BIRLA INSTITUTE OF TECHNOLOGY

CHOICE BASED CREDIT SYSTEM (CBCS) CURRICULUM

(Effective from Academic Session: Monsoon 2022)

NAME OF THE PROGRAMME

M. TECH. in Electronics and Communication Engineering
with
Specializations in

- **Wireless Communication**
- **Microwave Engineering**
- **Instrumentation**
- **VLSI Design & Embedded System**

NAME OF THE DEPARTMENT

Department of Electronics and Communication Engineering

Institute Vision

To become a Globally Recognised Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research, and technological service to the National needs.

Institute Mission

- To educate students at Under Graduate, Post Graduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education, and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision:

To become a centre of excellence in teaching and research for creating technical manpower to meet the technological, societal and environmental needs of the country in the field of Electronics and Communication Engineering.

Department Mission

- To offer state of the art education of global standards through innovative methods of teaching and learning with practical orientation aiming to prepare the students for successful career and to provide required technological services.

- To prepare the students to think independently, take initiative, lead a team in an organization, take responsibility and solve the problems related to industry, society, environmental, health, safety, legal and cultural issues maintaining the professional ethics.

- To pursue high quality contemporary research through continued interaction with research organizations and industries.

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
PG COURSE STRUCTURE - To be effective from academic session 2022-23
Based on CBCS & OBE model

Recommended scheme of study for

M. Tech. in Electronics and Communication Engineering

(First-Semester Common Courses)

Semester of Study (Recommended)	Course Level	Category of Course	Course Code	Courses	Mode of delivery & credits *L-Lecture; T-Tutorial; P-Practicals*			Total Credits *C-Credits*
					L	**T**	**P**	**C**
FIRST	**FIFTH**	Programme Core (PC)	EC501	Low Power Devices & Integrated Circuits	3	0	0	3
			EC503	Communication Systems & Networks	3	0	0	3
			EC505	Microwave Theory and Antenna	3	0	0	3
			EC507	Sensing and Measurements	3	0	0	3
			EC509	Artificial Intelligence and Machine Learning	3	0	0	3
		LABORATORIES						
		Programme Core (PC)	EC504	Communication System and Circuits Lab	0	0	4	2
			EC510	Artificial Intelligence and Machine Learning Lab	0	0	4	2
		HSS	MT132	Communication Skills-I	0	0	3	1.5
TOTAL in First Semester								**20.5**

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2022-23
Based on CBCS & OBE model
Recommended scheme of study for M. Tech. in Electronics and Communication Engineering with

Specialization in Wireless Communication

(Second-Semester Onwards Course Structure)

Semester of Study (Recommended)	Course Level	Category of Course	Course Code	Courses	Mode of delivery & credits			Total Credits
					L	T	P	C
SECOND	FIFTH	Programme Core (PC)	EC521	Wireless Signal Propagation	3	0	0	3
			EC523	Detection and Estimation Theory	3	0	0	3
			EC525	Information Theory and Error Control Coding	3	0	0	3
		Programme Elective (PE)		PE-I	3	0	0	3
		Programme Elective (PE)		PE-II	3	0	0	3
		LABORATORIES						
		Programme Core (PC)	EC522	Antenna Measurements Lab	0	0	4	2
			EC524	Wireless Communication and Networking Lab	0	0	4	2
		HSS	MT133	Communication Skills-II	0	0	3	1.5
TOTAL in Second Semester								**20.5**
TOTAL FOR FIRST YEAR								**41**
THIRD	SIXTH	Programme Core (PC)	EC600	Thesis (Part I)				8
		Open-Elective		OE I/ MOOC	3	0	0	3
				OE II/ MOOC	3	0	0	3
TOTAL in Third Semester								**14**
FOURTH	SIXTH	Programme Core (PC)	EC650	Thesis (Part II)				16
TOTAL in Fourth Semester								**16**
TOTAL FOR SECOND YEAR								**30**
GRAND TOTAL FOR M. TECH. PROGRAMME								**71**

List of Programme Electives for Wireless Communication:

PE-I	EC526	Advanced Wireless Technologies
	EC527	Spread Spectrum Techniques
	EC528	Satellite Communication Technology
	EC529	Modern Optimization Techniques
	EC548	Electromagnetic Interference & Electromagnetic Compatibility
PE-II	EC530	Adhoc and Wireless Sensor Networks
	EC531	MIMO and Space Time Wireless Communication
	EC565	Advanced Digital Signal Processing
	EC543	RF Circuit Design
	EC532	Cognitive Radio Communication and Networks
	EC533	Optical Wireless Communication

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2022-23
Based on CBCS & OBE model
Recommended scheme of study for M. Tech. in Electronics and Communication Engineering with

Specialization in Microwave Engineering

(Second-Semester Onwards Course Structure)

Semester of Study (Recommended)	Course Level	Category of Course	Course Code	Courses	Mode of delivery & credits L	T	P	Total Credits C
SECOND	FIFTH	Programme Core (PC)	EC541	Advanced Electromagnetic Engineering	3	0	0	3
			EC543	RF Circuit Design	3	0	0	3
			EC545	Numerical Techniques in Electromagnetics	3	0	0	3
		Programme Elective (PE)		PE-I	3	0	0	3
		Programme Elective (PE)		PE-II	3	0	0	3
		LABORATORIES						
		Programme Core (PC)	EC542	Microwave Measurement Lab	0	0	4	2
			EC544	Microwave Integrated Circuit Lab	0	0	4	2
		HSS	MT133	Communication Skills-II	0	0	3	1.5
TOTAL in Second Semester								**20.5**
TOTAL FOR FIRST YEAR								**41**
THIRD	SIXTH	Programme Core (PC)	EC600	Thesis (Part I)				8
		Open-Elective		OE I/ MOOC	3	0	0	3
				OE II/ MOOC	3	0	0	3
TOTAL in Third Semester								**14**
FOURTH	SIXTH	Programme Core (PC)	EC650	Thesis (Part II)				16
TOTAL in Fourth Semester								**16**
TOTAL FOR SECOND YEAR								**30**
GRAND TOTAL FOR M. TECH. PROGRAMME								**71**

List of Programme Electives for Microwave Engineering:

PE-I	EC546	MW & MM-Wave Planar Transmission Lines Design
	EC547	Microwave Semiconductor Devices
	EC548	Electromagnetic Interference & Electromagnetic Compatibility
	EC549	Electromagnetic and Microwave Applications of Metamaterials
	EC550	Antenna and Diversity
PE-II	EC528	Satellite Communication Technology
	EC551	RF Microelectronics Circuit Design
	EC552	Radar Signal Processing
	EC553	Microwave Photonics
	EC554	Microwave Measurement & Material Characterization

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2022-23
Based on CBCS & OBE model
Recommended scheme of study for M. Tech. in Electronics and Communication Engineering with

Specialization in Instrumentation

(Second-Semester Onwards Course Structure)

Semester of Study (Recommended)	Course Level	Category of Course	Course Code	Courses	Mode of delivery & credits			Total Credits
					L	T	P	C
SECOND	FIFTH	Programme Core (PC)	EC561	Applied Industrial Instrumentation	3	0	0	3
			EC563	Process Control	3	0	0	3
			EC565	Advanced Digital Signal Processing	3	0	0	3
		Programme Elective (PE)		PE-I	3	0	0	3
		Programme Elective (PE)		PE-II	3	0	0	3
		LABORATORIES						
		Programme Core (PC)	EC562	Advanced Instrumentation Lab	0	0	4	2
			EC566	Signal Processing and IoT Lab	0	0	4	2
		HSS	MT133	Communication Skills-II	0	0	3	1.5
TOTAL in Second Semester								**20.5**
TOTAL FOR FIRST YEAR								**41**
THIRD	SIXTH	Programme Core (PC)	EC600	Thesis (Part I)				8
		Open-Elective		OE I/MOOC	3	0	0	3
				OE II/MOOC	3	0	0	3
TOTAL in Third Semester								**14**
FOURTH	SIXTH	Programme Core (PC)	EC650	Thesis (Part II)				16
TOTAL in Fourth Semester								**16**
TOTAL FOR SECOND YEAR								**30**
GRAND TOTAL FOR M. TECH. PROGRAMME								**71**

List of Programme Electives for Instrumentation:

PE-I	EC585	Embedded Systems
	EC567	Optoelectronic Instrumentation
	EC529	Modern Optimization Techniques
	EC568	Introduction to Internet of Things
	EC548	Electromagnetic Interference & Electromagnetic Compatibility
PE-II	EC569	Digital Image Processing Techniques
	EC570	Speech Processing Techniques
	EC571	Biomedical Signal Processing
	EC572	Photonic Integrated Circuits
	EC573	Brain-Computer Interfacing

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEWCOURSE STRUCTURE - To be effective from academic session 2022-23
Based on CBCS & OBE model
Recommended scheme of study for M.Tech. in Electronics and Communication Engineering with

Specialization in VLSI Design & Embedded System

(Second-Semester Onwards Course Structure)

Semester of Study (Recommended)	Course Level	Category of Course	Course Code	Courses	Mode of delivery & credits			Total Credits
					L	T	P	C
SECOND	FIFTH	Programme Core (PC)	EC581	Analog VLSI Design	3	0	0	3
			EC583	Digital VLSI Design	3	0	0	3
			EC585	Embedded Systems	3	0	0	3
		Programme Elective (PE)		PE-I	3	0	0	3
		Programme Elective (PE)		PE-II	3	0	0	3
		LABORATORIES						
		Programme Core (PC)	EC582	VLSI Design Lab	0	0	4	2
			EC586	Embedded Systems Lab	0	0	4	2
		HSS	MT133	Communication Skills-II	0	0	3	1.5
TOTAL in Second Semester								**20.5**
TOTAL FOR FIRST YEAR								**41**
THIRD	SIXTH	Programme Core (PC)	EC600	Thesis (Part I)				8
		Open-Elective		OE I/MOOC	3	0	0	3
				OE II/MOOC	3	0	0	3
TOTAL in Third Semester								**14**
FOURTH	SIXTH	Programme Core (PC)	EC650	Thesis (Part II)				16
TOTAL in Fourth Semester								**16**
TOTAL FOR SECOND YEAR								**30**
GRAND TOTAL FOR M. TECH. PROGRAMME (38+30)								**71**

List of Programme Electives for VLSI Design & Embedded System:

PE-I	EC587	IC Technology
	EC547	Microwave Semiconductor Devices
	EC588	Deep Submicron CMOS IC Design
	EC589	Low Power VLSI Design
	EC568	*Introduction to Internet of Things*
	EC590	*Digital Signal Processing Algorithms and Architecture*
	EC591	*Embedded Computing Systems and Interfacing*
PE-II	EC592	Nanoelectronic Devices and Materials
	EC593	Memory Devices and Technologies
	EC594	Testing & Verification of VLSI Circuits
	EC551	RF Microelectronics Circuit Design
	EC595	*VLSI Signal Processing*
	EC596	*FPGA & System on Chip Design*
	EC597	*RTL Simulation and Synthesis with PLDs*

Department of Electronics & Communication Engineering

List of Open Electives (OE)* Offered in 3rd Semester of PG for other Branches

OE-I	EC601	Fundamentals of MEMS
	EC603	Introduction to Wireless Communication
	EC605	Modern Instrumentation Theory
	EC607	Fundamentals of Microwaves
OE-II	EC609	Fiber Optic System and Applications
	EC611	Sensors and Actuators
	EC613	Fundamentals of VLSI Design

COURSE INFORMATION SHEET

Low Power Devices & Integrated Circuits

Course Code: EC501
Course Title: Low Power Devices & Integrated Circuits

Pre-requisite(s): Basics of Electronics Engineering (BEE), Electronic Devices (ED)
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/V
Branch: ECE
SPECIALIZATION: N/A, Common Course

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	To understand VLSI Devices.
2.	To grasp Technology Scaling and Its Side Effects.
3.	To comprehend Power Dissipation in Integrated Circuits.
4.	To understand Leakage and power deduction Techniques.
5.	To apprehend Layout Optimization Techniques for Power Reduction.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Appraise VLSI Devices.
CO2	Apprehend Technology Scaling and Its Side Effects.
CO3	Apply the knowledge of Power Dissipation for analyzing Integrated Circuits.
CO4	Apply leakage and power deduction Techniques.
CO5	Apply Layout Optimization Techniques for Power Reduction.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Review of P-N junction:** Energy Bands in Solids, P-N Junction Under Thermal Equilibrium, Built-in Potential, Concept of Space Charge Layer, P-N Junction Under Applied Bias, Depletion Layer Capacitance in an Abrupt P-N Junction, Depletion Layer Capacitance in Junction with Arbitrary Doping Profile.	**8**
Module – II **Fundamentals of MOS Field Effect Transistor:** Structure and Principle of Operation of MOSFET, Region of Operation of MOSFETs, long-Channel MOSFET Current Equations, Static I-V and C-V characteristics, Small-Signal Model.	**8**
Module – III **Technology Scaling and its Side Effects:** Short Channel Effects such – channel length modulation effect, Hot Carrier Injection, Substrate Current-Induced Body Effect (SCBE), Impact ionization, Velocity Saturation, Mobility Degradation, Threshold voltage rolloff, Drain-Induced Barrier Lowering (DIBL), Excess Standby Power Dissipation, Transistor Variability and Degradation.	**8**
Module – IV **Power Dissipation in Integrated Circuits:** Dynamic Power/ Short-Circuit Power/ Static Power models, Leakage currents in CMOS Devices: Subthreshold Leakage current, Gate Leakage Current, Junction leakage current/Band to band tunneling current, gate-induced drain leakage current (GIDL), punch-through, Important Device features, Cross-sectional and 3-dimensional view of device structure.	**8**
Module – V **Layout Optimization and Power Reduction Techniques:** Design rules, layout of combinational and sequential circuits for Speed improvement and Power reduction. Process level techniques (Channel Engineering), Circuit level techniques, Use of high-K gate oxide, Types of process variation, sources of variation, Variability Mitigation Techniques. Design of combinational and sequential circuits and their VHDL and Verilog implementation.	**8**

Textbooks:

1. Nandita Dasgupta and Amitava Dasgupta, "Semiconductor Devices Modelling Technology", First Edition, Prentice-Hall of India, New Delhi, 2004, ISBN-81-203-2398-X.
2. Jan M. Rabaey, "Low power essentials", First Edition, Springer, 2009, ISBN 978-0-387-71712-8.
3. Alice Wang, Benton H. Calhoun, A. P. Chandrakasan "Sub-threshold Design for Ultra Low-Power Systems", Springer, 2006, ISBN-13: 978-0387335155.

Reference books:

1. Kaushik Roy, Sharat Prasad, "Low power CMOS VLSI circuit design", John Wiley sons Inc., 2000.
2. Jan M. Rabaey, "Digital Integrated Circuits - A Design Perspective", 2nd Edition, Prentice Hall, 2003.

COURSE INFORMATION SHEET

Communication Systems and Networks

Course Code: EC503
Course Title: Communication Systems and Networks
Pre-requisite(s): Knowledge of Networking fundamentals, basic idea of Digital Communication and Data Communication
Co-requisite(s):
Credits: L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech. (ECE)
Semester / Level: 1/5
Branch: ECE
Specialization: N/A, Common Course

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1	Understand various communication system and networks
2	Explain mobile cellular system, Interference, and cellular systems capacity
3	Understand different generations and standards of cellular system and various multiple access techniques employed in wireless communication system
4	Explain various techniques used in wireless communication system
5	Evaluate the Design Challenges in Ad-hoc wireless networks,

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Demonstrate understanding on various communication system and networks
CO2	Demonstrate and ability to evaluate mechanisms to enhance cellular system capacity
CO3	Evaluate various mechanisms for multiple access techniques
CO4	Compare different technologies used for wireless communication systems.
CO5	Demonstrate an ability to evaluate design challenges associated with Ad-hoc wireless networks.

SYLLABUS

MODULE	Lecture Hours
Module – I Wired and wireless communication systems. Optical fiber communication, Satellite communication, Global Positioning System, Wireless Local Loop, RFID, Wireless personal area networks (Bluetooth, UWB and ZigBee), wireless local area networks (IEEE 802.11, network architecture, medium access methods, WLAN standards), wireless metropolitan area networks (WiMAX).	**8**
Module – II Cellular concept and frequency reuse, Cellular system architecture, Frequency management and channel assignment, Hand-off in a cellular system, Co-channel interference Adjacent Channel Interference Enhancing capacity of cellular systems	**8**
Module – III Cellular Generations (1G, 2G,3G, 4G and 5G systems), Cellular standards (AMPS, GSM, GPRS, WCDMA. LTE, and LTE-Advanced). Multiple access techniques: contention-free multiple access schemes (FDMA TDMA, CDMA, SDMA and Hybrid), contention-based multiple access schemes (ALOHA and CSMA).	**9**
Module – IV Digital modulation for wireless communication, Pulse shaping, multicarrier modulation, OFDM, MIMO system, MIMO-OFDM system, smart-antenna, beamforming cognitive radio, software defined radio, communication relays, spectrum sharing.	**8**
Module – V Ad-hoc wireless networks: Design Challenges in Ad-hoc wireless networks, concept of cross layer design, security in wireless networks, energy constrained networks. MANET and WSN. Wireless system protocols: mobile network layer protocol (mobile IP, IPv6, dynamic host configuration protocol), mobile transport layer protocol (traditional TCP, classical TCP improvements), support for mobility (wireless application protocol).	**8**

Text Books:

1. Vijay K Garg, "Wireless Communications and Networks", Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian reprint)

Reference Books:

1. J. Schiller, "Mobile Communication" 2/e, Pearson Education, 2012.
2. Sanjay Kumar, "Wireless Communication the Fundamental and Advanced Concepts" River Publishers, Denmark, 2015 (Indian reprint).
3. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.
4. Iti Saha Misra, "Wireless Communication and Networks : 3G and Beyond", 2/e, McGraw Hill Education (india) Private Ltd, New Delhi, 2013.

