Instrumentation**", 3rd Edition, JohnWiley and Sons, Reprint 2008.*

REFERENCES

1 *Leslie Cromwell, "**Biomedical Instrumentation and Measurement**", Prentice Hall of India, New Delhi, 2007.*

2 *John G.Webster, "**Medical Instrumentation Application and Design**", 3rd Edition, Wiley India Edition, 2007.*

3 *Richard S.Cobbold, "**Transducers for Biomedical Measurements; Principle and applications**",John Wiley and sons, 2001.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Demonstrate the fundamental art of biomedical engineering.

CO2 Illustrate about wearable health devices and its importance.

CO3 Implement image processing applications using software and hardware.

CO4 Compare various embedded diagnostic applications.

CO5 Analyse using case study for some biomedical equipment.

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	L	M	L	L	L	L	-	-	-	M	M	L	M
CO2	M	M	L	L	L	L	L	L	-	-	-	L	M	L	M
CO3	M	M	L	L	L	L	L	L	-	-	-	M	M	L	M
CO4	H	H	L	L	L	L	L	L	-	-	-	M	M	L	L
CO5	H	H	M	M	L	L	L	L	-	-	-	M	M	L	M
18LPE$56	M	M	L	L	L	L	L	L	-	-	-	M	M	L	M

L - Low, M - Moderate (Medium), H - High

18LPE$57	WEARABLE TECHNOLOGIES

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

* This course focuses on the sensors and energy harvesting devices.

UNIT – I	SENSORS	(9 Periods)
Need for wearable systems, Sensors for wearable systems-Inertia movement sensors, Respiration activity sensor, Inductive plethysmography, Impedance plethysmography, pneumography,Wearable ground reaction force sensor, GSR, Radiant thermal sensor, Wearable motion sensors, CMOS –Based Biosensors, E-Textiles, Bio compatibility.		
UNIT – II	**SIGNAL PROCESSING**	**(9 Periods)**
Wearability issues -physical shape and placement of sensor, Technical challenges - sensor design, signal acquisition, Constraint on sampling frequency for reduced energy consumption,light weight signal processing, Rejection of irrelevant information, Datamining.		
UNIT – III	**ENERGY HARVESTING FOR WEARABLE DEVICES**	**(9 Periods)**
Solar cell, Vibration based, Thermal based, Human body as a heat source for power generation, Hybrid thermoelectric photovoltaic energy harvests, Thermopiles.		
UNIT – IV	**WIRELESS HEALTH SYSTEMS**	**(9 Periods)**
Need for wireless monitoring, Definition of Body area network, BAN and Healthcare, Technical Challenges- System security and reliability, BAN Architecture – Introduction, Wireless communication techniques.		
UNIT – V	**APPLICATIONS OF WEARABLE SYSTEMS**	**(9 Periods)**
Medical Diagnostics, Medical Monitoring-Patients with chronic disease, Hospital patients, Elderly patients, Multi parameter monitoring, Neural recording, Gait analysis, Sports Medicine, Smart Fabrics.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0Periods Total: 45 Periods

TEXT BOOK:

1 Annalisa Bonfiglio, Danilo De Rossi, "**Wearable Monitoring Systems**", Springer,2011.

2 Sandeep K.S. Gupta, Tridib Mukherjee, Krishna Kumar Venkatasubramanian, "**Body AreaNetworks Safety, Security, and Sustainability**," Cambridge University Press,2013.

REFERENCE BOOKS

1 Hang,Yuan-Ting, "**Wearable medical sensors andsystems**",Springer-2013.

2 Mehmet R. Yuce, Jamil Y. Khan, "**Wireless Body Area Networks Technology, Implementation and Applications**", Pan Stanford Publishing Pvt. Ltd, Singapore,2012.

3 Guang-ZhongYang(Ed.), "**Body Sensor Networks**, "Springer,2006.

4 Andreas Lymberis, Danilo de Rossi ," **Wearable eHealth systems for Personalized Health Management - State of the art and future challenges** "IOS press, The Netherlands,2009.

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Understand the sensor and signal processing requirement of wearable systems

CO2 Analyze the communication and security aspects

CO3 Elucidate the level of energy involvement in wearable systems.

CO4 Summarize the existing technology through demonstrations, contributions of scientist, national/international policies with a futuristic vision.

CO5 Build and analyze of some biomedical equipment.

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	L	M	M	M	-	M	-	-	-	M	M	L	L
CO2	M	M	L	L	L	M	-	M	-	-	-	M	M	L	L
CO3	M	M	L	L	L	M	-	M	-	-	-	M	M	L	L
CO4	H	H	L	L	L	M	-	M	-	-	-	M	M	L	L
CO5	H	H	M	M	M	M	-	M	-	-	-	M	M	L	L
18LPE$57	M	M	L	L	L	M	-	M	-	-	-	M	M	L	L

L - Low, M - Moderate (Medium), H - High

18LPE$58	HOSPITAL SAFETY AND MANAGEMENT

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES

- This course introduces the fundamentals of hospital administration and management.