COURSE INFORMATION SHEET

Communication Systems & Circuit Lab

Course code: EC504
Course Title: Communication Systems & Circuit Lab
Pre-requisite(s): Fundamental of Communications, Fundamental of VLSI Design
Co- requisite(s): Basic Electronics & Semiconductor Devices
Credits: L: 0 T: 0 P: 4 C: 2
Class periods per week: 04
Class: M. Tech.
Semester / Level: I
Branch: ECE
SPECIALIZATION: Common for M. Tech. (ECE)

Name of Teacher:
Course Objectives
This course enables the students to:

1.	Understand the inverse square law and get acquainted with RFID system and GPS satellite system.
2.	Understand 3G and 4G systems, CDMA system, pure ALOHA and slotted ALOHA protocols for WLAN System
3.	To understand the CMOS Logic Gates and implementation in EDA Tools like Cadence/ Mentor Graphics.
4.	To understand the Combinational Circuit & Sequential Circuit design and implantation in CAD Tools like VHDL
5.	To understand the Combinational Circuit & Sequential Circuit design and implantation in CAD Tools like Verilog

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Verify the inverse square law and get acquainted with RFID system and GPS satellite system.
CO2	Demonstrate the understand 3G and 4G systems, CDMA system, pure ALOHA and slotted ALOHA protocols for WLAN System
CO3	Design the CMOS Logic Gates and implementation in EDA Tools like Cadence/ Mentor Graphics.
CO4	Design the Combinational Circuit & Sequential Circuit design and implantation in CAD Tools like VHDL
CO5	Design the Combinational Circuit & Sequential Circuit design and implantation in CAD Tools like Verilog

Syllabus

Hands-on experiments related to the course:

Experiment No.	Name of the Experiments
1.	**Measurement of field strength of the radiated wave** AIM: Plot the variation of the field strength of the radiated wave with the distance (verification of inverse square law)
2.	**Realization of RFID System** AIM 1: Study the RFID system and its applications AIM 2: Study of Direct sequence Spread spectrum using CDMA trainer kit.
3.	**Realization of GPS systems and configuration of ZigBee** AIM 1: Set up a link between GPS satellite and GPS trainer kit to measure present position. AIM 2: Configure ZigBee module as an end user device and set up a communication link between two ZigBee modules.
4.	**Convolution Encoding and Viterbi decoding** AIM: Perform convolution encoding and Viterbi decoding for K=7 and code rate =1/2.
5.	**Realization of 4G base station** AIM: Configure 4G base station for signal transmission using 5-Nine radio.
6.	**Implementation of ALOHA protocols for WLAN System** AIM 1: Study of pure ALOHA for WLAN System AIM 2: Study of slotted ALOHA protocols for WLAN System
7.	**Design of 2-input CMOS NAND and its Layout** AIM1: Design 2-input CMOS NAND Gate using Cadence Software and write the switching action of transistors, calculate the aspect ratio, and verify the truth table AIM2: Design the Layout of 2- input CMOS NAND Gate using Cadence Software and apply the DRC & LVS & RCX for verifying the design.
8.	**Design of 2-input CMOS XOR and its Layout** AIM1: Design 2-input CMOS XOR Gate using Cadence Software and write the switching action of transistors, calculate the aspect ratio, and verify the truth table AIM2: Design the Layout of 2- input CMOS XOR Gate using Cadence Software and apply the DRC & LVS & RCX for verifying the design.
9.	**Design of Mux 16:1 and Decoder 4:16** AIM1: Design & write the VHDL code for Mux 16:1 using Xilinx Software and download the code on the FPGA/CPLD Kit. AIM2: Design & write the VHDL code for Decoder 4:16 using Xilinx Software and download the code on the FPGA/CPLD Kit.
10.	**Design of Flip-Flops and Up-down counter** AIM1: Design & write the VHDL code for Flip-Flops using Xilinx Software and download the code on the FPGA/CPLD Kit. AIM2: Design & write the VHDL code for Up-down counter using Xilinx Software and download the code on the FPGA/CPLD Kit.

11.	**Design of Mux 8:1 and Decoder 3:8** AIM1: Design & write the Verilog code for Mux 8:1 using Xilinx Software and download the code on the FPGA/CPLD Kit. AIM2: Design & write the Verilog code for Decoder 3:8 using Xilinx Software and download the code on the FPGA/CPLD Kit.
12.	**Design of 4-bit Shift Register and Modulo-10 Counter** AIM1: Design & write the Verilog code for 4-bit Shift Register using Xilinx Software and download the code on the FPGA/CPLD Kit. AIM2: Design & write the Verilog code for Modulo-10 Counter using Xilinx Software and download the code on the FPGA/CPLD Kit.

Textbooks:

1. Vijay K. Garg, "Wireless Communications and Networks", Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (1ndian reprint).
2. Simon Haykin, "Communication Systems", Wiley Eastern Limited, New Delhi, 2016,4/e. 3. J. Schiller, "Mobile Communication" 2/e, Pearson Education, 2012.
3. Stephen Brown and Zvonko Vranesic, Fundamental of Digital Logic Design with VHDL Design, McGraw Hill
4. Stephen Brown and Zvonko Vranesic, Fundamental of Digital Logic Design with Verilog Design, McGraw Hill

Reference Books/e-Learning:

Vijay Nath, VLSI Design, Developing Suitable Pedagogical Methods for Various Classes Intellectual Calibres and Research in e-Learning

http://www.ide.iitkgp.ac.in/Pedagogy_view/example.jsp?USER_ID=210

COURSE INFORMATION SHEET

Microwave Theory and Antenna

Course Code: EC505
Course Title: Microwave Theory and Antenna
Pre-requisite(s): Name of Theory Course
Co- requisite(s): Electromagnetic Theory
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: Ist/05
Branch: ECE
SPECIALIZATION: N/A, Common Course

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Understand important and unique engineering issues at microwave wave frequencies basic concepts of microwave systems.
2.	Enable the student to understand the basic principles in antenna and microwave system design
3.	Enhance the student knowledge in the area of various antenna designs
4.	enhance the student knowledge in the area of microwave components and antenna for practical applications.
5.	Identify components used in Microwave communication systems

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Identify the use of microwave components and devices in microwave applications.
CO2	Carry out the microwave network analysis
CO3	To Develop the concept of Wave Analysis of Periodic Structures
CO4	Choose and design antenna for particular application
CO5	Choose a suitable microwave measurement instruments and carry out the required measurements.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Microwave Network Analysis** Impedance and Equivalent Voltage and Currents, Impedance and Admittance Matrices, The Scattering Matrix, Reciprocal and lossless Networks, Generalized Scattering Parameters, The Transmission (ABCD) Matrix, Signal flow Graphs.	**8**
Module – II **Power Dividers and Directional couplers** Basic Properties of Dividers and Couplers (Three port and Four port Networks**),** The T junction Power divider, The Wilkinson Power Divider, Waveguide Directional coupler, The Quadrature (90^0) Hybrid, Coupled line Directional Coupler.	**8**
Module – III **Periodic Structures** Wave Analysis of Periodic Structures, Periodic structure composed of Unsymmetrical Two port Networks, Terminated Periodic Structures, Matching of Periodic Structures, k_0 -β Diagram, Group velocity and Energy flow, Floquet Theorem and Spatial Harmonics	**8**
Module – IV **Antenna basics & its Measurement** Radiation Mechanisms, Characteristics and Basic parameters of Antenna, (Patterns, Radiation Intensity, Directivity and Gain, Polarization, Beamwidth, Bandwidth, Effective Height) Antenna measurement (Radiation pattern, Directivity Gain**)**	**8**
Module –V **Antennas for Special Applications** LEO Satellite Link Antennas, Cell-Tower Trees, Antennas for Terrestial Mobile Communication Systems, Base Station Antennas, Mobile Station Antennas, Antennas for Ground Penetrating Radar, Antennas for Medical Applications	**8**

Textbooks:

1. Samuel Y.Liao, " Microwave Devices and Circuits", 3 rd edition, Pearson education
2. R. E. Collin, "Foundations for microwave Engineering", 2 nd edition, Tata Mc Graw Hill,1992.
3. David Pozar, *Microwave Engineering*, 3rd edition, (Wiley, 2005).
4. John Daniel Kraus, Ronald J. Marhefka ," Antennas for all Applications" ISBN 007123201X, 9780071232012,Publisher McGraw-Hill, 2002,3rd Edition

Reference books:

1. Electromagnetic waves & Radiating Systems "C.Jordan and K.G.Balmain, Pearson Education; Second edition (15 June 2015) , **ISBN-10 :** 9332551774 **ISBN-13 :** 978-93325517702.

COURSE INFORMATION SHEET

Sensing and Measurement

Course Code: EC507
Course Title: Sensing and Measurement
Pre-requisite(s): Electronic Measurement, Microwave, Wireless System
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/ V
Branch: ECE
SPECIALIZATION: N/A, Common Course

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Principles of operation Sensors and transducers
2.	Static and dynamic characteristics of measurement system
3.	RF sensor design
4.	Fabrication and packaging of MEMS sensor
5.	Characteristic and challenges in WSN

Course Outcomes

After the completion of this course, a student will be able to:

CO1	List the characteristics of a sensor and explain the principle of operation
CO2	Calculate the error in measurement system
CO3	Design an application specific RF sensor
CO4	Explain the MEMS sensors fabrication and packing process
CO5	Design an Energy efficient WSN

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Principles of operation Sensors and transducers, classification, characteristics. Recent trends in sensors technology. Introduction to smart sensors, Principles of operation, design approach, interface design, configuration supports	**8**
Module – II Measurement systems – Static and dynamic characteristics – units and standards of measurements, error, types of error, accuracy and precision, statistical analysis. Wave Analyzer, Spectrum Analyzer. Vector network analyzer.	**8**
Module – III RF AND Microwave Sensor: RF sensor, antenna for sensing, RF sensor design, Radar sensor, Radar applications, RFID sensor, RFID standards, RFID applications	**8**
Module – IV MEMS sensor, Comparison between MEMS and Macro sensor, Fabrication and packaging issue in sensor design, Thick film and thin film technique, Bio sensor, Fiber Optic Sensors	**8**
Module – V Wireless Sensing Techniques: Characteristic and challenges, WSN vs Adhoc Networks, Sensor node architecture, Physical layer and transceiver design considerations in WSNs, Energy usage profile, Choice of modulation scheme, Dynamic modulation scaling, Antenna considerations. IoT sensor nodes, Examples of IoT infrastructure.	**8**

Textbooks:

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.

Reference books:

1. Jun Zheng, Abbas Jamalipour, "Wireless Sensor Networks: A Networking Perspective", 2014, 1 st ed., Wiley-IEEE Press, USA.
2. Finkenzeuer Klaus, "RFID Handbook", 2011, 3rd edition, John Wiley and Sons, New Jersey.

COURSE INFORMATION SHEET

Artificial Intelligence and Machine Learning

Course Code: EC509
Course Title: Artificial Intelligence and Machine Learning
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/V
Branch: ECE
SPECIALIZATION: Common to All

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Understand the importance and impact of artificial Intelligence.
2.	Understand the atrificial neural work and different learning strategies.
3.	Develop and analyze the applications using machine learning and Regression techniques.
4.	Develop and design various machine learning techniques such as MLP, RBFNN, FLANN, deep Learning
5.	Learn the fuzzy theory and inference system.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Describe the Artificial Intelligence and Machine Learning.
CO2	Apply the regression techniques and statistical tests for inferencing
CO3	Develop and apply the neural network techniques to solve the complex pattern recognition, classification, clustering, and prediction problems.
CO4	Apply the Deep Learning techniques, CNN, LSTM to various engineering applications.
CO5	Develop fuzzy logic techniques for control, prediction and clustering applications

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Definition of AI, Turing test, brief history of AI, Problem solving and search, Uniform Search Strategies: Breadth First Search, Depth First Search, Heuristic Search Strategies: Greedy Best-First Search, A* Search, Local search, local search in continuous spaces: Hill Climbing Search, Simulated Annealing Search, genetic algorithm, Particle swarm optimization	**8**
Module – II Linear Regression Analysis: Simple Linear Regression; Logistic Regression, multivariate regression, Multiple Linear Regression, Statistical Parametric Tests: T-test, Paired t-test, Analysis of Variance (ANOVA), Statistical Non Parametric Tests: The Wilcoxon Signed Rank Test, Kruskal-Wallis Test, Chi-square Test	**8**
Module – III Machine Learning: Introduction to machine learning, Learning strategies: supervised, unsupervised reinforcement learning, Artificial neural network, multilayer perceptron networks, Back propagation algorithm, virtues and limitations of back propagation, methods of speeding: momentum, variable learning rate, Levenberg Marquardt Algorithm, radial basis functional neural network, support vector machine, Clustering	**8**
Module – IV **Deep Learning**: Concept of deep learning, Convolutional neural network, Autoencoder network, Multichannel deep neural network, Siamese deep network, RNN, Long Short-Term Memory network	**8**
Module – V **Fuzzy Logic & System**: Introduction to fuzzy systems, membership function, Fuzzy rules: Linguistics variables, fuzzy IF-Then rules, Fuzzy reasoning. Fuzzy inference systems: Mamdani fuzzy model, Sugeno fuzzy model, Tekamoto fuzzy model, Neuro-fuzzy systems	**8**

Textbooks:

1. S.J. Russell and P. Norvig. *Artificial Intelligence: A Modern Approach (3rd edition)*, Pearson Education, 2010.
2. “Neural network Design”- M.T. Hagan, B. Demuth & M. Beale, Thomson Learning, 2002
3. “Neuro-Fuzzy and Soft Computing”- J.S.R. Jang, C. T. Sun and E. Mizutani, PHI, NewDelhi

Reference books:

1. “Neural Networks: A comprehensive Foundation” – Simon Haykin, Pearson education

COURSE INFORMATION SHEET

Artificial Intelligence and Machine Learning Lab

Course code: EC510
Course Title: Artificial Intelligence and Machine Learning Lab
Pre-requisite(s):
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class periods per week: 04
Class: M. Tech.
Semester / Level: 1/V
Branch: ECE
SPECIALIZATION: Common to All

Name of Teacher:
Course Objectives
This course enables the students to:

1.	Demonstrate difference AI based search techniques.
2.	Understand the atrificial neural work and different learning strategies.
3.	Demonstrate the regression techniques and statistical tests.
4.	Develop and design various machine learning techniques such as MLP, RBFNN, FLANN, deep Learning
5.	Learn the concept of fuzzy theory and inference system.

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Apply the different search algorithms for engineering applications.
CO2	Design machine learning algorithms and evaluate its performance.
CO3	Apply clustering applications in real time data and find inference.
CO4	Design and apply deep learning algorithms for classification and recognition tasks.
CO5	Develop fuzzy logic based system for industrial and home automation.

Syllabus

Hands-on experiments related to the course:

Experiment No.	**Name of the Experiments**
1.	Implement and demonstrate the search algorithm for a specific task. AIM: Design a search application defining a objective and find its solution using the search algorithm.
2.	Build an Artificial Neural Network by implementing the Back propagation algorithm and test using appropriate data sets. AIM: Design multilayer perceptron network and evaluate its performance on a specific classification task.

3.	Implement the Regression algorithm to fit data points. Select appropriate data set for your experiment and draw insight of the data. AIM: apply linear regression/ multivariate regression techniques to fit a dataset and perform forecasting.
4.	Perform different statistical test on a dataset. AIM: Apply t-test, ANOVA, Kruskal wallis test for finding the significance of data.
5.	Construct a convolutional neural network considering medical image data. AIM: Design the convolutional neural network and evaluate its performance in classification task.
6.	Construct an auto encoder deep network using any training data. AIM: Design the auto encoder deep network and evaluate its performance in classification task.
7.	Implementation of a classifier to distinguish audio clips by finding features for automatic speech recognition. AIM: extract features from the speech signals and classify into groups using machine learning techniques.
8.	Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering a few test data sets. AIM: Design a naïve Bayesian classifier and evaluate its performance.
9.	Anomaly Detection and Classification using Nanoedge AI studio software. AIM: Collect the data in real time scenario and detect the anomaly in it.
10.	Implementation of k-means clustering algorithm for binary and multi-class classification of image data. AIM1: Design a K-means clustering algorithms and evaluate its performance metrices.
11.	Study of the Support Vector Machine technique and apply this to data classification. AIM1: Prepare the feature extraction of data in .CSV file and apply the SVM and analyse the confusion matrix. AIM2:
12.	Design and implement fuzzy controller for home automation. AIM: Design a fuzzy inference system and control water level/ temperature level.

Text Books:

1. "Neural network Design"- M.T. Hagan, B. Demuth & M. Beale, Thomson Learning, 2002

Reference Books:

1. "Neuro-Fuzzy and Soft Computing"- J.S.R. Jang, C. T. Sun and E. Mizutani, PHI, NewDelhi

COURSE INFORMATION SHEET

Wireless Signal Propagation

Course Code: EC521
Course Title: Wireless Signal Propagation
Pre-requisite(s): Basic understanding of Analog and Digital communication
Co-requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
Specialization: Wireless Communication

Name of Teacher:

Course Objectives:

This course aims to develop

1	An understanding on the nature of wireless signal propagation, and models describing wireless signal propagation.
2	An ability to explain different characteristics of wireless communication channels, and different channel parameters.
3	An ability to analyze causes of channel impairments and compare various removal techniques.
4	An ability to evaluate capacity of wireless communication systems under different channel conditions.

Course Outcomes

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

CO1	Demonstrate understanding of the nature of wireless signal propagation and models describing wireless signal propagation.
CO2	Have an ability to explain different characteristics of wireless communication channels, and different channel parameters.
CO3	Have an ability to analyze causes of channel impairments and compare various removal techniques.
CO4	Evaluate capacity of wireless communication systems under different channel conditions.
CO5	Analyse the channel capacity in various channel fading conditions

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I: ***Introduction to wireless signal propagation*** Basic propagation mechanisms, wireless mobile environment, multipath propagation, fading in wireless mobile environment, channel impulse response, digital modulation over wireless channels	**8**
Module – II: ***Wireless propagation models*** Free space propagation model, two ray ground reflection model, path loss, outdoor propagation models (Okumura model, Hata model, COST 231 model), indoor propagation models, log normal shadowing, typical small-scale fading models (Rician distribution and Rayleigh distribution)	**8**
Module – III: ***Channel parameters and its impact*** Power delay profile, delay spread, doppler spread, coherence bandwidth, coherence time, level crossing rate and average duration of fades, dispersive and non-dispersive wireless channels	**8**
Module – IV: ***Channel impairments and removal techniques*** *Channel impairments and removal techniques*: diversity mechanisms (space, time, frequency, and polarization), diversity gain and array gain, combining techniques (SC, MRC, TC and EGC), ISI free transmission, equalization, coding for wireless channels.	**8**
Module – V: ***Wireless system capacity*** AWGN channel capacity, flat fading channel capacity, frequency selective fading channel capacity, link adaptation and adaptive modulation and coding.	**8**

Textbooks:

1. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.

Reference books:

1. Vijay K Garg, "Wireless Communications and Networks", Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian reprint).
2. Simon Haykin and Michael Moher, "Modern Wireless Communications", Pearson Education, Delhi, 2005.
3. Sanjay Kumar, "Wireless Communication the Fundamental and Advanced Concepts" River Publishers, Denmark, 2015 (Indian reprint).

COURSE INFORMATION SHEET

Antenna Measurements Lab

Course code: EC522
Course Title: Antenna Measurements Lab
Pre-requisite(s): Electromagnetic Fields and Waves, Microwave Theory and Antenna
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class periods per week: 04
Class: M. Tech.
Semester / Level: II/ V
Branch: ECE
SPECIALIZATION: Wireless Communication

Name of Teacher:
Course Objectives
This course enables the students to:

1.	To understand important and fundamental antenna engineering parameters.
2.	To develop the basic skills to learn software and apply in the design of various antennas.
3.	To develop the basic skills necessary to measure antenna performance parameters.
4.	To apply the concepts learnt through theory
5.	Develop the ability to analyze the performance parameters of different types of antenna

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Implement the theoretical knowledge and prepare the reports and present the results.
CO2	Apply numerical modelling tools (software) to design antennas, with reference to low profile printed antennas.
CO3	Perform antenna measurements
CO4	Understand and visualize the radiation characteristics and its limitations and provide the environment friendly solutions in terms of antenna design.
CO5	Verify different microwave antenna theories.

SYLLABUS

Hands-on experiments related to the course:

Experiment No.	Name of the Experiments
1.	**Design of a rectangular microstrip patch antenna with inset feed (IE3D)** AIM: Design of a rectangular microstrip patch antenna for operating frequency 1.88 GHz with ε_r =4.4, h=31 mils with inset feed. (IE3D)
2.	**Design of a rectangular microstrip patch antenna with coaxial feed (IE3D)** AIM: Design of a rectangular microstrip patch antenna for operating frequency 1.88 GHz with ε_r =4.4, h=31 mils with coaxial feed. (IE3D)
3.	**Design of a rectangular microstrip patch antenna with transformer coupled microstrip feed (IE3D)** AIM: Design of a rectangular microstrip patch antenna for operating frequency 5 GHz with ε_r =3.2, h=0.762 mm & transformer coupled microstrip feed. (IE3D)
4.	**Design of a circular microstrip patch antenna for circular polarization with dual feed (IE3D)** AIM: Design of a circular microstrip patch antenna for circular polarization with dual feed. Assume resonant frequency =2.78 GHz, ε_r =2.33, h=2.184mm, $\tan\delta$=0.0012. (IE3D)
5.	**Design of a rectangular microstrip patch antenna with inset feed (HFSS)** AIM: Design of a rectangular microstrip patch antenna for operating frequency 1.88 GHz with ε_r =4.4, h=31 mils & inset feed. (HFSS)
6.	**Design of a rectangular microstrip patch antenna with transformer coupled microstrip feed (HFSS)** AIM: Design of a rectangular microstrip patch antenna for operating frequency 1.88 GHz with ε_r =4.4, h=31 mils & transformer coupled microstrip feed. (HFSS)
7.	**To plot the radiation pattern of a directional antenna.**
8.	**To plot the radiation pattern of an omnidirectional antenna.**
9.	**To calculate the resonant frequency and estimate the VSWR of an antenna.**
10.	**To prove inverse square law for any antenna.**
11.	**Characterization of a linearly polarized and circularly polarized antenna.**
12.	**The gain measurement of an antenna under test.**

Books recommended:

Textbooks:

1. Antenna Theory, Analysis and Design, 3/E, A. Balanis, John Wiley.
2. Antennas, J. D. Kraus, TMH
3. Wireless Communications, Principles and Practices, Rappaport, PHI

Reference books:

1. Software Radio A Modern Approach to Radio Engineering, J. H. Reed, Pearson Education.
2. Wireless and Cellular Communications, William C. Y. Lee, McGraw-Hill.
3. Wireless Communications, Principles and Practices, Rappaport, PHI.

COURSE INFORMATION SHEET

Detection and Estimation Theory

Course Code: EC523
Course Title: Detection and Estimation Theory
Pre-requisite(s): Probability and statistics
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/5
Branch: ECE
Specialization: Wireless Communication

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	understand how to cast a generic detection problem into a hypothesis testing framework and to find the optimal test for the given optimization criterion
2.	understand about statistical decision theory used for signal detection and estimation (Classical and Bayesian Estimation Approaches).
3.	understand about finding optimal estimators for various signal parameters, derive their properties and assess their performance.
4.	understand about the detection of deterministic and random signals using statistical models.
5.	demonstrate an ability to apply the estimation techniques to various areas of Engineering and Science.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Demonstrate the mathematical background of signal detection and estimation
CO2	Use classical and Bayesian approaches to formulate and solve problems for signal detection and parameter estimation from noisy signals.
CO3	Derive and apply filtering methods for parameter estimation.
CO4	Analyse signal estimation in discrete-time domain using filters.
CO5	Develop and apply the detection and estimation theory in various engineering applications and play role of team leader in industry.

SYLLABUS

MODULE	LECTURE HOURS
Module – I Review of Vector Spaces: Vectors and matrices: notation and properties, orthogonality and linear Independence, bases, distance properties, matrix operations, Eigen values and eigenvectors, Properties of Symmetric Matrices: Diagonalization of symmetric matrices, symmetric positive definite and semi definite matrices.	9
Module – II Detection and decision theory Neyman Pearson Theorem, Receiver Operating Characteristics, minimum probability of error, Bayes risk, Elementary hypothesis testing, Multiple hypothesis testing, Composite Hypothesis Testing.	**8**
Module – III Matched filters, Multiple signals, Linear model, Detection of signals with unknown amplitude, phase and frequency, chernoff bounds, detection of signals in Gaussian Noise.	**9**
Module – IV Estimation Theory, Minimum-variance unbiased estimator (MVUE), Cramer-Rao Lower bound, Best Linear Unbiased Estimator, Maximum likelihood Estimator, General Bayesian Estimator	**8**
Module – V Linear Signal waveform estimation: least square estimation, Kalman Filter, extended Kalman Filter, Order selection criterion of AR model, Minimum-variance, Maximum entropy and Maximum likelihood spectrum estimation Harmonic models and frequency estimation techniques, Applications of detection and estimation.	**8**

Textbooks:

1. Steven M Kay, Fundamentals of Statistical Signal Processing: Detection Theory, Prentice Hall, 1998
2. Steven M Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Vol II: Detection Theory, Prentice Hall, 1993.

Reference books:

1. H. V. Poor, "An Introduction to Signal Detection and Estimation," Springer, Second Edition, 1998.
2. Thomas Kailath, BabakHassibi, Ali H. Sayed, “Linear Estimation”, Prentice Hall, 2000
3. Van Trees, Harry L., 'Detection, estimation, and modulation theory, part I: detection, estimation, and linear modulation theory'. John Wiley & Sons, 2004.

COURSE INFORMATION SHEET

Wireless Communication and Networking Lab

Course code: EC524
Course Title: Wireless Communication and Networking Lab
Pre-requisite(s):
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class periods per week: 04
Class: M. Tech.
Semester / Level: II/05
Branch: ECE
Specialization: Wireless Communication

Name of Teacher:

Course Objectives

This course enables the students to:

1.	develop an ability to design various kind of wired networks using network simulator.
2.	develop an ability to design various kind of wireless networks using network simulator
3.	evaluate and compare the performance of several network protocols (AODV, DYMO etc.).
4.	design and interpret wireless sensor networks and standards
5.	design and examine the hardware setup for wireless network

Course Outcomes:

After the completion of this course, students will be able to:

CO1	design various kind of wired/wireless networks.
CO2	evaluate the performance of both wired/wireless networks.
CO3	analyze and compare the performance of various routing protocols (like AODV, DYMO etc.) for wireless adhoc network as well as for infrastructure based wireless network
CO4	design and interpret wireless networks and standards (WLAN, Bluetooth etc) through simulation software as well as evaluate the impact of various system parameters on wireless standards.
CO5	design and analyze the hardware setup (GSM and WSN etc) for wireless network.

Syllabus

Hands-on experiments related to the course:

Experiment No.	Name of the Experiments
1.	**Network Performance evaluation in Ad-hoc mode** AIM1: To design and evaluate an Ad hoc mode scenario using QualNet Network Simulator AIM2: To configure and estimate the effect of mobility to the data transferred in an Ad hoc mode scenario.
2.	**Network Performance evaluation in Infrastructure mode** AIM1: To configure and evaluate an infrastructure mode scenario using QualNet Simulator GUI. AIM2: To configure and estimate the effect of mobility to the data transferred in an infrastructure mode.
3	**Implementation of VOIP Application Layer Protocol** AIM1: To configure VOIP Application layer protocol based on H.323 in an ad-hoc mode AIM2: To configure VOIP Application layer protocol based on H.323 in an infrastructure mode
4	**Implementation and Performance evaluation of Multicasting Operation** AIM1: To configure and evaluate a multicasting application in a wired network scenario AIM2: To configure and evaluate a multicasting application in a wireless network scenario.
5	**Interfacing analog sensors in Wireless Sensor Network** AIM1: To Interface analog sensor with Scientech 2311W Wireless sensor network AIM2: To investigate point to point and star topology using Scientech 2311W Wireless sensor network
6	**Data extraction from Wireless sensor module** AIM1: To write a code to read data from temperature sensor and light sensor modules using SENSnuts GUI platform AIM2: To write a code to read data from Humidity sensor module using SENSnuts GUI platform
7	**Transmission control protocol (TCP)** AIM1: To measure Throughput performance of TCP AIM2: To examine TCP data transfer reliability
8	**LTE (Long term Evolution)** AIM1: To evaluate the variation in the throughput of LTE network due to variation in distance between the ENB (Evolve Node) and UE (User Equipment). AIM2: To evaluate the variation in the throughput of LTE network due to variation in the Channel bandwidth in the ENB

9	**Cognitive radio (CR) & GSM** AIM1: To analyze the effect of allocation of frequency spectrum to the Incumbent (Primary) and CR CPE (Secondary User) on throughput AIM2: To evaluate the call blocking probability due to variation of the load on the GSM network.
10	**Internet of Things (IoT)** AIM1: To analys the working of IoT AIM2: To analyse the performance of One Hop IoT Network over IEEE 802.15.4
11	**Virtual Local Area Network (VLAN)** AIM1: To investigate the VLAN operation in Layer 2 and Layer 3 Switches AIM2: To investigate the Access and Trunk Links in VLANs
12	**Orthogonal Frequency Division Multiplexing (OFDM) using GNURADIO Waveguru** AIM1: To Examine working of OFDM transmitter AIM2: To Examine working of OFDM receiver

Text Books:

1. Vijay K Garg, “Wireless Communications and Networks”, Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian reprint)
2. J. Schiller, “Mobile Communication” 2/e, Pearson Education, 2012.

Reference Books:

1. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005.
2. Iti Saha Misra, “Wireless Communication and Networks: 3G and Beyond”, 2/e, McGraw Hill Education (india) Private Ltd, New Delhi, 2013.
3. Sanjay Kumar, “Wireless Communication the Fundamental and Advanced Concepts” River Publishers, Denmark, 2015 (Indian reprint).

COURSE INFORMATION SHEET

Information Theory and Error Control Coding

Course Code: EC525
Course title: Information Theory and Error Control Coding
Pre-requisite(s): Knowledge of digital electronics, probability theory, basic understanding of communication system.
Co-requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/ 5
Branch: ECE
Specialization: Wireless Communication

Name of Teacher:

Course Objectives

This course aims to develop

1	An understanding on information coding fundamentals with several source coding techniques for efficient representation of a source.
2	Fundamental understanding on channel capacity and its evaluation under various channel conditions.
3	An understanding of channel coding techniques to achieve efficient as well as reliable communication.
4	Fundamental understanding on block codes, cyclic codes and convolutional codes with its practical challenges.
5	An ability to design and provide solutions for practical low cost, efficient, and reliable communication system.

Course Outcomes

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

CO1	Explain fundamentals of several lossy & lossless source coding techniques and further elaborate its possible extension in practical scenarios.
CO2	Demonstrate the concept of channel capacity and its evaluation under various channel conditions.
CO3	Elaborate the concept of block codes, bounds for block codes and design aspects of linear block codes with its encoding as well as decoding.
CO4	Demonstrate the fundamentals of cyclic codes and convolutional codes with its circuit implementation. The students will be able to analyse various advance channel coding techniques.
CO5	Have an ability to provide practical solutions and apply the subject expertise for the well fare of society.

SYLLABUS

Module	Lecture Hours
Module – I: ***Introduction to Information Theory*** Entropy, Relative Entropy, Mutual Information, Entropy rates of a stochastic process, Differential entropy, Kraft's inequality, Source Coding Theorem, Prefix Coding, Huffman Coding, Shannon-Fano Coding, Arithmetic Coding, Lempel-Ziv Algorithm, and Introduction to Network Information Theory.	**10**
Module – II: ***Channel Capacity and Coding*** Noisy Channel Coding Theorem, Converse of Noisy Channel Coding Theorem, Shannon's Channel Capacity Theorem, Channel Capacity of Binary Symmetric and Binary Erasure Channel, Gaussian Channel and its channel capacity, Parallel Gaussian Channel, Water Filling Theorem, and Rate Distortion Theory.	**8**
Module – III: ***Block Codes*** Galois Fields, Hamming Weight and Hamming Distance, Linear Block Codes, Encoding and decoding of Linear Block-codes, Parity Check Matrix, Bounds for block codes, Hamming Codes, Standard Decoding and Syndrome Decoding.	**8**
Module – IV: ***Cyclic Codes*** Introduction to cyclic code, Method for generating Cyclic Codes, Matrix description of Cyclic codes, Cyclic Redundancy Check (CRC) codes, Circuit implementation of cyclic codes, Burst error correction, and BCH codes.	**8**
Module – V: ***Convolutional Codes*** Introduction to Convolutional Codes, Polynomial description of Convolutional Codes, Generator function, Matrix description of Convolutional Codes, Viterbi Decoding of Convolutional code, Introduction to Turbo Code and LDPC code.	**8**

Textbooks:

1. "Information Theory, Coding & Cryptography", by Ranjan Bose, TMH, Second Edition.
2. "Communication Systems", by S. Haykin, 4th Edition, Wiley-Publication.

Reference books:

1. "Elements of Information Theory" by Thomas M. Cover, J. A. Thomas, Wiley-Interscience Publication.
2. "Error Correction Coding Mathematical Methods and Algorithms" by Todd K. Moon, Wiley India Edition.