UNIT – I	OVERVIEW OF HOSPITAL ADMINISTRATION	(9 Periods)
Distinction between Hospital and Industry, Challenges in Hospital Administration – Hospital Planning- Equipment Planning – Functional Planning - Current Issues in Hospital Management – Telemedicine - Bio-Medical Waste Management.		
UNIT – II	**HUMAN RESOURCE MANAGEMENT IN HOSPITAL**	**(9 Periods)**
Principles of HRM – Functions of HRM – Profile of HRD Manager – Tools of HRD –Human Resource Inventory – Manpower Planning. Different Departments of Hospital, Recruitment, Selection, Training Guidelines –Methods of Training – Evaluation of Training – Leadership grooming and Training, Promotion – Transfer, Communication – nature, scope, barriers, styles and modes of communication.		
UNIT – III	**MARKETING RESEARCH PROCESS**	**(9 Periods)**
Marketing information systems - assessing information needs, developing & disseminating information - Market Research process - Other market research considerations – Consumer Markets & Consumer Buyer Behaviour - Model of consumer behaviour - The buyer decision process - Model of business buyer behaviour – Major types of buying situations - WTO and its implications.		
UNIT – IV	**HOSPITAL INFORMATION SYSTEMS & SUPPORTIVE SERVICES**	**(9 Periods)**
Management Decisions and Related Information Requirement - Clinical Information Systems - Administrative Information Systems - Support Service Technical Information Systems –Medical Transcription, Medical Records Department – Central Sterilization and Supply Department– Pharmacy– Food Services - Laundry Services.		
UNIT – V	**QUALITY AND SAFETY ASPECTS IN HOSPITAL**	**(9 Periods)**
Quality system – Elements, implementation of quality system, Documentation, Quality auditing, International Standards ISO 9000 – 9004 – Features of ISO 9001 – ISO 14000 – Environment Management Systems. NABA, JCI, NABL. Security – Loss Prevention – Fire Safety – Alarm System – Safety Rules. Health Insurance & Managing Health Care – Medical Audit – Hazard and Safety in a hospital Setup.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *R.C.Goyal, "**Hospital Administration and Human Resource Management**", PHI – Fourth Edition,2006.*

2 *G.D.Kunders, "**Hospitals – Facilities Planning and Management – TMH**," New Delhi – Fifth Reprint 2007.*

REFERENCE BOOKS

1 *Arnold D. Kalcizony& Stephen M. Shortell, "**Health Care Management**", 6th Edition Cengage Learning, 2011.*
2 *Norman Metzger, "**Handbook of Health Care Human Resources Management**", 2nd edition Aspen Publication Inc. Rockville, Maryland, USA, 2003.*
3 *Peter Berman "**Health Sector Reform in Developing Countries**" - Harvard University Press,2005.*
4 *William A. Reinke "**Health Planning For Effective Management**" - Oxford University Press.2006.*
5 *Blane, David, Brunner, "**Health and Social Organization: Towards a Health Policy for the 21st Century**", Eric Calrendon Press 2002.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Understand the principles of Hospital administration.

CO2 Identify the importance of Human resource management

CO3 Applying various marketing research techniques.

CO4 Identify Information management systems and its uses.

CO5 Understand the quality and safety procedures followed in hospitals.

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	L	M	L	L	L	M	-	-	-	M	M	L	M
CO2	M	M	L	L	L	L	L	M	-	-	-	L	M	L	M
CO3	M	M	L	L	L	L	L	M	-	-	-	M	M	L	M
CO4	H	H	L	L	L	L	L	M	-	-	-	M	M	L	L
CO5	H	H	M	M	L	L	L	M	-	-	-	M	M	L	M
18LPE$58	M	M	L	L	L	L	L	M	-	-	-	M	M	L	M

L - Low, M - Moderate (Medium), H - High

VERTICAL VI
EMBEDDED SYSTEMS AND IOT

18LPE$03	INTRODUCTION TO MEMS

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To learn the fabrication process in MEMS and acquire knowledge on various sensors and actuators