COURSE INFORMATION SHEET

Advanced Wireless Technologies

Course Code: EC526
Course Title: Advanced Wireless Technologies
Pre-requisite(s): Communication Systems and Networks
Co-requisite(s): NIL
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE
Specialization: Wireless Communications

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1	Understand the Current trends and future vision in wireless systems
2	Develop an ability to compare recent technologies being used for wireless communication.
3	Develop an ability to comprehend upcoming technologies used for wireless communication.
4	an ability to explain the channel modelling techniques for next generation wireless communication systems
5	An ability to evaluate Transmission techniques and multiple access schemes for next generation wireless mobile communication system

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Understand the Current trends and future vision in wireless systems
CO2	Compare recent technologies being used for wireless communication systems.
CO3	Explain different upcoming technologies used for wireless communication systems
CO4	Apply different channel modelling techniques for next generation wireless communication system
CO5	Evaluate Transmission techniques and multiple access schemes for next generation wireless mobile communication system

SYLLABUS

Module	Lecture Hours
Module – I Current trends and future vision in wireless communication, WCDMA, HSPA, LTE, LTE-Advanced, 4G vs. 5G, 5G and its enabling technologies, **6G vision.**	**8**
Module – II Technological components for 5G & beyond-1: Massive MIMO, mm Wave Communication, CR Networks (CRN), SDR Networks (SDN), Multi RAT, HetNet, Visible Light Communication (VLC). Cooperative Cognitive Communication (CCC), Coordinated Multiple Point transmission (CoMP).	**8**
Module – III Technological components for 5G & beyond-2: Reconfigurable Antenna Design, Smart Antenna, Intelligent Reflecting Surface (IRS), Autonomous Network Configuration & Operation, Femto-cell deployment, Dynamic Adhoc Wireless Networks (DAWN), Ambient Intelligence, Cloud Radio Access Networks (CRAN), Network Function Virtualization (NFV), Support of IPv6, Flat IP Control, Multi Homing.	**8**
Module – IV *Channel models for next generation wireless communication*: Wireless mobile environment and its challenges, wireless channel parameters, types of wireless mobile channel, mmWave MIMO channel model, Massive MIMO channel model, Model for Terahertz Communication, Role of machine learning in channel modelling, Deep leaning based MIMO CSI compression.	**8**
Module – V *Transmission techniques and multiple access schemes for next generation wireless mobile communication system*: multicarrier communications, OFDM, MIMO-OFDM, OFDMA, GFDM (Generalized Frequency division multiplexing), NOMA (Nonorthogonal multiple access), BDMA (Beam division multiple access), Vandermonde-subspace frequency division multiplexing (VFDM)	**8**

Reference Books & Articles:

1. Ramjee Prasad, “5G: 2020 and beyond” River publishers, Denmark, 2014.
2. Cheng-Xiang Wang et. al. “Cellular Architecture and Key Technologies for 5G Wireless Communication networks” IEEE Communication Magazine, Feb, 2014.
3. Rupendra Nath Mitra, Dharma P Agrawal, “5G mobile technology: a survey”, science direct January 2016 (available online www.sciencedirect.com)
4. Research papers pertaining to next generation wireless communication system.
5. W. Jiang, B. Han, M. A. Habibi and H. D. Schotten, "The Road Towards 6G: A Comprehensive Survey," in *IEEE Open Journal of the Communications Society*, vol. 2, pp. 334-366, 2021.

COURSE INFORMATION SHEET

Spread Spectrum Techniques

Course code: EC527
Course title: Spread Spectrum Techniques
Pre-requisite(s): Digital Communication
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
Specialization: Wireless Communication

Name of Teacher:

Course Objectives:
This course aims to develop

1	An understanding of spread-spectrum concept and its implementation in various systems.
2	An ability to understand binary sequences and its generation.
3	An ability to evaluate performance of various Spread–Spectrum Systems in Jamming Environments
4	An ability to design and provide solutions for practical and efficient system and Multiple Access Techniques.
5	An ability to explain various types of CDMA standards and multi user detection.

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

CO1	Demonstrate their understanding on functioning of a spread-spectrum system and minimize the design challenges.
CO2	Have an ability to demonstrate several pseudo random sequences and its applications.
CO3	To design a broadband spread –spectrum under in Jamming Environments.
CO4	Demonstrate an ability to explain various multiple access techniques,
CO5	Have an ability to provide practical solutions and apply the subject expertise for the welfare of the society.

SYLLABUS

MODULE	LECTURE HOURS
Module – I Introduction to Spread-Spectrum Systems: Direct-sequence Spread−Spectrum for BPSK, QPSK, MSK, Frequency-Hop Spread Spectrum: Coherent and Non-coherent, Hybrid Direct−Sequence/ Frequency−Hop Spread Spectrum.	**8**
Module – II Binary Shift – Register Sequences for Spread- Spectrum Systems: Definitions, Finite field Arithmetic, Sequence Generator fundamentals, State –Machine Representation of Shift Register Generators, Maximal length - Sequences, Gold codes, orthogonal codes, Walsh codes.	**8**
Module – III Performance of Spread–Spectrum Systems in Jamming Environments: AWGN jamming, Partial – band jamming, pulsed noise jamming, single tone jamming, multiple - tone jamming.	**8**
Module – IV Multiple Access Techniques: Frequency Division Multiple Access, Time Division Multiple Access, Code Division Multiple Access, Space Division Multiple Access and Orthogonal Frequency Division Multiple Access, ALOHA, Slotted ALOHA, Carrier Sense Multiple Access, Packet Reservation Multiple Access, Busy Tone Multiple Access, Digital Sense Multiple Access.	**8**
Module – V Specific Application of CDMA Digital cellular Systems: cdma one, cdma 2000 and WCDMA: Carrier Spacing & Deployment Scenarios, Logical & Physical Channels, Hand over, Spread Spectrum Receivers: RAKE Receiver, Multiuser Detection (MUD).	**9**

Textbooks:

1. Introduction to Spread Spectrum Communications: Roger L. Peterson, R. E. Ziemer, David E. Borth, Pearson Education.

Reference books:

1. Wideband CDMA for Third Generation Mobile Communications-T. Ojanpera & R. Prasad, Artech House, 1992
2. Wireless Communication –Principles & Practice – T.S.Rappaport, Pearson Edu., 2002.
3. Cellular Mobile Systems Engineering-S. Faruque, Artech House, 1996.

COURSE INFORMATION SHEET

Satellite Communication Technology

Course Code: EC528
Course Title: Satellite Communication Technology
Pre-requisite(s): Knowledge on Digital Communication
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II / 5
Branch: ECE
SPECIALIZATION: Wireless Communication / Microwave Engineering

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	An understanding on Satellite communication system, satellite sub system and earth station.
2.	An ability to evaluate the impact of interference on the satellite communication and complete link design.
3.	An ability to analyze different system parameters, causes of impairments in satellite communication system.
4.	An understanding of Multiple access techniques to support satellite communication and special satellite systems.
5.	An understanding on basics of satellite networks and applications of satellites.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Demonstrate an understanding on orbital and functional principles of satellite Communication, Satellite sub system and Earth station system.
CO2	Architect, Interpret and select appropriate technologies for implementation of specified satellite communication systems.
CO3	Analyze and evaluate a satellite link and suggest enhancements to improve the link performance.
CO4	Demonstrate an understanding of advancement and multiple access techniques to support satellite communication and various satellite systems.
CO5	Demonstrate an understanding of satellite communication for various applications.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Origin, History, Current Technology and Overview of Satellite Communication System, Satellite Orbits, Kepler's law, Orbital Mechanics and Orbital Elements, Azimuth and Elevation, Coverage Angle and Slant Range, Look angle determination, Eclipse effect, Sun transit outage, Placement of a satellite in a geostationary orbit, Station keeping and Stabilization, Components & functionalities of Earth Station.	**10**
Module – II Basic Radio Transmission Theory, Uplink and Downlink Design, Design of Satellite Links for Specified Carrier-to-Noise plus Interference Ratio, Noise figure and Noise temperature. Absorbitive Attenuation Noise by Atmospheric Gases, Rain Attenuation, Noise due to Rain, Rain Depolarization, Tropospheric Multipath and Scintillation Effects. Interference Analysis, Interference to and from Adjacent Satellite Systems, Terrestrial Interference, Cross polarization Interference, Intermodulation Interference.	**8**
Module – III Frequency Division Multiple Access-SCPC, MCPC. Time Division Multiple Access-random (ALOHA, S-ALOHA) and time synchronized access. Code Division Multiple Access-Fixed and On-demand Assignment.	**8**
Module – IV Advantages and Disadvantages of Multibeam Satellites, Interconnection by Transponder Hopping, Interconnection by On-board Switching, Interconnection by Beam Scanning, On-Board Processing, Intersatellite Links.	**7**
Module – V Fixed Point Satellite Network, INTELSAT, Mobile Satellite Network, INMARSAT, Low Earth Orbit and Medium Earth Orbit Satellite Systems, Very Small Aperture Terminal (VSAT) Network, Direct Broadcast Satellite Systems, Global Positioning System.	**7**

Textbooks:

1. Digital Satellite Communications, 2/e, McGraw-Hill, 1990.Tri T. Ha

Reference books:

1. Satellite Communications, John Willey, and Sons, 2000T. Pratt, C.W. Bostian
2. Satellite Communications Systems Engineering, Pearson Education, 2/e; 2003 W.L. 3. Prichard, H.G. Suyderhoud and R.A. Nelson
3. Satellite Communications Systems: systems, techniques and technology, 6th edition, by G. Maral, M.Bousquet, Z.Sun,Publisher: John Willy and sons

COURSE INFORMATION SHEET

Modern Optimization Techniques

Course Code: **EC529**
Course Title: Modern Optimization Techniques
Pre-requisite(s): Probability and Random Processes
Co-requisite(s):
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Instrumentation
Name of Teacher:

Course Objectives:

This course enables the students to:

1	Gain understanding on optimization theory and its elements
2	Demonstrate single variable optimization, linear programming, dynamic programming concepts and techniques.
3	Demonstrate multivariable and constraint optimization concepts and techniques.
4	Understand on advance single and multi-objective optimization techniques such as GA, PSO, Pareto font, NSGA

Course Outcomes

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

CO1	Develop an understanding to formulate an optimization problem and its characteristics.
CO2	Have an ability to analyze and apply algorithms for design optimization.
CO3	Have an ability to find optimum solution to engineering optimization problem.
CO4	Develop an ability to apply use optimization techniques to finance, economics, medical applications, control
CO5	Develop an ability to apply use optimization techniques to communication, power, mechanical problems, chemical and biology.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1: Optimal problem formulation, Design variables constraints, Objective function, Variable bounds, Search methods: optimality Criteria, Bracketing methods: Exhaustive search methods, Region – Elimination methods; Interval halving method, Fibonacci search method, Golden section search method, Point-estimation method; Successive quadratic estimation method.	**8**
Module 2: Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cauchy's steepest descent and Newton's method. Linear Programming: Graphical method, Simplex Method, Revised simplex method, Duality in Linear Programming (LP), integer linear programming, Dynamic programming, Sensitivity analysis.	**8**
Module 3: Optimality criteria, Unidirectional search, Direct search methods: Simplex search method, Hooke-Jeeves pattern search method. Gradient based method, conjugate gradient method, concept of lagrangian multiplier, complex search method. Characteristics of a constrained problem. Direct methods: The complex method, Cutting plane method, Indirect method: Transformation Technique, Basic approach in the penalty function method, Interior penalty function method, convex method.	**8**
Module 4: Genetic algorithm and its working principle, GA variants, Particle swarm optimization and its working principle, Differential evolution, Multi-objective optimization principle, pareto font, NSGA.	**8**
Module 5: Application to communication, dynamic spectrum allocation, medical, clustering, bioinformatics, control, finance, mechanical structure optimization, power system	**8**

Text Books:

1. Optimization for Engineering Design - Kalyanmoy Deb, 2006, PHI
2. S.S. Rao, Engineering Optimization, Theory and practice, New age International Publisher, 2012
3. D.E. Goldberg, genetic Algorithm in search, optimization and machine learning, Addison-Wesley Longman Publisher, 1989

Reference Book:

1.Analytical Decision Making in Engineering Design - Siddal.

2. G. Hadley,"Linear programming", Narosa Publishing House, New Delhi, 1990.

COURSE INFORMATION SHEET

Adhoc and Wireless Sensor Networks

Course code: EC530
Course title: Adhoc and Wireless Sensor Networks
Pre-requisite(s): Understanding of communication system
Co- requisite(s): Nil
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
Specialization: Wireless Communication

Name of Teacher:

Course Objectives: This course aims to develop

1	An understanding of the concept of wireless adhoc and wireless sensor network with its major challenges.
2	An understanding of WSN architecture and its design principles.
3	Fundamental understanding on MAC and routing protocols.
4	An ability to evaluate Localization And Positioning techniques in wireless adhoc and wireless sensor network.
5	An ability to design and provide solutions for practical low cost, energy efficient, reliable and secure wireless sensor network.

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

CO1	Have an ability to evaluate wireless adhoc & sensor network based on its performance as well as minimize the design challenges.
CO2	Have an ability to demonstrate several architectures of WSN and provide a new design solution according to the required applications.
CO3	Have an ability to design several MAC, Routing and transport protocols for WSNs.
CO4	Demonstrate several Localization & Positioning techniques in wireless adhoc & sensor network. Have an ability to provide practical solutions and apply the subject expertise for the welfare of society.
CO5	Demonstrate and identify several security concepts in WSN. Also provide solutions for practical low cost, energy efficient, reliable and secure wireless sensor network.

SYLLABUS

MODULE	LECTURE HOURS
Module – I: ***Introduction to Wireless Adhoc and Sensor Network*** Fundamentals of Wireless Communication Technology, The Electromagnetic Spectrum, Radio propagation Mechanisms, Characteristics of the Wireless Channel, mobile ad hoc networks (MANETs) and wireless sensor networks (WSNs): concepts and architectures, Applications of Ad Hoc and Sensor networks, Design Challenges in Ad hoc and Sensor Networks.	**8**
Module – II: ***Single Node and Network Architecture*** Single node architecture: hardware and software components of a sensor node, WSN Network Architecture: typical network architectures-data relaying and aggregation strategies, Energy consumption of sensor nodes, Operating system and execution environments, sensor network scenarios, Optimization goals and figures of merit, Design principles of WSNs.	**8**
Module – III: ***Mac Protocols for Wireless Sensor Network*** Fundamental of MAC protocols, MAC protocols for WSN, Low duty cycle protocols and wakeup concepts, contention based and scheduled based protocols (LEACH, SMACS, TRAMA), IEEE 802.15.4 MAC protocols, Topology control and clustering.	**8**
Module – IV: ***Routing Protocols and Transport Control Protocols For WSN*** Routing challenges and design issues in WSN, Wireless network routing protocols, Energy efficient unicast routing, energy efficient broadcast /multicast routing, Geographical routing, traditional transport control protocols, Design issues of transport control protocols, Ad hoc Transport protocols (ATP), Localization and Positioning procedures in WSN (Proximity, Trilateration and Triangulation).	**8**
Module – V: ***Security for wireless Ad hoc and sensor network*** Introduction to network security: from Crypto to Security Protocols, Cryptographic protocols for wireless networks and key management, Security standards in current wireless systems, Security architectures and protocols in WPAN Networks, Role of sensors to enable security.	**8**

Text books:

1. Kazem Sohraby, Daniel Minoli, Taieb Znati, “Wireless Sensor Networks’, John Wiley & Sons Inc. Publication, 2007(8)
2. Holger Karl, and Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks” John Wiley & Sons Inc. Publication.

Reference books:

1. XiangYang Li, “Wireless Adhoc and Sensor Networks: Theory and Applications”, Cambridge university press, USA, 2008.

COURSE INFORMATION SHEET

MIMO and Space Time Wireless Communication

Course Code: EC531
Course Title: MIMO and Space Time Wireless Communication
Pre-requisite(s): Communication systems, Probability and statistics
Co- requisite(s): Nil
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
Specialization: Wireless Communications

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Understand Different antenna configurations
2.	Understand MIMO configuration and MIMO channel models
3.	Understand different space time coding schemes used in MIMO system.
4.	Understand different detection schemes used in MIMO system.
5.	Conceptualize different applications of MIMO systems.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Evaluate different antenna configurations leading to MIMO system
CO2	Analyze MIMO configuration and different channel models used for MIMO system.
CO3	Apply different space time coding schemes for MIMO system design.
CO4	Evaluate the performance of different detectors used for MIMO system
CO5	Apply MIMO for different applications.

SYLLABUS

Module	Lecture Hours
Module – I: Introduction to MIMO Systems Different antenna configurations (SISO, SIMO, MISO, MIMO), Why MIMO Array gain, Diversity gain and Spatial multiplexing gain, Diversity Multiplexing trade-off, Smart antenna, beamforming, and MIMO.	**8**
Module – II: MIMO Channel Wireless channel and its characterization, different fading models, MIMO configuration and MIMO channel model, Power allocation in MIMO systems, MIMO system capacity (for flat fading and frequency selective channels), MIMO capacity based on channel state information.	**8**
Module – III: Space Time Coding Basics of linear algebra, Space Time Coding (STC) in MIMO, Alamouti scheme, STTC and STBC, higher order STBC, STBC concatenated with TCM, Choice of MIMO system design parameters.	**8**
Module – IV: MIMO Detection Maximum Likelihood detector, Linear sub-optimal detectors, Sphere decoding, Advanced MIMO detection, successive interference cancellation detection, Lattice reduction-based detector	**8**
Module – V: MIMO Applications Cooperative MIMO, cognitive MIMO, MIMO-OFDM system, MIMO in Mobile Communication System, Massive MIMO, concept of ultra-dense MIMO.	**8**

Textbooks:

1. David Tse, Pramod Viswanath, ‘Fundamentals of Wireless Communications’, Cambridge University Press, 2005.
2. Arogyaswami Paulraj, Rohit Nabar, Dhananjay Gore, ‘Introduction to Space-Time Wireless Communications’, Cambridge University Press, 2003.

Reference books:

1. Jerry R. Hampton, “Introduction to MIMO Communications”, Cambridge University Press, 2014.
2. Rakhesh Singh Kshetrimayum, ‘Fundamentals of MIMO Wireless Communications’, Cambridge University Press, 2017.
3. Andrea Goldsmith, “Wireless Communication”, Cambridge University Press, 2005.
4. Sanjay Kumar, “Wireless Communication the Fundamental and Advanced Concepts” River Publishers, Denmark, 2015 (Indian reprint).

COURSE INFORMATION SHEET

Cognitive Radio Communication and Networks

Course Code: EC532
Course Title: Cognitive Radio Communication and Networks
Pre-requisite(s): Knowledge of communication system and networks
Co- requisite(s): NA
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/5
Branch: ECE
Specialization: Wireless Communication

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Understand software defined radio architecture and its design principles.
2.	Understand various components, functions and capabilities of cognitive radio.
3.	Evaluate different spectrum sensing mechanisms in cognitive radio.
4.	Analyze the spectrum management functions using cognitive radio systems and cognitive radio networks.
5.	Understand cognitive radio network and terminal architecture

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Demonstrate an understanding on software defined radio architecture and design principles.
CO2	Demonstrate an understanding on cognitive radio components, functions and capabilities.
CO3	Evaluate different spectrum sensing mechanisms in cognitive radio.
CO4	Analyse the spectrum management functions using cognitive radio systems and cognitive radio networks.
CO5	Demonstrate an understand cognitive radio network and terminal architecture

SYLLABUS

MODULE	LECTURE HOURS
Module – I Software Defined Radio (SDR): Essential functions of the SDR, SDR architecture, design principles of SDR, traditional radio implemented in hardware and SDR, transmitter architecture and its issues, A/D & D/A conversion, parameters of practical data converters, techniques to improve data converter performance, complex ADC and DAC architectures, digital radio processing, reconfigurable wireless communication systems.	**9**
Module – II Cognitive Radio (CR) features and capabilities, CR functions, CR architecture, components of CR, CR cycle, CR and dynamic spectrum access, interference temperature, CR architecture for next generation networks, CR standardization.	**8**
Module – III Spectrum sensing and identification, primary signal detection. energy detector, cyclostationary feature detector, matched filter, cooperative sensing, spectrum opportunity, spectrum opportunity detection, fundamental trade-offs: performance versus constraint, sensing accuracy versus sensing overhead.	**9**
Module – IV Spectrum management of cognitive radio networks, spectrum decision, spectrum sharing and spectrum mobility, mobility management of heterogeneous wireless networks, research challenges in CR	**8**
Module – V Cognitive radio networks (CRN) architecture, terminal architecture of CRN, diversity radio access networks, routing in CRN, Control of CRN, Self-organization in mobile communication networks, security in CRN, cooperative communications, cooperative wireless networks, user cooperation and cognitive systems	**8**

Textbooks:

1. Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons, Ltd, 2009.

Reference books:

1. Alexander M. Wyglinski, Maziar Nekovee, and Y. Thomas Hou, "Cognitive Radio Communications and Networks - Principles and Practice", Elsevier Inc., 2010.
2. Jeffrey H. Reed "Software Radio: A Modern Approach to radio Engineering", Pearson Education Asia

COURSE INFORMATION SHEET

Optical Wireless Communication

Course Code: EC533
Course Title: Optical Wireless Communication
Pre-requisite(s): Knowledge of Semiconductor Devices, Data Communication, Fiber Optic Communication
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Wireless Communication

Name of Teacher:

Course Objectives:
This course enables the students:

A.	To understand the characteristics of Indoor and Outdoor IR systems, performance of Wireless IR link under Atmospheric turbulence.
B.	To understand the transmitter design considerations and receiver design considerations for optical wireless communication.
C.	To understand different modulation schemes and different multiple access techniques for sharing IR medium.
D.	To understand the standards of IrDA technology, features and the different layers of the IrDA protocols for optical wireless networking.

Course Outcomes:
After the completion of this course, students will be:

CO1	To explain the characteristics of Indoor and Outdoor IR systems, transmission impairments of Wireless IR communication
CO2	To design the transmitter based on LED/Laser diode for optical wireless communication.
CO3	To design the receiver based on semiconductor photodiodes for optical wireless communication.
CO4	To choose a right modulation scheme for indoor & outdoor applications and the different multiple access techniques
CO5	To apply IrDA protocols to create simple, cost-effective and low power transceivers that enable wireless IR communication in a number of devices.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module-1: Basic concept of Optical wireless communication, Optical Wireless channels, Light sources, Modulators, Detectors, Atmospheric transmission limitations, Effect of Rain, Fog, and Mist, Scintillation, Optical Path Length and Fermat's Principle, The Etendue or Lagrange Invariant, Edge Ray Principle.	**8**
Module-2: Gaussian Beam, Telescope, beam expander, Optical filter and anti- reflection coating, Optical Concentrators, Wireless IR Receiver Requirements, DTIRC Characteristics. Comparison of Concentrators. Practical Issues. Different Shapes of DTIRCs, Tracking system, Laser beam steering device.	**8**
Module-3: Optical Wireless Transmitter Design, Transmitter Design Considerations, Optical Source Characteristics. Types of Optical Modulation. Driver Circuit Design Concepts. Current Steering Output Circuit, Back Termination Circuit, Predriver, Data Retiming, Automatic Power Control, Transmitters Linearization Techniques.	**8**
Module-4: Optical wireless receiver design, Receiver Design Considerations, Photodetection in Reverse-biased Diodes. Choosing the Photodetector, Receiver Noise Consideration, Bit Error Rate and Sensitivity, Bandwidth, Signal Amplification Techniques, Receiver Main Amplifier (RMA). Transceiver Circuit Implementation Technologies.	**8**
Module -5: Modulation and Multiple Access Techniques, IrDA PROTOCOLS. Wireless Protocol Standards. The Infrared Data Association, The Physical Layer Protocol, Framer/Driver, IrLAP, IrLMP, Information Access Service and Protocol, Tiny Transport Protocol, Session and Application Layer Protocols, WIRELESS IR NETWORKING, The Ad Hoc Network, Quality of Service (QoS), MIMO Wireless optical channel, Pixelated Wireless optical channel.	**8**

Books Recommended

TEXTBOOKS:

1. “Optical and Wireless Communications”, Sadiku, Matthew N. O. CRC Press
2. “Optical Wireless Communications: IR for Wireless Connectivity”, Ramirez-Iniguez, Roberto Idrus, Sevia M., Auerbach Publications.

REFERENCE BOOKS:

1. “Microwave Photonics”, Chi Lee, CRC Press, 2006.
2. “Wireless Optical Communication Systems” Steve Hranilovic, Springer.

COURSE INFORMATION SHEET

Advanced Electromagnetic Engineering

Course Code: EC541
Course Title: Advanced Electromagnetic Engineering
Pre-requisite(s): Electromagnetic Theory and Microwave Engineering
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Microwave Engineering

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Introduction to the wave equation and transmission line concept
2.	To develop an ability to analyze the plane waves functions and various rectangular shaped microwave components and their properties for different modes in rectangular coordinate system.
3.	To develop an ability to analyze the cylinder & spherical wave functions, and various cylindrical/spherical shaped microwave components and their properties for different modes in cylindrical coordinate systems.
4.	To develop and ability to evaluate different parameters of microwave components using perturbational and variational techniques.
5.	To develop and ability to analyze the various microwave networks

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Understand and develop the concept of wave equations, its behavior in dielectrics and lossy matter, develop the transmission line, waveguide, and resonator concept
CO2	Demonstrate understanding on the plane waves functions and calculation of various performance parameters of different kinds of rectangular microwave components such as waveguide, cavity, partially filled waveguide and dielectric slab waveguide apart from the concepts of surface guided waves and modal expansion of fields.
CO3	Have an ability to analyze the cylindrical and spherical wave functions and calculation of various performance parameters of different kinds of cylindrical/spherical microwave components, sources of cylindrical/spherical waves, cavities, and wave transformations, scattering by spheres.
CO4	Demonstrate insight to use the perturbational and variational techniques to evaluate the different parameters due to perturbations on cavity walls, cavity materials and waveguide apart from the knowledge of stationary formulas for cavity.
CO5	Have an ability to understand the concepts of various microwave networks.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module- I: Introduction to Waves The wave equation, Waves in Perfect Dielectrics, Waves in Lossy matter, Reflection of waves, Transmission Line Concepts, Waveguide and Resonator concepts, Radiation, Duality, Uniqueness and reciprocity theorem	**8**
Module – II Plane Wave Functions The Wave Functions Plane Waves, Rectangular Waveguide, Alternative Mode Sets, The Rectangular Cavity. Partially Filled Waveguide, Surface Guided Waves, Modal Expansion of Fields. Currents in Waveguides.	**8**
Module – III Cylindrical and Spherical Wave functions Cylindrical Wave Functions, Circular Waveguide, Radial Waveguides, Partially Filled Radial Waveguide, Sources of Cylindrical Waves, Two-Dimensional Radiation, Spherical Wave Functions, Spherical Cavity, Orthogonality Relationships, Sources of Spherical Waves, Wave Transformations and scattering by Cylinders/Spheres, Maximum Antenna Gain.	**10**
Module – IV Perturbation & Variational Techniques Perturbation of Cavity Walls, Cavity Material Perturbations, Waveguide Perturbations, Stationary Formulas for Cavities, The Reaction Concept, Stationary Formulas for Waveguide, Spectral Domain Analysis.	**6**
Module – V Microwave Networks Cylindrical Waveguide, Modal expansion of waveguides, the network Concept, One-port Network, Two-port Network, Obstacles in waveguide, Posts in waveguide, Waveguide Junctions, Probes in Cavities, Aperture Coupling in Cavities.	**8**

Textbooks:

Time Harmonic Electromagnetic Fields; By Roger F. Harrington; McGraw Hill Book Company; 1961. (T1)

Reference books:

1. Foundations for Microwave Engineering; Second Edition; By Robert E. Collin; McGraw Hill International Edition; 1992. (R1)

2. Microwave Engineering; Second Edition; by David M. Pozar; John Wiley & Sons; Inc. Copyright 2001, (R2)

3. Advanced Engineering Electromagnetics, Second Edition, Constantine A. Balanis, Wiley, 2012.

COURSE INFORMATION SHEET

Microwave Measurement Lab

Course code: EC542
Course title: Microwave Measurement Lab
Pre-requisite(s): Electromagnetic Fields and Waves
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class schedule per week: 04
Class: M. Tech**.**
Semester / Level: II/05
Branch: ECE
SPECIALIZATION: M. Tech. Microwave Engineering

Name of Teacher:

Course Objectives: This course enables the students to

1.	Understand and use of microwave measurement instruments
2.	Understand the measurement of radiated emission from mobile tower and from mobile phone.
3.	Develop the ability to analyse of linearly polarized and circularly polarized antenna
4.	to analyze, measure and evaluate crosstalk, radiated and conducted emissions to examine the shielding effectiveness of conducting materials.
.5	To to analyze, measure various parameters of micro strip filters (LPF,HPF,BPF,BSF)

Course Outcomes:

After the completion of this course, a student will be able to

CO1	Measure dielectric constant of unknown dielectric material.
CO2	Measure and analyze radiated emission from mobile tower and from mobile phone.
CO3	Measure and analyze the performance parameters microstrip filters
CO4	To analyze, measure and evaluate crosstalk, radiated and conducted emissions to examine the shielding effectiveness of conducting materials
CO5	Measure and analyze the performance parameters of different types of Antenna

Syllabus

Hands-on experiments related to the course:

Experiment No.	Name of the Experiments
1.	**Study of Various measuring equipment, connectors, adapters etc. and Measurement of Microwave signal in time and frequency domain using Spectrum Analyser (SA) and Digital Storage Oscilloscope (DSO).**
2.	**Measurement of various parameters in Microstrip Patch Antenna (MSA) having different feeding technique such as, (i.) Inset feed (ii.) Co-axial feed, and (iii.) Transformer coupled feed.**
3.	**Measurement of different crosstalk in cable and its reduction technique.**
4.	**Measurement of crosstalk in a three conductor Microstrip Transmission Line (MTL) using VNA.**
5.	**Measurement of Shielding Effectiveness of conducting material.**
6.	**Measurement of the conducted emission using LISN and current probe.**
7.	**Measurement of the radiated emission from mobile tower and from mobile phone.**
8.	**Measurement of dielectric constant of unknown dielectric material using ring resonator method.**
9.	**Characterization of a linearly polarized and circularly polarized antenna.**
10.	**The gain measurement of an antenna under test.**
11.	**To plot the radiation pattern of a directional antenna and omnidirectional antenna.**
12.	**Measurement of various parameters of micro strip filters (LPF, HPF, BPF, BSF)**

Optional Experiments (EMI-EMC Lab):

1. Design of Microstrip patch antenna using HFSS, IE3D and CST
2. Near Field measurement using Magnetic Field loop Probes.

TEXTBOOKS:

1. David M. Pozar, "Microwave Engineering", Third Edition, Wiley India.
2. R. Ludwig and G. Bogdanov, “RF Circuit Design, Theory and Applications”, Pearson, 2nd Edition.
3. Antenna Theory, Analysis and Design, 3/E, A. Balanis, John Wiley

REFERENCE BOOKS:

1. Paul, C., Introduction to Electromagnetic Compatibility, John Wiley & Sons, 1992.

COURSE INFORMATION SHEET

RF Circuit Design

Course code: EC543
Course title: RF Circuit Design
Pre-requisite(s): Electromagnetic Fields and Waves, Microwave Theory & Technique
Co- requisite(s):
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 03
Class: M. Tech. Microwave Engg. & Wireless Communication
Semester / Level: II/05
Branch: ECE
SPECIALIZATION: Microwave Engineering

Name of Teacher:

Course Objectives : This course enables the students

A.	To explain radio frequency design concept and impart knowledge on design and implementation of high frequency transceiver system.
B.	To develop an ability to analyze various components of radio frequency communication system architecture.
C.	To develop an ability to analyze the impact of different design parameters in transceiver circuit design, besides developing an insight to make use of several high frequency design techniques.
D.	To develop the prototype models of the various RF circuit components.
E.	To review and refer the literature related to RF Circuit design and report it ethically.

Course Outcomes

After the completion of this course, students will be:

1.	Able to explain radio frequency design concept and impart knowledge on design and implementation of high frequency transceiver system.
2.	Able to develop an ability to analyze various components of radio frequency communication system architecture.
3.	Able to develop an ability to analyze the impact of different design parameters in transceiver circuit design, besides developing an insight to make use of several high frequency design techniques.
4.	Able to develop the prototype models of the various RF circuit components.
5.	Able to review and refer the literature related to RF Circuit design and report it ethically.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1: **Introduction** Importance of RF Design, RF Behavior of Passive Components: High Frequency Resistors, High-Frequency Capacitors, High-Frequency Inductors. Chip Components and Circuit Board Considerations: Chip Resistors, Chip Capacitors, Surface-Mounted Inductors.	**6**
Module 2: **RF Filter Design** Basic Resonator and Filter Configurations: Filter Type and Parameters, Low-Pass Filter, High Pass Filter, Bandpass and Bandstop Filters, Insertion Loss, Special Filter Realizations: Butterworth –Type, Chebyshev and Denormalization of Standard Low-Pass Design. Filter Implementations: Unit Elements, Kuroda's Identities and Examples of Microstrip Filter Design. Coupled Filter: Odd and Even Mode Excitation, Bandpass Filter Section, Cascading Bandpass Filter Elements, Design Examples.	**10**
Module 3: **Matching and Biasing Network** Impedance Matching using Discrete Components: Two Component Matching Networks, Forbidden regions, Frequency Response and Quality Factor, Microstrip Line Matching Networks: From Discrete Components to Microstrip Lines, Single-Stub Matching Networks, Double-Stub Matching Networks, Amplifier Classes of Operation and Biasing Network: Classes of Operation and Efficiency of Amplifiers, Bipolar Transistor Biasing Networks, Field Effect Transistor Biasing Networks.	**8**
Module 4: **RF Transistor Amplifier Design** Characteristics of Amplifiers, Amplifier Power Relations: RF source, Transducer Power Gain, Additional Power Relations, Stability Considerations: Stability Circles, Unconditional Stability, Stabilization Methods, Constant Gain: Unilateral Design, Unilateral Figure of Merit, Bilateral Design, Operating and Available Power Gain Circles. Noise Figure Circles, Constant VSWR Circles. Broadband, High Power and Multistage Amplifiers.	**8**
Module 5: **RF Oscillators and Mixers** Basic Oscillator Model: Negative Resistance Oscillator, Feedback Oscillator Design, Design Steps, Quartz Oscillators. High Frequency Oscillator Configuration: Fixed Frequency Oscillators, Dielectric Resonator Oscillators, YIG-Tuned Oscillators, Voltage Controlled Oscillators, Gunn Element Oscillator. Basic Characteristics of Mixers: Basic Concepts, Frequency Domain Considerations, Single-Balanced Mixer Double-Balanced Mixer.	**8**

TEXT BOOKS:

1. RF Circuit Design Theory and Application, Reinhold Ludwig and Pavel Bretchko, Ed. 2004, Pearson Education.

REFERENCE BOOKS:

1. Microstrip Filters for RF/Microwave Applications, Jia-Sheng Hong, M. J. Lancaster, John Wiley & Sons, 2001.

COURSE INFORMATION SHEET

Microwave Integrated Circuit Lab

Course code: EC544
Course title: Microwave Integrated Circuit Lab
Pre-requisite(s): EC Microwave Theory &Techniques
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class schedule per week: 04
Class: M. Tech.
Semester / Level: II/05
Branch: ECE
SPECIALIZATION: Microwave Engg.