UNIT I: INTRODUCTION	**(9 Periods)**
History of Micro Electro Mechanical Systems (MEMS) – MEMS Materials: Silicon and other materials - Intrinsic Characteristics of MEMS – Energy Domains and Transducers– Silicon based MEMS processes – New Materials – Review of Electrical and Mechanical concepts in MEMS – Stress and strain analysis – Flexural beam bending- Torsional deflection.	
UNIT II: MEMS FABRICATION	**(9 Periods)**
MEMS fabrication processes: Review of IC fabrication process. Micromachining: Bulk Micromachining - Dry and Wet etching - Surface micromachining - Deposition, Evaporation, Sputtering, Epitaxial growth - Deep Reaction ion etching - Advanced Lithography - LIGA process - Multi User MEMS Process.	
UNIT III: ELECTROSTATIC SENSORS	**(9 Periods)**
Electrostatic sensors – Parallel plate capacitors – Applications – Interdigitated Finger capacitor – Comb drive devices – Micro Grippers – Micro Motors – Thermal Sensing and Actuation – Thermal expansion – Thermal couples – Thermal resistors – Thermal Bimorph – Magnetic Actuators – Micromagnetic components – Actuation using Shape Memory Alloys.	
UNIT IV: MAGNETOSTATIC SENSORS	**(9 Periods)**
Piezoresistive sensors – Piezoresistive sensor materials – Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile and FLow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials – Applications to Inertia , Acoustic, Tactile and FLow sensors.	
UNIT-V: APPLICATION CASE STUDIES	**(9 Periods)**
Application case studies: MEMS Scanners and Retinal Scanning Displays (RSD), Grating Light Valve (GLV), Digital Micromirror Devices (DMD), Optical switching, Capacitive Micromachined Ultrasonic Transducers (CMUT), Air bag system, Micromotors, Scanning Probe Microscopy.	

Contact periods:
Lecture:45 Periods Tutorial:0 Periods Practical:0 Periods Total:45 Periods

TEXT BOOKS:

*1. Chang Liu, "**Foundations of MEMS**", Pearson Education Inc.,2nd edition 2006.*
*2. Stephen D Senturia, "**Microsystem Design**", Springer Publication,1st edition 2000*

REFERENCE BOOKS:

*1. Julian W.Gardner, Vijay K.Varadan, Osama O. AwadelKarim, "**Micro sensors MEMS and Smart Devices**", John Wiby& sons Ltd., 1st edition 2001.*
*2. Mohamed Gad – el – Hak, "**MEMS Handbook**", CRC Press, 2nd edition 2002.*
*3. Rai - Choudhury P. "**MEMS and MOEMS Technology and Applications**", PHI Learning Private Limited, 1st edition 2009*

*4. Sabrie Solomon, "**Sensors Handbook**," 2nd edition McGraw Hill, 1998.*
*5. Marc F Madou, "**Fundamentals of Micro Fabrication**", CRC Press, 2nd Edition, 2002.*
*6. Tai Ran Hsu, "**MEMS & Micro systems Design and Manufacture**" 2nd edition Tata McGraw Hill, New Delhi, 2002.*

COURSE OUTCOMES:

Upon completion of this course, the students will be able to

CO1: Knowledge on materials used in MEMS and MEMS fabrication process
CO2: In-depth knowledge on different types of sensors and actuators.
CO3: Exposure to applications and case studies of MEMS.

COURSE ARTICULATION MATRIX

CO	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	PSO 2	PSO 3
CO1	L	-	-	-	-	-	L	-	-	-	-	-	H	-	-
CO2	H	-	L	-	-	-	-	-	-	-	-	-	L	M	-
CO3	L	-	L	-	-	-	L	-	-	M	-	-	L	H	-
18LPE$03	H	-	L	-	-	-	L	-	-	M	-	-	H	H	-

L - Low, M - Moderate (Medium), H - High

18LPE$07	AUTOMOTIVE ELECTRONICS

PRE-REQUISITES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To acquire in-depth knowledge on the basic electrical and electronic components used in an automotive systems.
- To apply knowledge of an embedded system in automotive electronic systems.
- To learn the various vehicle communication protocols.

UNIT- I : ELECTRONICS IN AUTOMOTIVE SYSTEMS	**(9 Periods)**
Overview of Automotive Mechanical systems- Need for Automotive Electronics System - Performance (Speed, Power and Torque) - Control (Emission, Fuel Economy, Drivability and Safety) and Legislation (Environmental legislation for pollution and safety norms) - Overview of vehicle electronic systems - Basic electrical components and their operation in an automobile- Power train subsystem(Starting systems, Charging systems, Ignition systems, Electronic fuel control) - Chassis subsystem(ABS,TCS and ESP) - Comfort and safety subsystems (Night vision, airbags, Seatbelt Tensioners, Cruise Control- Lane-departure-warning, Parking)	
UNIT- II : FABRICATION AND MEASUREMENT TECHNIQUES	**(9 Periods)**
Hardware module - Introduction to an embedded board -components - Software Module: IDE - Getting started: Creating new project, creating new files, adding files to project, compile, build, debug and simulation of a project.	
UNIT- III : EMBEDDED SYSTEM PROGRAMMING AND DEBUGGING	**(9 Periods)**
Embedded System Programming - Up-loaders- ISP - ROM Emulators - In-Circuit Emulators - Debug Interfaces: BDM and JTAG.	
UNIT- IV: EMBEDDED SYSTEM IN AUTOMOTIVE APPLICATIONS	**(9 Periods)**
Engine management systems - Gasoline/ Diesel systems, various sensors used in system - Electronic transmission control - Vehicle safety system - Electronic control of braking and traction - Body electronics - Infotainment systems - Navigation systems - System level tests - Software calibration using engine and vehicle dynamometers - Environmental tests for Electronic Control Unit - Application Control Unit - Application of Control elements and control methodology in Automotive System.	
UNIT- V : EMBEDDED SYSTEM COMMUNICATION PROTOCOLS	**(9 Periods)**
Introduction to control networking - Communication protocols in embedded systems - SPI, I 2C, USB - Vehicle communication protocols - Introduction to CAN, LIN, FLEXRAY, MOST, KWP2000.	