Name of Teacher:

Course Objectives: This course enables the students

A.	To develop an understanding for design & analysis of LPF/ BPF and phase shifter
B.	To develop an understanding for design and analysis of coupled line coupler and branch line coupler.
C.	To develop an understanding for design and analysis of microstrip diplexer and power divider.
D.	To develop an understanding of active components based microstrip circuits such as LNA, oscillators and mixer
E.	To develop an understanding of combination of active and passive microwave circuits and their fabrications and measurement.

Course Outcomes

After the completion of this course, students will be able to:

1	Demonstrate understanding of the design & analysis of LPF/ BPF and phase shifter.
2	Demonstrate understanding of the design and analysis of coupled line coupler and branch line coupler.
3	Demonstrate understanding of the design and analysis of microstrip diplexer and power divider.
4	Understand and analyse the active components based microstrip circuits such as LNA, oscillators and mixer
5	Demonstrate understanding of combination of active and passive microwave circuits and their fabrications and measurement.

Syllabus

LIST OF EXPERIMENTS:

Hands-on experiments related to the course: (Experiments will be in 1-30 GHz)

Experiment No.	Name of the Experiments
1.	Design of microstrip low pass filter/ band pass filter.
2.	Design of microwave band 45^0 and 90^0 Phase Shifters.
3.	Design of coupled line coupler with arbitrary coupling coefficient.
4.	Design of 3-dB branch line coupler by using open stubs.
5.	Design of planar microstrip diplexer and triplexer using resonators.
6.	Design of microstrip 3dB Wilkinson power divider.
7.	Design of high gain Low Noise Amplifier.
8.	Design of microstrip transistor Oscillator
9.	Design of matched microwave mixer
10.	Design of microstrip tuneable filter with PIN/ Varactor diode
11.	Fabrication and Measurement of passive LPF/ BPF
12.	Fabrication and Measurement of microstrip tuneable filter with PIN/ Varactor diode.

TEXTBOOKS:

1**.** Microwave Integrated circuit, K. C. Gupta, John Wiley, Newyork, 1974.
2. Microstrip lines and Slot lines, K.C. Gupta, R. Garg., I. Bahl, P. Bhartia, Artech House, Boston, 1996.

REFERENCE BOOKS:

1. RF Circuit Design, Reinhold Ludwig and Pavel Bretchko, Pearson, 2006.
2. Stripline-like Transmission lines for Microwave Integrated circuits, B. Bhat, S. K. Koul, Wiley Eastern Ltd., New Delhi.
2. Microwave Integrated Circuits, By Ivan Kneppo, J. Fabian, P. Bezousek

COURSE INFORMATION SHEET

Numerical Techniques in Electromagnetics

Course Code: EC545
Course Title: Numerical Techniques in Electromagnetics
Pre-requisite(s): Electromagnetic Theory
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: 2/5
Branch: ECE
SPECIALIZATION: Microwave Engineering

Name of Teacher: Vibha Rani Gupta

Course Objectives

This course envisions to impact to students:

1.	To describe the need of numerical techniques and classification of EM problems
2.	To describe the various numerical techniques used in analyzing EM problems
3.	To formulate real life problem to mathematical model.
4.	To solve simple EM problems using deterministic numerical techniques
5.	To solve simple EM problems using non-deterministic numerical techniques

Course Outcomes

After the completion of this course, a student will be able to:

CO1	To classify the EM problems.
CO2	To acquire theoretical knowledge and explain various numerical methods of electromagnetics.
CO3	To formulate real life problem to mathematical model.
CO4	To apply various deterministic numerical methods to different static, scattering and radiation problems
CO5	To apply non-deterministic numerical methods to different static, scattering and radiation problems

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Introduction:** Need for Numerical Solution of Electromagnetic problems, Selection of a numerical method, Classification of Electromagnetic problems, Classification of Solution Region, Classification of Boundary Conditions.	**8**
Module – II **Finite Difference (FD) and Finite Difference Time Domain (FDTD Methods:** Introduction, FD schemes for parabolic, hyperbolic & Elliptical partial differential equations, solving the Laplace, diffusion and wave equations by FD method. Application to Guided structures: microstrip line and rectangular waveguide. Yee's FD algorithms, Accuracy & stability, Lattice truncation condition, Initial fields, Absorbing Boundary conditions for FDTD, Scattering problems.	**8**
Module – III **Integral Equations and Method of Moments (MoM):** Classification of Integral Equations, Relation between differential and integral Equations, Green's function: definition, Green's function for free space, Solution of integral equations using MoM, Quasi-static problems (thin conducting wire, parallel plate capacitor), Dipole antenna current distribution & input impedance, mutual impedance of two short dipoles, Scattering from a dipole antenna.	**8**
Module – IV **Finite Element Method:** Finite Element Discretization, Element Governing Equations, Assembling of all Elements, Solving the resulting equations, Typical Applications.	**8**
Module – V **Monte Carlo (MC) methods:** Introduction, Fixed and Floating Random Walks, Markov Chains, Solving typical electromagnetic problems with random walk and Markov chain methods.	**8**

Textbooks:

Numerical Techniques in Electromagnetics Mathew N. O. Sadiku (CRC Press)

Reference books:

Analytical and Computational Methods in Electromagnetics, Ramesh Garg, Artech House, 2008.

COURSE INFORMATION SHEET

MW & MM-Wave Planar Transmission Line Design

Course code: EC546
Course title: MW & MM-Wave Planar Transmission Line Design
Pre-requisite(s): Microwave Theory and Antenna
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class period per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: Microwave Engineering
Name of Teacher:
Course Objectives:
This course enables the students to:

1.	Understand the requirement of MMIC / HMIC technologies and to acquire knowledge of GaAs fabrication technologies with various processes involved.
2.	Know common planar transmission lines, merits and demerits, and usage.
3.	Analyze and design the high frequency planar transmission lines using Conformal Mapping and Variational Methods.
4.	Analyze and design the high frequency planar transmission lines.
5.	Analyze & design the high frequency planar Coupled Lines.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Implement the MMIC / HMIC technologies and GaAs fabrication technologies with various processes involved.
CO2	Implement the common planar transmission lines
CO3	Design the high frequency planar transmission lines using Conformal Mapping and Variational Methods.
CO4	Design the high frequency planar transmission lines.
CO5	Design the high frequency planar Coupled Lines.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module -1: **Introduction to MMIC / HMIC and Fabrication Technology:** Introduction to Monolithic Microwave Integrated Circuits (MMICs), Merits and Demerits, MMIC fabrication techniques. Thick and Thin film Technologies, Materials, Encapsulation, GaAs Fabrication Technology and Various Processes.	**8**

Module -2: **Introduction to Planar Transmission Lines** Transmission Line Parameters, Static Analysis, Dynamic Analysis, Microstrip Line, Coplanar Waveguide (CPW), Coplanar Strips (CPS), Strip Line, Slot Line, Fin line.	**8**
Module -3: **Planar Transmission Line Analysis & Design -I** *Conformal Mapping*: The Schwarz–Christoffel Transformation, Schwarz-Christoffel Transformation in Transmission Line Analysis, Conformal-Mapping Equations for Planar Transmission Lines. *Variational Methods*: Variational Expressions for the Capacitance per Unit Length of Transmission Lines, Determination of Characteristic Parameters (C, $Z_{0,}$ ϵ_{eff}), Formulation of Variational Methods in the Space Domain, Variational Methods in the Spectral Domain.	**8**
Module -4: **Planar Transmission Line Analysis & Design -II** *Spectral-Domain Method*: Galerkin's Method, Formulation of the Quasi-static Spectral-Domain Analysis, Formulation of the Dynamic Spectral-Domain Analysis. *Mode-Matching Method*: Mode-Matching Analysis of Planar Transmission lines, Mode-Matching Analysis of Discontinuities, Single-Step Discontinuity, Multiple-Step Discontinuity.	**8**
Module -5: **Coupled Lines Analysis & Design:** Physics of Coupling, Low-Frequency Capacitance Model of Coupled, Formulas for Characteristic Impedance of Coupled Microstrip Lines, Terminated Coupled Lines, Differential and Common Modes, Common Impedance Coupling.	**8**

Books recommended:

TEXT BOOK:

1. Analysis Methods for RF, Microwave, and Millimeter-Wave Planar Transmission Line Structures, CAM NGUYEN, JOHN WILEY & SONS, INC
2. Microwave and RF Design Transmission Lines Volume 2, Third Edition, Michael Steer, 2019, NC State University Press
3. Microwave Integrated circuits, K.C. Gupta.

REFERENCE BOOK:

1. Micro strip lines and Slot lines, Third edition, I. Bahl, M. Bozzi, R. Garg, Artech House
2. Microwave Devices & Circuits 3/e, Samuel Y. Liao.
3. Microwave Integrated circuits. By lvan Kneppo, J Fabian, P. Bezousek
4. Millimeter wave Integrated Circuit by E. Carey and S. Lidholm, Springer, 2005

COURSE INFORMATION SHEET

Microwave Semiconductor devices

Course code: EC547
Course title: Microwave Semiconductor devices
Pre-requisite(s): EC201 Electronics Devices
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II / V
Branch: ECE
SPECIALIZATION: Microwave Engineering &VLSI Design and Embedded System
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understand the Material Properties of Semiconductors.
2.	Grasp the principle of operation of Microwave BJTs, HBTs, and Tunnel Diodes and apply the same.
3.	Appraise and analyse the characteristics of Microwave Field Effect Transistors.
4.	Evaluate the characteristics of Transferred Electron Devices (TEDs).
5.	Comprehend the characteristics of Avalanche Transit-Time Devices and create their structures.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Describe and illustrate the Material Properties of Semiconductors.
CO2	Sketch and explain the characteristics of Microwave BJTs, HBTs and Tunnel Diodes.
CO3	Illustrate with the sketch of the structure of Microwave Field Effect Transistors, diagram their characteristics and analyse them.
CO4	Appraise the principle of operation Transferred Electron Devices (TEDs), schematize their characteristics, assess and summarize their features.
CO5	Schematize the structure and design Avalanche Transit-Time Devices to observe high frequency response. Schematize their characteristics and prepare an inference.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Material Properties of Semiconductors:** Frequency range for semiconductor materials, Crystalline structure of Si, Strain of SiGe films grown on Si, Crystalline structure of GaAs, wafer orientation for semi-insulating GaAs, Orientation-dependent etching profiles of GaAs, Energy bandgaps of GaAs, Si, and Ge as a function of temperature, Electron velocity for Si, InP and GaAs, Relative dielectric constant of GaAs, Thermal conductivity of various materials, II-V heterostructures used for Microwave and RF Applications, Energy bandgap and associated lattice constants for II-V heterostructures, Double pulsed doped pseudomorphic HEMT layer structure, InP, SiC, GaN, Comparison of conventional and wide bandgap materials.	**8**
Module – II **Microwave Transistors and Tunnel Diodes:** Microwave Bipolar Transistors: Physical Structures, Bipolar Transistor Configurations, Principles of Operation, Amplification Phenomena, Power-Frequency Limitations; Heterojunction Bipolar Transistors (HBTs): Physical Structures, Operational Mechanism, Electronic Applications; Microwave Tunnel Diodes: Principles of Operation, Microwave Characteristics	**8**
Module – III **Microwave Field Effect Transistors:** Junction Field-Effect Transistors (JFETs): Physical Structure, Principles of Operation, Current-Voltage (1-V) Characteristics; Metal-Semiconductor Field-Effect Transistors (MESFETs): Physical Structures, Principles of Operation, Small-Signal Equivalent Circuit, Drain Current Id, Cutoff Frequency f_{co} and Maximum Oscillation Frequency f_{max}; High Electron Mobility Transistors (HEMTs): Physical Structure, Operational Mechanism, Performance Characteristics, Electronic Applications; Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs): Physical Structure, Electronic Mechanism, Modes of Operation, Drain Current and Transconductance, Maximum Operating Frequency, Electronic Applications.	**8**
Module – IV **Transferred Electron Devices (TEDs):** Gunn-Effect Diodes-GaAs Diode: Background, Gunn Effect; Ridley-Watkins--Hilsum (RWH) Theory: Differential Negative Resistance, Two-Valley Model Theory, High-Field Domain; Modes of Operation: Gunn Oscillation Modes, Limited-Space-Charge Accumulation (LSA) Mode, Stable Amplification Mode; LSA Diodes, InP Diodes, CdTe Diodes; Microwave Generation and Amplification	**8**

Module – V **Avalanche Transit-Time Devices:** Read Diode: Physical Description, Avalanche Multiplication, Carrier Current I_0(t) and External Current I_e(t), Output Power and Quality Factor Q; IMPATT Diodes: Physical Structures, Negative Resistance, Power Output and Efficiency; TRAPATT Diodes: Physical Structures, Principles of Operation, Power Output and Efficiency; BARITT Diodes: Physical Description, Principles of Operation, Microwave Performance; Parametric Devices: Physical Structures, Applications.	**8**

Books recommended:

Textbooks:

1. Mike Golio, The RF and Microwave Handbook, 2e, CRC Press, 2008.
2. Samuel Y. Liao, Microwave Devices and Circuits, 3e, Prentice-Hall of India, 2003.

Reference books:

1. S. M. Sze, Kwok K. Ng, Physics of Semiconductor Devices, 3e, Wiley-Interscience, 2006.
2. Stephen A. Campbell, The Science and Engineering of Microelectronic Fabrication, 2/e, Oxford University Press, 2001.
3. I. A. Glover, S. R. Pennock and P. R. Shepherd, Microwave Devices, Circuits and Subsystems for Communications Engineering, John Wiley & Sons, 2005.
4. C. Y. Chang & F. Kai, "GaAs High Speed Devices: Physics, Technology, and Circuit Applications", Wiley, NY 1994.
5. Michael Shur, Michael Shur, Paul Maki, "Advanced High-Speed Devices", World Scientific Publishing Company, 2009.

COURSE INFORMATION SHEET

Electromagnetic Interference and Electromagnetic Compatibility

Course Code: EC548
Course Title: Electromagnetic Interference and Electromagnetic Compatibility
Pre-requisite(s): Electromagnetic Theory
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II / 5
Branch: ECE
SPECIALIZATION: All

Name of Teacher:

Course Objectives: This course enables the students to

A.	Explain requirement of EMI & EMC concept and impart knowledge on different units and standards used for Electromagnetic compatibility in electronic/electric system.
B.	Develop an ability to analyse, measure and evaluate the radiated and conducted emissions to examine the compatibility.
C.	Develop an ability to analyse and evaluate the impact of EMI mitigation techniques such as shielding and grounding.
D.	Develop an ability to explain the impact of EMI on system design.
E.	Review the literature related to EMI & EMC to report it ethically.

Course Outcomes

After the completion of this course, students will be able to:

1.	Explain the requirement of EMI & EMC concept and impart knowledge on different units and standards used for Electromagnetic compatibility in electronic/electric system.
2.	Analyse, measure and evaluate radiated and conducted emissions to examine the electromagnetic compatibility.
3.	Analyse and evaluate the impact of EMI mitigation techniques such as shielding and grounding.
4.	Explain the impact of EMI on system design.
5.	Review and write the literature related to EMI & EMC to report it ethically.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1: Introduction A brief history of EMI/EMC, Analysis of EMI, Type of Noise and Interference, Electromagnetic Compatibility, Radiated Emission and susceptibility, Conducted Emission and Susceptibility, Benefits of good EMC Design, Brief description of EMC	

regulations, Examples of EMC related problems. EMC requirements for Electronic Systems: Government regulations, Requirement for Commercial products and Military products, Radiated Emission limits for Class A, Class B, FCC and CISPR, measurement of Emissions for verification of compliance: Radiated Emission and Conducted Emissions, Typical product emissions, Additional product requirements, design constraints for products, Advantages of EMC Design.	**8**
Module 2: Conducted Emission and Susceptibility Measurement of Conducted emission: LISN, Common and Differential mode currents, Power supply filters: Basic properties of filters, A generic power supply filter topology, Effect of filter elements on common and differential mode currents, Separation of conducted emissions into common and differential mode components for diagnostic purpose, Power supplies: Linear and SMPS, Effect of Power Supply Components on Conducted emissions, Power Supply and Filter placement, Conducted Susceptibility.	**8**
Module 3: Radiated Emission and Susceptibility Simple Emission models for wires and PCB lands: Differential mode versus Common mode currents, Differential mode current emission model Common mode current emission model, Current probes, Simple susceptibility models for wires and PCB lands: Shielded cables and surface transfer impedance.	**8**
Module 4: Cross talk Three conductor transmission lines and crosstalk, Transmission line equations for lossless lines, The per unit length parameters: Homogeneous versus Inhomogeneous media, Wide separation approximation for wires, Numerical methods for other structures, The Inductive-Capacitive Coupling Approximation model: Frequency domain Inductive-Capacitive coupling model, Time domain Inductive-Capacitive coupling model, Lumped circuit approximate models. Shielded Wires: Per unit length parameters, Inductive and Capacitive Coupling, Effect of Shield grounding, Effect of pigtails, Effects of Multiple shields, MTL model predictions, Twisted wires: Per unit length parameters, Inductive and Capacitive Coupling, Effects of Twist, Effects of Balancing.	**8**
Module 5: Shielding Shielding Effectiveness, Far field Sources: Exact solution, Approximate solution, Near field sources: Near field versus far field, Electric sources, Magnetic sources, Low frequency, magnetic field shielding, Effect of Apertures. System Design for EMC: Shielding and Grounding, PCB Design, System configuration and design, Electrostatic Discharge, Diagnostic tools.	**8**

TEXTBOOKS:

1. Paul, C., Introduction to Electromagnetic Compatibility, John Wiley & Sons, 1992.

REFERENCE BOOKS:

1. Ott, W. Henry, Electromagnetic Compatibility Engineering, John Wiley & Sons, 2009.
2. Satellite Communications Systems Engineering, Pearson Education, 2/e; 2003 W.L. 3. Prichard, H.G. Suyderhoud and R.A. Nelson
3. Satellite Communications Systems: systems, techniques and technology, 6th edition, by G. Maral, M.Bousquet, Z.Sun,Publisher: John Willy and sons

COURSE INFORMATION SHEET

Electromagnetic and Microwave Applications of Metamaterials

Course code: EC549
Course title: **Electromagnetic and Microwave Applications of Metamaterials**
Pre-requisite(s): Electromagnetic Theory and Microwave Engineering
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE
SPECIALIZATION: Microwave Engineering

Course Objectives: This course enables the students to:

1	To develop an ability to understand about left-handed metamaterial and its characteristics and properties
2	To develop an ability to analyse the physical realization of left-handed metamaterials using the resonant approach.
3	To develop an ability to analyse the physical realization of left-handed metamaterials using the non-resonant approach
4	To develop and ability to understand the guided-wave applications of left-handed metamaterials
5	To develop and ability to understand the radiated-wave applications of left-handed metamaterials

Course Outcomes:

After the completion of this course, a student will be able to:

CO1.	Demonstrate understanding of left-handed metamaterial and its characteristics and properties
CO2.	Have an ability to design the left-handed metamaterials using the resonant approach.
CO3.	Have an ability to design the left-handed metamaterials using the non-resonant approach
CO4.	Demonstrate insight the guided-wave applications of left-handed metamaterials.
CO5.	Demonstrate insight the radiated-wave applications of left-handed metamaterials.