Contact Periods:
Lecture: 45 Periods **Tutorial:0 Periods** **Practical: 0 Periods** **Total:45 Periods**

TEXT BOOKS:

*1. Denton.T, "**Automobile Electrical and Electronic Systems**", Edward Arnold Publishers, 4th Edition 2012.*
*2. Nicholas Navit, "**Automotive Embedded System Handbook**", CRC press, 2009.*

REFERENCE BOOKS:

*1.Robert Bosch GmbH, "**Automotive Handbook**", John Wiley & Sons, 6th Edition, 2004.*
*2.Knowles.D, "**Automotive Electronic and Computer Controlled Ignition Systems**", Prentice Hall,1998*
*3.William B. Ribbens, "**Learning Automotive Electronics**", Newnes Publishing, 6th Edition 2003*
*4.Joerg Schaeuffele, Thomas Zurawka - "**Automotive Software Engineering- Principles, Processes, Methods and Tools**", SAE Publications,2005*

COURSE OUTCOMES

Upon completion of the course, the students will be able to

CO1: An in-depth knowledge of the basic electrical and electronic components used in an automotive systems.
CO2: An ability to do projects using Embedded hardware and software.
CO3: An in- depth knowledge on programming and debugging skills.
CO4: An ability to apply knowledge of an embedded system in automotive electronic Systems.
CO5: Knowledge on various Embedded system communication protocols.
CO6: Knowledge on various vehicle communication protocols.

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	M	L	-	L	L	L	-	-	L	-	-	L	M	M	-
CO2	M	M	M	L	H	L	-	-	-	-	-	L	M	H	-
CO3	M	M	H	M	M	L	L	-	-	L	L	L	M	M	-
CO4	M	H	-	M	H	L	-	-	-	-	-	L	M	H	-
CO5	M	H	H	M	H	L	L	-	L	L	L	L	L	M	-
CO6	M	L	-	L	L	L	-	-	L	-	-	L	M	M	-
16LPE $07	M	H	H	M	H	L	L	-	L	L	L	L	M	M	-

L - Low, M - Moderate (Medium), H - High

18LPE$09	EMBEDDED SYSTEMS

PRE-REQUISITES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To learn the architecture and programming of ARM processor.
- To become familiar with the embedded computing platform design and analysis.
- To get thorough knowledge in interfacing concepts.
- To design an embedded system and to develop programs.

UNIT I INTRODUCTION TO EMBEDDED COMPUTING AND ARM PROCESSORS	**(9 Periods)**
Complex systems and micro processors– Embedded system design process –Design example: Model train controller- Instruction sets preliminaries - ARM Processor – CPU: programming input and output supervisor mode, exceptions and traps – Co-processors- Memory system mechanisms – CPU performance- CPU power consumption.	
UNIT II EMBEDDED COMPUTING PLATFORM DESIGN	**(9 Periods)**
CPU Bus-Memory devices and systems–Designing with computing platforms – consumer electronics architecture – platform-level performance analysis - Components for embedded programs Models of programs- Assembly, linking and loading – compilation techniques- Program level performance analysis – Software performance optimization – Program level energy and power analysis and optimization – Analysis and optimization of program size- Program validation and testing.	
UNIT III SENSOR INTERFACING WITH ARDUINO	**(9 Periods)**
Basics of hardware design and functions of basic passive components-sensors and actuators-Arduino code - library file for sensor interfacing-construction of basic applications.	
UNIT IV EMBEDDED FIRMWARE	**(9 Periods)**
Reset Circuit, Brown-out Protection Circuit-Oscillator Unit - Real Time Clock-Watchdog Timer - Embedded Firmware Design Approaches and Development Languages.	
UNIT V EMBEDDED C PROGRAMMING	**(9 Periods)**
Introduction-Creating hardware delays‘ using Timer 0 and Timer 1-Reading switches-Adding Structure to the code-Generating a minimum and maximum delay-Example: Creating a portable hardware delay-Timeout mechanisms-Creating loop timeouts-Testing loop timeouts- hardware timeouts-Testing a hardware timeout	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical:0 Periods** **Total:45Periods**