Syllabus

MODULE	(NO. OF LECTURE HOURS)
Module 1: Introduction to Metamaterials Definition of Metamaterials and left-handed Metamaterials. Theoretical speculation by Viktor Veselago**.** Wave Propagation in Left-Handed Media, Energy Density and Group Velocity, Negative Refraction, Fermat Principle, Inverse Doppler Effect, Backward Cerenkov Radiation, Negative Goos–Hanchen Shift, Waves at interfaces, Waves through left-handed slabs, Phase Compensation and Amplification of Evanescent Modes, Perfect Tunnelling, The Perfect Lens, Losses, and Dispersion.	**8**
Module 2: Realization of Metamaterials using Resonant Approach Scaling Plasmas at Microwave Frequencies, Metallic Waveguides and Plates as One- and Two-Dimensional Plasmas, Wire Media, Spatial Dispersion in Wire Media, Synthesis of Negative Magnetic Permeability, Design and Analysis of the Edge and Broad Coupled SRR, The Double and Multiple Split SRR, Spirals Resonators, Higher-Order Resonances in SRRs, Isotropic SRRs, Scaling Down SRRs to Infrared and Optical Frequencies , 1/2/3 Dimensional SRR-Based Left-Handed Metamaterials, Ferrite Metamaterials, Chiral Metamaterials.	**8**
Module 3: Realization of Metamaterials using Non-Resonant Approach Ideal homogeneous CRLH TLs, Fundamental TL Characteristics, Equivalent MTM Constitutive Parameters, Balanced and Unbalanced Resonances, lossy CRLH TL model, LC Network Implementation, Difference with Conventional Filters, Transmission Matrix Analysis, Input Impedance, Cutoff Frequencies, Analytical Dispersion Relation, Bloch Impedance, Real Distributed 1D CRLH Structures, General Design Guidelines, Microstrip Implementation, Parameters Extraction.	**8**
Module 4: Guided-Waves Applications of Metamaterials Dual-Band Components, Dual-Band Property of CRLH TLs, Quarter-Wavelength TL and Stubs, Quadrature Hybrid and Wilkinson Power Divider, Enhanced-Bandwidth Components, Principle of Bandwidth Enhancement, Rat-Race Coupler, Tight Edge-Coupled Coupled-Line Couplers, Generalities on Coupled-Line Couplers, Symmetric Impedance Coupler, Asymmetric Phase Coupler, Negative and Zeroth-Order Resonator. SRRs based Filters and Diplexers Design.	**8**
Module 5: Radiated-Wave Applications of Metamaterials: Fundamental aspects of Leaky-Wave Structures, Principle of Leakage Radiation, Uniform and Periodic LW Structures, Backfire-to-Endfire (BE) leaky-wave (LW) antenna, electronically scanned LW antenna, Passive Retro-Directive Reflector, Two-Dimensional LW Radiation, Conical-Beam Antenna, Full-Space Scanning Antenna, Zeroth Order Resonating Antenna, Dual-Band CRLH-TL Resonating Ring Antenna, Heterodyne Phased Array, Non-uniform Leaky-Wave Radiator, The Future of MTMs.	**8**

TEXTBOOKS:

1. Metamaterials with Negative Parameters, Theory, Design and Microwave Applications by Ricardo Marques, Ferran Martin, and Mario Sorolla "Wiley Series in Microwave and Optical Engineering, Wiley Interscinces 2007" (T1)
2. Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications, The Engineering Approach," Christophe Caloz and Tatsuo Itoh, John Wiley & Sons, Inc., Hoboken, New Jersey 2006. (T2)

REFERENCE BOOKS:

1. Foundations for Microwave Engineering; Second Edition; By Robert E. Collin; McGraw Hill International Edition; 1992. (R1)
2. Microwave Engineering; Second Edition; by David M. Pozar; John Wiley & Sons; Inc. Copyright 2001. (R2)

COURSE INFORMATION SHEET

Antennas and Diversity

Course Code: EC550
Course Title: Antennas and Diversity
Pre-requisite(s): Electromagnetic Theory
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: 2/5
Branch: ECE
SPECIALIZATION: Microwave Engineering

Name of Teacher: Vibha Rani Gupta

Course Objectives

This course envisions to impact to students to:

1.	Develop and apply the mathematical tools to analyze radiation characteristics of aperture antennas.
2.	Design and analyze various broadband, high gain, planar antennas
3.	Design of antennas for high frequency applications.
4.	Summarize cellular radio system and its evolution and diversity schemes in wireless communication.
5.	Describe smart antenna and algorithms

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Develop the mathematical model to analyse radiation characteristics of antennas for wireless applications.
CO2	Apply the mathematical models in the design and analysis of antennas.
CO3	Design various types of antennas for wireless communication applications.
CO4	Characterize and compare various diversity and combining techniques.
CO5	Describe smart antennas and algorithms.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Radiation Equations, Rectangular Apertures: Uniform Distribution on an infinite ground plane, Uniform distribution in Space, Circular Apertures: Uniform Distribution on an infinite ground plane, Design Considerations.	**8**
Module – II Antennas for Wireless Communication: Horn Antenna - E-Plane, H-Plane, Pyramidal horn, Microstrip antenna – Basic Characteristics, Feeding Methods, Method of analysis, Transmission line model and cavity model for rectangular patch antenna, Circular Patch Antenna.	**8**
Module – III Dielectric Resonator Antenna: Introduction to Dielectric Resonator Antennas. Major Characteristics, Simple-Shaped Dielectric Resonator Antennas - The Hemispherical DRA. The Cylindrical DRA. The Rectangular DRA, Coupling to DRAs, Hybrid DRAs Bandwidth Enhancement of DRAs, Low Profile and Compact DRAs, DRAs with High Dielectric Constants, Circular-Polarized and Dual-Polarized DRAs	**8**
Module – IV Cellular Radio Systems Evolution, Signal propagation, Diversity Schemes: Macroscopic diversity scheme, Microscopic diversity scheme – Space diversity, Field diversity, Polarization diversity, Angle diversity, Frequency diversity and time diversity scheme. Combining techniques for Macroscopic diversity, Combining techniques for Microscopic diversity	**8**
Module – V Smart Antenna: Introduction, Smart Antenna System, Benefits and drawbacks of Smart Antennas, Antenna beamforming: Overview of Direction-Of-Arrival (DOA) Algorithms, Adaptive Beamforming, Mutual Coupling, Optimal Beamforming Techniques.	**8**

Textbooks:

1. Antenna Theory, Analysis and Design, 3/E, A. Balanis, John Wiley.
2. Microstrip and Printed Antennas: New Trends, Techniques and Applications 1st Edition, Kindle Edition by Debatosh Guha (Editor), Yahia M.M. Antar (Editor)
3. Wireless Communications, Principles and Practices, Rappaport, PHI

Reference books:

1. Antennas, J. D. Kraus, TMH
2. Dielectric Resonator Antenna Handbook, Aldo Petosa, ARTECH House.
3. Software Radio A Modern Approach to Radio Engineering, J. H. Reed, Pearson Education.
4. Wireless and Cellular Communications, William C. Y. Lee, McGraw-Hill.
5. Mobile Communications Design Fundamentals, William C. Y. Lee, McGraw-Hill.
6. Smart Antenna, T. K. Sarkar.

COURSE INFORMATION SHEET

RF Microelectronics Circuit Design

Course Code: EC551
Course Title: RF Microelectronics Circuit Design

Pre-requisite(s): EC201 Electronic Devices, EC253 Analog Circuits
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: M.Tech. in VLSI Design and Embedded System
Name of Teacher:
Course Objectives
This course envisions to impact to students to:

1.	Understand RF frequency response of MOSFET.
2.	Grasp the RF technology and basic concepts in RF design.
3.	Apprehend Communication concepts and transceiver architectures.
4.	Perceive Basic blocks in RF systems such as LNA, Mixer and VCO and their VLSI implementations.
5.	Comprehend Radio Frequency Synthesizers and Power Amplifiers.

Course Outcomes
After the completion of this course, a student will be able to:

CO1	Interpret RF frequency response of MOSFET.
CO2	Articulate the RF technology and basic concepts in RF design.
CO3	Explain communication concepts in transceiver architectures.
CO4	Appraise basic blocks in RF systems such as LNA, Mixer and VCO
CO5	Design basic blocks in RF systems such as RF Synthesizer and Power Amplifiers

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **RF frequency response of MOSFET:** Derivation and estimation of MOS capacitor, MOS capacitor in cutoff, linear and saturation region, derivation and estimation of MOSFET's long-channel model including threshold voltage, body effect, transconductance (g_m), output conductance (g_{ds}), small-signal output resistance (r_o), A Medium-Frequency Small-Signal Model for	**8**

the Intrinsic Part, Intrinsic Transition Frequency, High frequency Small-Signal Model, Transition Frequency (f_T) and Maximum oscillation (f_{max}) of MOSFET.	
Module – II **RF technology and basic concepts in RF design:** Introduction to RF and Wireless Technology: Challenges in RF Design, Complexity Comparison, Design Bottleneck, Applications, Choice of Technology; Basic concepts in RF Design: Units in RF Design, Time Variance, Nonlinearity, Effects of nonlinearity; Noise as Random Process, effect of transfer function on noise, device Noise, Representation of Noise in Circuits. Sensitivity and Dynamic Range.	**8**
Module – III **Communication concepts and transceiver architectures:** Analog modulation, Digital modulation, Spectral Regrowth, Mobile RF Communications, Multiple Access techniques Wireless standards; **Receiver Architectures**: Basic Heterodyne Receivers, Modern Heterodyne Receivers, Direct-Conversion Receivers, Image Reject Receivers, Low-IF Receivers; **Transmitter Architectures**: Direct-Conversion Transmitters, Modern Direct-Conversion Transmitters, Heterodyne Transmitters.	**8**
Module – IV **Basic blocks in RF systems and their VLSI implementation:** **Low Noise Amplifier**: General considerations, Problem of input matching, Basic LNA Topologies. **Mixers**: General Considerations, Active Down-conversion Mixers. **Oscillators**: Performance Parameters, Voltage-Controlled Oscillators (VCOs).	**8**
Module – V **Radio Frequency Synthesizer and Power Amplifiers:** **Phase-locked loops**: Basic concepts, Type-I PLLs, Type-II PLLs (Phase/Frequency detectors, Charge-pump PLLs). **Radio Frequency Synthesizes**: General considerations, Basic integer-N synthesizer, Basic concepts of fractional-N synthesizers. **Power Amplifiers**: General Considerations, Classification of Power Amplifiers, High-Efficiency Power Amplifiers.	**8**

Textbooks:

4. John W. M. Rogers, Calvin Plett, Radio Frequency Integrated Circuit Design, Artech House, 2010.
5. Yannis Tsividis, Colin McAndrew, Operation and Modeling of MOS Transistor, Oxford University Press, 3rd edition, 2011.
6. Behzad Razavi, RF Microelectronics, 2e, Prentice Hall, 2011

Reference books:

3. Samuel Y. Liao, Microwave Devices and Circuits, 3e, Prentice-Hall of India, 2003.
4. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis and Roberst G. Meyer, Analysis and Design of Analog Integrated Circuits, 5/e, Wiley, 2009.
5. The Design of CMOS Radio-Frequency Integrated Circuits by Thomas H. Lee. Cambridge University Press, 2004.

COURSE INFORMATION SHEET

Radar Signal Processing

Course Code: EC552
Course Title: Radar Signal Processing
Pre-requisite(s): Microwave Engineering
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Microwave Engineering

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	To appraise an overview of Radar Systems.
2.	To perceive the Target Detection, Pulse Integration and Pulse Compression
3.	To grasp Matched Filter and Ambiguity Function-Analog and Discrete Coded Waveforms.
4.	To understand the concept of Radar Clutter.
5.	To grasp the Doppler and Adaptive Array Processing

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Able to explain the Radar Systems.
CO2	Able to demonstrate Target Detection, Pulse Integration and Pulse Compression
CO3	Able to explain Matched filter and Ambiguity Function-Analog and Discrete Coded Waveforms
CO4	Able to demonstrate the Radar Clutter
CO5	Able to explain Doppler and Adaptive Array Processing

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Radar Systems (an overview)** The Radar Equation, Surveillance Radar Equation, Range Measurements, Doppler effects, Radar Cross Section, Radar Equation with Jamming, Effects of the Earth's Surface on the Radar Equation, Noise Figure, Atmospheric Attenuation.	**8**
Module – II **Target Detection, Pulse Integration and Pulse Compression** Target Detection in the Presence of Noise, Probability of False Alarm, Probability of Detection, Pulse Integration, Computation of the Fluctuation Loss, Cumulative Probability of Detection, Constant False Alarm Rate (CFAR), Time-Bandwidth Product, Pulse Compression, Correlator.	**8**
Module – III **Matched Filter and Ambiguity Function** Principle of Matched Filtering, Radar Signal Resolution and Ambiguity, Range and Doppler Uncertainty, Target Parameter Estimation, Ambiguity Function, Nonlinear FM Ambiguity Diagram Contours, Interpretation of Range-Doppler Coupling, Pulse-Train Codes, Ambiguity Plots for Discrete Coded Waveforms.	**8**
Module – IV **Radar Clutter** Clutter, Surface Clutter, Volume Clutter, Clutter RCS, Moving Target Indicator (MTI), PRF Staggering, Delay Line Cancelers with Optimal Weights.	**8**
Module – V **Doppler and Adaptive Array Processing** Digital Doppler processing, Arrays, Adaptive Beamforming Nonadaptive Beamforming, Adaptive Array Processing.	**8**

TEXTBOOKS:

1. Bassem R. Mahafza, Radar Signal Analysis and Processing Using MATLAB, Chapman and Hall/CRC, 2008.

REFERENCE BOOKS:

1. M.I. Skolnik, "Introduction to Radar Systems", 3/e, TMH, New Delhi, 2001
2. Nathanson, F. E., Radar Design Principles, New York, McGraw-Hill, 2nd Edition, 1991
3. Toomay, J. C., Radar Principles for the Non-Specialist, New York, Van Nostrand, Reinhold, 1989
4. Buderi R., The Invention That Changed the World, New York, Simon and Schuster, 1996
5. R.J Sullivan, Radar foundation for imaging & advanced concepts, PHI, 2004.
6. Mark A Richards, Fundamentals of Radar Signal Processing,McGrah -Hill Company, 2005

COURSE INFORMATION SHEET

Microwave Photonics

Course code: EC553
Course title: Microwave Photonics
Pre-requisite(s): Microwave Theory &Techniques, Optoelectronics Devices
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE
SPECIALIZATION: Microwave Engineering

Name of Teacher:
Course Objectives: This course enables the students

A.	To understand the basic concepts of microwave photonics
B.	To understand the characteristics of the components of microwave photonic system
C.	To understand the concepts of photonic processing of RF signal
D.	To understand the design aspects of microwave fibre optic link, and application of microwave photonics in sensing and imaging

Course Outcomes:

After the completion of this course, students will be:

1.	To explain the key properties of microwave photonics
2.	To explain the key characteristics of microwave photonic components
3.	To explain the photonic processing of RF signal
4.	To design the microwave fiber optic link for RF over fiber
5.	To design the microwave photonics system for terahertz sensing and imaging applications

Syllabus

MODULE	(NO. OF LECTURE HOURS)
Module 1: Basic concepts of microwave photonics Microwave link architecture, E/O conversion, External modulation, O/E conversion, Photodetection, O/O components, Signal transport and signal generation, Signal processing, Radio over fibre.	**8**
Module 2: Microwave photonics components Fast lasers sources, Tunable sources, Mode locked microchip lasers, Fast modulators, Electro-absorption modulators and photo-oscillators, High speed photodetectors, Travelling wave (TW) photodetector, GaAs MESFET Optical Detector, HBT phototransistor for optic/ millimeter-wave converter.	**8**
Module 3: Microwave photonics signal processing (MWPSP) Fundamental concepts and limitations, Optical sources of performance limitation, Electrical sources of performance limitation, Incoherent MWPSP, Fibre delay line filters, Bragg grating delay line filter, Incoherent RF optical filter.	**8**
Module 4: Microwave Fibre-Optic link design Requirements, Modulation techniques, Interfacing, Intrinsic link gain performance, Signal to noise performance, Link dynamic range, Fibre Radio systems, RF over fibre, IF over fibre, Baseband over fibre, WDM in fibre radio system, Optical Control of Phased Array antenna, Multi-Beam Photonic Array Feed antenna.	**8**
Module 5: Terahertz sensing techniques Pulsed and Continuous wave system, Time domain spectroscopic system, Explosive identification, Terahertz imaging techniques, Passive and active imaging, CCD-based two-dimensional imaging, Space shuttle foam inspection, Tomography.	**8**

TEXTBOOKS:

1. Stavros Iezekiel, “Microwave photonics: Devices and applications”, IEEE Press, Willey,2009.
2. Anne Vilcot, Béatrice Cabon & Jean Chazelas, MICROWAVE PHOTONICS: From Components to Applications and Systems, Kluwer academic publishers.