TEXT BOOKS:

*1.Marilyn Wolf, — “**Computers as Components - Principles of Embedded Computing System Design”**, Third Edition —Morgan Kaufmann Publisher (An imprint from Elsevier), 2012. (unit I & II)*

2 https://www.coursera.org/learn/interface-with-arduino#syllabus (Unit III)

*3 .Michael J. Pont, — “**Embedded C”**, 2nd Edition, Pearson Education, 2008.(Unit IV & V)*

REFERENCE BOOKS:

*1.Shibu K.V, “**Introduction to Embedded Systems”**, McGraw Hill.2014.*

*2.Jonathan W.Valvano, “**Embedded Microcomputer Systems Real Time Interfacing”**, Third Edition Cengage Learning, 2012.*

*3 Raj Kamal, “**Embedded Systems-Architecture, Programming and Design”**, 3 edition, TMH.2015.*

*4. Lyla, “**Embedded Systems”**, Pearson, 2013.*

*5. David E. Simon, “**An Embedded Software Primer”**, Pearson Education, 2000.*

COURSE OUTCOMES:

Upon completion of the course, students will be able to:

CO1: Describe the architecture and programming of ARM processor.
CO2: Explain the concepts of embedded systems.
CO3: Understand the Concepts of peripherals and interfacing of sensors.
CO4: Capable of using the system design techniques to develop firmware
CO5: Illustrate the code for constructing a system .

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L
CO2	M	M	M	-	-	-	-	-	-	-	-	L	M	L	L
CO3	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L
CO4	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L
CO5	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L
18LPE $09	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L

L - Low, M - Moderate (Medium), H - High

18LPE$16	CONTROL SYSTEMS

PRE-REQUISITES:

* **SIGNALS AND SYSTEMS**

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

* This course enables the students to compute transfer function of the system, analyze time and frequency response, stability and state variables of the system.

UNIT- I : MODELING OF CONTROL SYSTEMS	**(9 Periods)**
Basic Elements of Control System - Open loop and Closed loop systems - Differential equation - Transfer function, Modeling of Electric systems, Translational and rotational mechanical systems - Block diagram reduction Techniques - Signal flow graph.	
UNIT- II : TIME RESPONSE ANALYSIS	**(9 Periods)**
Time response analysis - First Order Systems - Impulse and Step Response analysis of second order systems - Steady state errors - P, PI, PD and PID Compensation.	
UNIT- III : FREQUENCY RESPONSE ANALYSIS	**(9 Periods)**
Frequency Response - Bode Plot, Polar Plot, Nyquist Plot - Frequency Domain specifications from the plots - Constant M and N Circles - Nichol's Chart - Use of Nichol's Chart in Control System Analysis-Series, Parallel, series-parallel Compensators - Lead, Lag, and Lead Lag Compensators.	
UNIT- IV : STABILITY ANALYSIS	**(9 Periods)**
Stability - Routh-Hurwitz Criterion, Root Locus Technique- Construction of Root Locus - Dominant Poles, Application of Root Locus Diagram - Nyquist Stability Criterion - Relative Stability.	
UNIT- V : STATE VARIABLE ANALYSIS	**(9 Periods)**
State space representation of Continuous Time systems - State equations - Transfer function from State Variable Representation - Solutions of the state equations – Kalman's test of Controllability and Observability - State space representation for Discrete time systems- Sampled Data control systems- Sampling Theorem- Sampler and Hold - Open loop and Closed loop sampled data systems.	

Contact periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total:45 Periods**

TEXT BOOKS:

1. *J.Nagrath and M.Gopal, "**Control Systems Engineering**", NewAge International Publishers, 5th Edition, 2008.*
2. *Norman Nise, **" Control Systems Engineering"** John Wiley & Sons, 6th Edition,2011*

REFERENCE BOOKS:

1. B. *C. Kuo, **"Digital Control Systems"**, Oxford University Press, 2/e, Indian Edition, 2007.*
2. *M.Gopal, "**Control System – Principles and Design**", Tata McGraw Hill, 4th Edition, 2012.*
3. *Ogata K, **"Modern Control Engineering"**, PHI Publishers, 5th Edition, 2010.*
4. *Richard C. Dorf & Robert H. Bishop, "**Modern Control Systems**", Prentice Hall, 12th edition, 2010.*
5. *Constantine H. Houpis, Stuart N. Sheldon, "**Linear Control System Analysis and Design with MATLAB**", CRC Press, 6th edition 2013.*

COURSE OUTCOMES:

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

CO1: An ability to compute differential equation and transfer function of a given control system
CO2: Knowledge on time response analysis.
CO3: Ability to analyze the frequency domain response.
CO4: Ability to analyze the stability of the system.
CO5: Knowledge on state variable analysis.

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	M	H	M	L	-	-	-	-	-	-	-	L	M	-	-
CO2	M	L	L	-	-	-	-	-	-	-	-	L	M	-	-
CO3	M	H	H	L	-	-	-	-	-	-	-	M	M	M	-
CO4	M	H	H	M	-	-	-	-	-	-	-	M	M	M	-
CO5	L	M	-	-	-	-	-	-	-	-	-	M	M	-	-
18LPE $16	M	H	H	M	-	-	-	-	-	-	-	M	M	M	-

L - Low, M - Moderate (Medium), H - High

18LPE$25	INTERNET OF THINGS

PRE-REQUISITES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To learn about the fundamentals of Internet of Things
- To build a small Low cost embedded system using Arduino/ Raspberry Pi or equivalent boards
- To apply the concept of Internet of Things in real world scenario.

UNIT- I : : FUNDAMENTALS OF IOT	**(9 Periods)**
Introduction-Characteristics - Physical design - Protocols-Logical design - Enabling technologies - IoT levels-Domain specific IoTs - IoTvs M2M	
UNIT- II : IOT DESIGN METHODOLOGY	**(9 Periods)**
IoT systems management - IoT design methodology-Specifications - Integration and Application Development.	
UNIT- III : IOT COMPONENTS	**(9 Periods)**
Sensors and activators - Communication modules - Zigbee-RFID-Wi-Fi-Power sources.	
UNIT- IV : BUILDING IOT WITH HARDWARE PLATFORMS	**(9 Periods)**
Platform - Arduino/Intel Galileo/Raspberry Pi- Physical device - Interfaces - Programming - APIs/Packages - Web services.	
UNIT- V : CASE STUDIES AND ADVANCED TOPICS	**(9 Periods)**
Various Real time applications of IoT-Connecting IoT to cloud-Cloud storage for IoT-Data Analytics for IoT-Software & Management Tools for IoT.	

Contact periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

*1.ArshdeepBahga, Vijay Madisetti, "**Internet of Things-A hands-on approach**", Universities Press, 2015.*

REFERENCE BOOKS:

1.Manoel Carlos Ramon, —Intel® Galileo and Intel® Galileo Gen 2: API Features and Arduino Projects for Linux Programmers, Apress, 2014.
*2.Marco Schwartz, **—Internet of Things with the Arduino Yun**, Packt Publishing.*

COURSE OUTCOMES:

Upon completion of this course, the students will have the:

CO1: Ability to Design a portable IoT using Arduino/Equivalent boards and relevant protocols
CO2: Ability to Develop web services to access/control IoT devices
CO3: Ability to Deploy an IoT application and connect to the cloud
CO4: Ability to BuiltIoT applications for real time scenario
CO5: Ability to Analyze IoT Components
CO6: Ability to Apply IoT for various Interdisciplinary applications.

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	L	M	H	L	L	L	L	-	-	-	-	-	H	H	M
CO2	L	M	H	L	L	L	L	-	-	-	-	-	M	M	M
CO3	L	L	H	L	-	-	-	-	-	-	-	-	M	M	M
CO4	L	L	H	L	L	L	-	-	-	-	-	-	H	H	M
CO5	L	L	M	L	L	L	-	-	-	-	-	-	M	H	L
CO6	L	L	H	L	M	M	-	-	-	-	L	-	H	H	L
18LPE $25	L	L	H	L	L	L	L	-	-	-	L	-	H	H	M

L - Low, M - Moderate (Medium), H - High

18LPE$59	SMART SENSORS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

COURSE OBJECTIVES:

- This course enables the students to learn the different types of sensors, smartsensors, interfacing sensors with MCU and their applications.

UNIT- I: DISPLACEMENT, FORCE AND PRESSURE SENSORS	(9Periods)
Definition, Classification and selection of sensors – Measurement of displacement using Potentiometer, LVDT and Optical Encoder – Measurement of force using strain gauge – Measurement of pressure using LVDT based diaphragm and piezoelectric sensor.	
UNIT-II: TEMPERATURE, POSITION, FLOW AND LEVEL SENSORS	**(9Periods)**
Thermocouple and RTD – Concept of thermal imaging– Measurement of position using Hall effect sensors, Proximity sensors: Inductive and Capacitive – Use of proximity sensor as accelerometer and vibration sensor – Flow Sensors: Ultrasonic and Laser – Level Sensors: Ultrasonic and Capacitive.	
UNIT-III :SMART SENSORS	**(9Periods)**
General Structure of smart sensors and its components – Characteristic of smart sensors: Self calibration, Self testing and self-communicating – Application of smart sensors: Automatic robot control and automobile engine control.	
UNIT-IV:INTERFACING SENSOR INFORMATION AND MCU	**(9Periods)**
Amplification and Signal Conditioning– Integrated Signal Conditioning – Digital conversion, MCU Control – MCUs for Sensor Interface, Techniques and System Consideration– SensorIntegration.	
UNIT-V:COMMUNICATION FOR SMART SENSORS	**(9Periods)**
Automotive Protocols – Industrial Networks – Home Automation– MCU Protocols – Wireless Data Communications – RF Sensing, Telemetry. Standards: IEEE 1451, STIM,Smart Plug-and-Play.	

Contact periods:

Lecture : 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods

TEXTBOOKS:

1 *D.Patranabis, -**Sensors and Transducers,**Second Edition, Prentice Hall of India, 2005.*

2 *Randy Frank, -**Understanding Smart Sensors**, Third Edition, Artech House Publishers,2013*

REFERENCE BOOKS:

1 *Jacob Fraden, "**Hand Book of Modern Sensors: physics, Designs and Applications**", 2015, 3rd edition, Springer, New York.*

2 *Jon. S. Wilson, "**Sensor Technology Hand Book**", 2011, 1st edition, Elsevier, Netherland.*

3 *SabrieSolomon,"**SensorsHandbook**,"2nd editionMcGrawHill,1998.*

4 *Y.L. Lin, **"Smart Sensors and Systems",** Springer, 2017.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Understand the displacement, force and pressure sensors.

CO2 Exploit the temperature, position, flow and level sensors.

CO3 Gain knowledge on smart sensors and their applications.

CO4 Interface sensor information and MCU.

CO5 Gain knowledge about communication for smart sensors.

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	L	M	H	L	L	L	L	-	-	-	-	-	H	H	M
CO2	L	M	H	L	L	L	L	-	-	-	-	-	H	H	M
CO3	L	M	H	L	L	L	L	-	-	-	-	L	H	H	M
CO4	H	H	H	L	L	L	-	-	-	-	-	-	H	H	M
CO5	L	M	H	L	L	L	L	-	-	-	-	-	H	H	M
18LPE$59	L	M	H	L	L	L	L	-	-	-	-	L	H	H	M

L-Low, M-Moderate(Medium), H-High

18LPE$60	**INDUSTRIAL INTERNET OF THINGS** *(Common to ECE & EIE)*

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PE**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES

- To explain in concise manner how IoT is used in industry

UNIT – I	**INTERNET OF THINGS**	**(9Periods)**
Internet in general and Internet of Things: layers, protocols, packets, services, performanceparameters of a packet network as well as applications such as web, Peer-to-peer, sensor networks, and multimedia		
UNIT – II	**LAYERS IN IoT**	**(9Periods)**
Transport services: TCP, UDP, socket programming. Network layer: forwarding and routing algorithms (Link, DV), IP-addresses, DNS, NAT and routers.		
UNIT – III	**LOCAL AREA NETWORKS**	**(9Periods)**
Local Area Networks, MAC level, link protocols such as: point-to-point protocols, Ethernet, WiFi 802.11, cellular Internet access, and Machine-to-machine and IoT Analytics.		
UNIT – IV	**INDUSTRIAL AUTOMATION**	**(9Periods)**
Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things.		
UNIT – V	**IoT APPLICATIONS FOR INDUSTRY**	**(9Periods)**
Introduction, IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Value Creation from Big Data and Serialization, IoT for Retailing Industry, IoT for Oil and Gas Industry, Opinions on IoT Application and Value for Industry.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Dr. Ovidiu Vermesan, Dr. Peter Friess* ***"Internet of Things: Converging Technologies forSmart Environments and Integrated Ecosystems"*** *River Publishers, 2013*

2 *Vijay Madisetti and Arshdeep Bahga,* ***"Internet of Things (A Hands-on-Approach)"*** *1st Edition, VPT, 2015*

3 *Adrian McEwen* ***"Designing the Internet of Things"*** *Wiley Publishers, 2013*

REFERENCE BOOKS:

1 *Manoel Carlos Ramon* ***"Intel® Galileo and Intel® Galileo Gen 2: API Features and Arduino Projects for Linux Programmers"*** *Apress, 2014*

2 *Mark Harrison, Florian Michahelles* ***"Architecting the Internet of Things"*** *Springer – 2011*

3 *Olivier Hersent, David Boswarthick, Omar Elloumi* ***"The Internet of Things – Key applications and Protocols"*** *Wiley, 2012*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Comprehend the functions of layered tasks and protocols employed in packet network to build IoT

CO2 Explain purposes of transport services, forwarding and routing algorithms and IP addressing mechanism

CO3 Assimilate various protocols in pertinent to local Area Networks for IOT

CO4 Gain knowledge on different industrial standards involved in the development of IIoT solution for Industrial Automation

CO5 Identify IoT use cases in various industries and demonstrate the IoT Project implementation modalities

COURSE ARTICULATION MATRIX :

CO	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	PSO 2	PSO 3
CO1	M	M	L	L	L	-	-	-	-	-	-	-	M	L	L
CO2	M	M	L	L	L	-	-	-	-	-	-	-	M	L	L
CO3	M	M	L	L	L	-	-	-	-	-	-	-	M	L	L
CO4	M	M	L	L	L	-	-	-	-	-	-	-	M	L	L
CO5	M	M	L	L	L	-	-	-	-	-	-	-	M	L	L
18LPE$60	M	M	L	L	L	-	-	-	-	-	-	-	M	L	L

L – Slight, M – Moderate, L– Substantial

18LPE$61	EMBEDDED OPERATING SYSTEMS

PREREQUISITES	CATEGORY	L	T	P	C
NIL		3	0	0	3

COURSE OBJECTIVES

* This course enables the students to study the concepts of real time operatingSystem, real time communication and databases.

UNIT – I	INTRODUCTION TO REAL TIME OPERATING SYSTEM	(9Perods)
Introduction – Example of Real time applications – Structure of a Real time system – Characterization of Real time systems and tasks – Hard and Soft timing constraints– Design challenges– Performance metrics – Prediction of Execution time: Source code analysis, Cache and Pipeline issues– Programming Languages for Real Time System.		
UNIT – II	**THREADS AND TASKS**	**(9Periods)**
Real time OS - Threads – Kernel – Structure of Microkernel – Tasks and Process – Timing Requirements on Processes – CPU Metrics – Process State and Scheduling – Inter process Communication Mechanisms – Context Switching – Task Synchronization – Software interrupt.		
UNIT – III	**TASK SCHEDULING AND ALGORITHMS**	**(9Periods)**
Task assignment – Task allocation algorithms: Event driven Scheduling – Rate-Monotonic Scheduling, Earliest-Deadline First Scheduling – Clock driven scheduling – Table driven scheduling, Cyclic Schedulers – Fault tolerant Scheduling.		
UNIT – IV	**REAL TIME COMMUNICATION**	**(9Periods)**
Real Time Communication Network – Topologies and architecture issues-protocols – Contention based, Token based, Polled bus, Deadline based protocol, Fault tolerant routing. RTP and RTCP.		
UNIT – V	**REAL TIME DATABASES**	**(9Periods)**
Real time Databases – Transaction priorities – Concurrency control issues – Disk scheduling algorithms – Two phase approach to improve predictability.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1 *Philip A. Laplante and Seppo J. Ovaska,* ***"Real Time Operating Systems Design and Analysis: Tools for the Practitioner"****, IV Edition IEEE Press, Wiley. 2013.*

2 *Jane W.S. Liu,* ***"Real Time Operating Systems"****, Pearson Education India, 2000.*

3 *Marilyn Wolf, —* ***"Computers as Components - Principles of Embedded Computing System Design"****, Third Edition —Morgan Kaufmann Publisher (An imprint from Elsevier), 2012.*

4 *Alan Holt and Chi-Yu Huang, "****Embedded Operating Systems: A Practical Approach****" , Springer, 2014.*

REFERENCE BOOKS:

1 *C.M. Krishna, Kang G. Shin –**"Real Time Operating Systems"**, International Edition, McGraw Hill Companies, Inc., New York, 2013.*

2 *Rajib Mall, **"Real-Time Systems: Theory and Practice"**, Pearson, 2008.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Exploit the fundamental concepts of RTOS.

CO2 Interpret the mechanisms of threads and tasks.

CO3 Analyze various task scheduling mechanisms and algorithms.

CO4 Knowledge on real time communication protocols

CO5 Relate the handling of real time databases.

COURSE ARTICULATION MATRIX:

CO	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	PSO 2	PSO 3
CO1	M	L	M	L	-	-	M	-	-	-	-	M	H	L	M
CO2	M	M	H	M	M	L	L	-	-	-	-	M	H	M	M
CO3	M	L	M	L	M	M	M	-	-	-	-	M	H	M	M
CO4	M	L	M	L	M	M	M	-	-	-	-	M	H	M	M
CO5	M	L	M	L	M	M	M	-	-	-	-	M	H	M	M
18LPE$61	M	L	M	L	M	M	M	-	-	-	-	M	H	M	M

L-Low, M-Moderate(Medium), H-High