REFERENCE BOOK:

1. Vincent J. Urick Jr, Jason D. McKinney, Keith J.Williams, Fundamentals of Microwave photonics, Willey Press.
2. Chi H. Lee, Microwave photonics, CRC Press
3. Anne Vilcot, MICROWAVE PHOTONICS: From Components to Applications and Systems, Kluwer academic publishers.

COURSE INFORMATION SHEET

Microwave measurement and Material Characterization

Course code: **EC554**
Course title: **Microwave Measurement and Material Characterization**
Pre-requisite(s): Microwave Theory &Techniques, Electromagnetic Fields and Waves

Co- requisite(s):
Credits: **L:3 T:0 P:0 C:3**
Class schedule per week: 3
Class: **M. Tech.**

Semester / Level: **II / V**
Branch: ECE

SPECIALIZATION: Microwave Engineering

Name of Teacher:

Course Objectives

This course enables the students:

A.	To understand the general properties of electromagnetic materials and their underlying physics at microwave frequency
B.	To provide the principles of various microwave methods for material characterization.

Course Outcomes

After the completion of this course, students will be able:

1.	To discuss the parameters describing the electromagnetic properties of materials at microscopic and macroscopic scales.
2.	To categorize electromagnetic materials.
3.	To identify suitable method for material characterization.
4.	To apply various methods to characterize materials at microwave frequencies.
5.	Acquire the capability to modify basic material characterization techniques.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1: Electromagnetic Properties of Materials: Materials Research and Engineering at Microwave Frequencies, Physics for Electromagnetic Materials, General Properties of Electromagnetic Materials**.**	**8**
Module 2: Reflection and Transmission/ Reflection Methods Introduction, Coaxial-Line Reflection Method, Free-Space Reflection Method, Measurement of Both Permittivity and Permeability Using Reflection Methods. Transmission/Reflection: Working Principle of Transmission/Reflection Methods, NRW algorithm Coaxial Air-Line Method, Hollow Metallic Waveguide Method, Free-Space Method**.**	**8**
Module 3: Resonator Methods Introduction, Dielectric Resonator Methods, Coaxial Surface-Wave Resonator Methods, Split-Resonator Method, Dielectric Resonator Methods.	**8**
Module 4: Resonant Perturbation Methods Basic Theory, Cavity-Perturbation Method, Dielectric Resonator Perturbation Method, Measurement of Surface Impedance.	**8**
Module -5: Planar-Circuit Methods Introduction, Stripline Methods, Microstrip Methods, Coplanar-Line Methods.	**8**

TEXTBOOK:

1. Microwave Electronics: Measurement and Materials Characterization, L. F. Chen, C. K. Ong, C. P. Neo, V. V. Varadan, Vijay K. Varadan, John Wiley , ISBN: 978-0-470-84492-2

COURSE INFORMATION SHEET

Applied Industrial Instrumentation

Course Code: EC561
Course Title: Applied Industrial Instrumentation
Pre-requisite(s): Electronic Measurement, Sensor and Transducer
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Instrumentation

Name of Teacher:

Course Objectives:
This course enables the students:

A.	Explain the role of instrumentation in Industrial Automation and Control
B.	To classify the various control schemes used in industry for process control
C.	To discuss the working of PLC and CNC machines for controlling various Industrial processes
D.	To outline the construction and working of commonly used Actuators and Final Control Elements in industry.
E.	To state and outline the networking of sensors and actuators.

Course Outcomes:
After the completion of this course, students will be:

CO1	Explain the role of various instruments used in process industry.
CO2	Analyze the select suitable control scheme for controlling a given process.
CO3	Demonstrate the working of PLC and CNC machines.
CO4	Will be able to suggest the suitable actuator and valve for give control action.
CO5	Architect and design networking of sensors and actuators on field bus

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module -1: **Industrial Instrumentation:** Introduction to Industrial Automation and Control, Architecture, Sensors for Industrial measurement, Measurement of Temperature, Pressure, Force, Displacement, Speed, Flow, Level, Humidity and PH. Signal conditioning and processing, Estimation of Errors and Calibration.	**8**
Process Control: On /off control, PID control**,** Controller Tuning, Implementation of PID Controllers, feed forward control, ratio control, Predictive Control, Control of Systems with Inverse Response, Cascade Control, Overriding Control, Selective Control, Split Range Control	**8**
Module -3: **Programmable Logic Controller:** Introduction to Sequence Control, PLCs and Relay Ladder Logic, PLC Architecture, Scan Cycle, Structured Design Approach, RLL syntax and programming. Hardware, CNC Machine tools.	**8**
Module -4: **Actuators and Final Control Elements:** Flow control valves, Hydraulic actuators, Pumps and Motors, Servo valves, Pneumatic controllers, Electric drives, DC motor drives, Induction motor drives, adjustable speed and servo drives.	**8**
Introduction to Field bus Network: Networking of sensors, Actuators and field bus, Communication protocol, Production control	**8**

TEXTBOOKS:

1. Industrial Instrumentation, Control and Automation, S. Mukhopadhyay, S. Sen and A.K. Deb, Jaico Publishing House
2. Electric Motor Drives, Modelling, Analysis and Control, R. Krishnan, Prentice Hall India,
3. Hydraulic Control Systems, Herbert E. Merritt, Wiley

REFERENCE BOOKS:

1. Process control Instrumentation Technology by CD Johnson, PHI Learning
2. D. M. Considine, Process/Industrial Instruments and Control Handbook, Fourth Edition, McGraw-Hill Inc., 1993.

COURSE INFORMATION SHEET

Advanced Instrumentation Lab

Course Code: EC562
Course Title: Advanced Instrumentation Lab
Pre-requisite(s):
Co-requisite(s):
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Instrumentation

Name of Teacher:

Course Objective: This course enables the students:

A.	To understand the basics of Instrumentation.
B.	To develop basic and advanced techniques in Instrumentation.
C.	To implement various basic Instrumentation and Virtual Instrumentation Devices.
D.	To develop Ladder diagram for different applications

Course Outcome: After the completion of this course, students will be able to:

CO1	Develop virtual instruments using LabVIEW
CO2	Use Data acquisition system with LabVIEW
CO3	Implement PLC for different applications
CO4	Use of automation studio for interfacing PLC
CO5	Use PLC for digital systems

Syllabus

Hands-on experiments related to the course:

List of experiments

Experiment No.	Name of the Experiments
1.	Logic gates implementation using case structure in LabVIEW.
2.	Implementation of mathematical operations using Maths block in LabVIEW.
3.	Design of function generator and CRO using case structure and for-loop in LabVIEW.
4.	To blink LED externally using myRIO DAC card and LabVIEW.
5.	To interface a seven-segment LED with myRIO in LabVIEW.
6.	To implement a servo feedback control system using myRIO in LabVIEW.
7.	To implement an IR range finder in the range of 0 cm and 80 cm using myRIO in LabVIEW.
8.	To implement a sonic range finder with maximum range of 6m using myRIO in LabVIEW.
9.	Use of automation studio for interfacing PLC
10.	Study of Application of automation studio
11.	Logic-gate simulation using PLC.
12.	Drink dispenser simulation using PLC

Text Books:

1. Computer Based Industrial Control – By Krishna Kant, PHI
2. Process Control Instrumentation – By Curtis D. Johnson, Pearson Education
3. National Instruments LabVIEW manual.

Reference Books:

1. "Principle of Industrial Instrumentation" By D. Patranabis, TMH publications
2. High performance Instrumentation and Automation, CRC Press, Taylor & Francis Group, 2005

COURSE INFORMATION SHEET

Process Control

Course Code: **EC563**
Course Title: Process Control
Pre-requisite(s): Control Theory, Electronics Measurement
Co-requisite(s):
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Instrumentation
Name of Teacher:

Course Objectives:
This course enables the students:

A.	To develop the mathematical model of the physical system
B.	To analyze the interdependency of multivariable controller.
C.	To design a controller for practical systems under different condition
D.	Explain the different processes involved in power generation

Course Outcomes:
After the completion of this course, students will be:

CO1	Analyze a physical system and develop the mathematical model of the physical system
CO2	Design a controller for practical systems under different condition.
CO3	Understand the operation of different complex control schemes.
CO4	Implement Plant wide control and Model predictive control
CO5	Understand the need of process control in different plants and industries

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module -1: Introduction Introduction to process control, Examples of surge tank, shower, Use of instrumentation in Process control, Process model and dynamic behaviour. Reason of modelling, Lumped parameter system models, Balanced equation, Material balances, Form of dynamic model.	**8**
Module -2: Design of Controller Closed loop controller design procedure. PID controller, tuning of PID controller. Internal model control: Introduction to model control, Static control law, Dynamic control law, Practical open loop controller design, Generation of open-loop controller design procedure, model uncertainty and disturbances.	**8**
Module -3: Complex Control Schemes Complex control schemes: Background, Introduction to cascade control, cascade control analysis and design, feed forward control, feed forward control design, examples of feed forward control. Ratio control, selective and override control, split -range control. Multivariable control, general pairing problem, Steady state effective gain, Relative Gain Array (RGA), Properties and application of RGA, Use of RGA to determine variable pairing.	**8**
Module -4: Plant wide control and Model predictive control Steady state and dynamic effect of recycle, compressor control, Heat exchanger, the control and optimisation hierarchy. Optimisation problem, dynamics matrix control (DMC).	**8**
Module -5: Application of Process Control Application of process control in thermal power plant: Process of power generation in coal –fired and oil-fired thermal power plants, types of boilers, Combustion process, Super heater, Turbine. Application of process control in Petrochemical Industries: Introduction to Refinery and Petrochemical processes, Control of distillation column, Catalytic cracking unit, Catalytic reformer, Pyrolysis unit, Automatic Control of polyethylene production, Control of vinyl chloride and PVC production.	**8**

Text Books:

1. . "Process control: Modelling Design and simulation" By B.Wayne Bequette,

Reference Books:

1. "Principle of Industrial Instrumentation" By D. Patranabis, TMH publications
2. "Principles of Process Control" By D. Patranabis, TMH publication
3. "Power plant performance " By A. B. Gill, Elsevier, India, New Delhi.
4. J.G. Balchan. and K.I. Mumme, 'Process Control Structures and Applications', Van Nostrand Reinhold Company, New York, 1988.

COURSE INFORMATION SHEET
Advanced Digital Signal Processing

Course Code: EC565
Course Title: Advanced Digital Signal Processing
Pre-requisite(s): Signal Processing Techniques
Co-requisite(s):
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Instrumentation
Name of Teacher:

Course Objectives:

This course enables the students to:

1	Understand the concept of signals and systems and filters.
2	Impart knowledge on various transformation techniques.
3	Impart knowledge on multirate signal processing and its applications.
4	Understanding on optimum linear filters and power spectral estimation.

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

CO1	Develop an understanding to concept of signals and systems and to design filters.
CO2	Have an ability to analyze and apply various single and multi-domain transformation techniques.
CO3	Have an ability to apply multirate signal processing on various engineering applications.
CO4	Develop an ability to apply use optimum linear filters and power spectral estimation.
CO5	Estimate the power spectrum using Parametric and Nonparametric methods.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1 Review of Signals and Systems, Sampling and data reconstruction processes, Z transforms. Chirp Z Algorithm, Goertzel's Algorithm, Discrete linear systems, Digital filter design and structures: Basic FIR/IIR filter design &structures, design techniques of linear phase FIR filters, IIR filters by impulse invariance, bilinear transformation, FIR/IIR Cascaded lattice structures.	**8**
Module 2 DSP Transforms: Fourier transform, Discrete sine and cosine transform, Discrete Hartely transform, short time Fourier transform, wavelet transform, Hilbert transform, Hilbert-Huang transform, Stockwell transform	**8**
Module 3 Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, QMF, digital filter banks, Multi resolution signal analysis, wavelet decomposition, Applications in subband coding.	**8**
Module 4 Linear prediction and Optimum Linear Filters: Random signals and power spectra, Forward and backward Linear prediction, solutions of the normal equations, AR lattice and ARMA lattice-ladder filters, Wiener filters.	**8**
Module 5 Power spectrum estimation: Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigenanalysis Algorithms for Spectrum Estimation.	**8**

Text Books:

1. J.G.Proakis and D.G.Manolakis"Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Prentice Hall, 2007.
2. N. J. Fliege, "Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets", 1st Edition, John Wiley and Sons Ltd, 1999.
3. D. G. Manolokis, V. K. Ingle and S. M. Kogar, "Statistical and Adaptive Signal Processing", Mc Graw Hill International Edition, 2000.
4. S. Haykin and T. Kailath, Adaptive Filter Theory, Pearson Education, 4th Edition, 2005.

Reference Books:

1. Digital Signal Processing 3/E by S.K.Mitra TMH Edition.
2. Fundamentals of adaptive filtering, A. H. Sayed, Wiley, 2003.
3. Monson H. Hayes, Statistical Digital Signal Processing and Modelling, Wiley, 2002

COURSE INFORMATION SHEET

Signal Processing and IoT Lab

Course code: EC566
Course Title: Signal Processing and IoT Lab
Pre-requisite(s):
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class periods per week: 04
Class: M. Tech.
Semester / Level:
Branch: ECE
SPECIALIZATION: Instrumentation

Name of Teacher:

Course Objectives

This course enables the students to:

1.	Demonstrate the digital filter design techniques.
2.	Apply the time-frequency techniques STFT and CWT.
3.	Understand the concept of multi-rate signal processing and spectral estimation.
4.	Demonstrate the knowledge of Internet of Things for various applications.
5.	Understand the IoT applications with cloud and its analytics.

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Design the filters and apply for various signal processing application.
CO2	Apply the time-frequency techniques STFT and CWT and analyse the signals in spectral domain.
CO3	Apply the multirate signal processing and signal modeling.
CO4	Apply the IoT knowledge with cloud and the analytics.
CO5	Use and apply the IoT set up for smart home applications and agricultural application.

Syllabus

Hands-on experiments related to the course:

Experiment No.	**Name of the Experiments**
1.	Realizing Convolution in FIR filter and Design LP/HP/BP FIR filter. AIM: Design the LP/ HP/ BP filter and apply in speech signal to realizing the filtering operation.
2.	Generate a synthetic non-stationary signal and find its time-frequency representation. AIM: apply the short-time Fourier transform and wavelet transform and analyze the time-frequency map.

3.	Implement the adaptive system as wiener filter. AIM: Implement the system identification using Least mean square (LMS) algorithm.
4.	Realize the multi-rate signal processing. AIM: Implement the decimation and interpolation on a synthetic signal. Look at it the power spectrum.
5.	Implement the linear prediction filter and power spectrum estimation. AIM: Modeling a signal using the AR/ARMA model and estimate the power spectrum.
6.	Interfacing Arduino Uno with Raspberry pi to acquire analog data for LED blinking operation using Raspberry-Pi and Speed Control of motors using PWM with python programming and Raspberry-Pi.
7.	Measure temperature, humidity, light in Arduino/ Tru-IoT setup. AIM: Sense the temperature and humidity variation using the sensor and display in an OLED display.
8.	Connect IoT devices through the cloud using IoT protocols such as MQTT. Create a Wireless network of sensors using Zigbee/ LoRaWAN.
9.	Measure the room temperature Over Internet With Cloud and perform the analytics. AIM: Sense the temperature and humidity in Tru-IoT setup and display in cloud and perform the forecasting.
10.	Actuation of light bulb based on light sensor in Tru-IoT setup. AIM: Light activated control circuits like Automatic HeadLight Dimmer, Automatic bedroom Lights, Automatic Rear view mirror etc. in home automation.
11.	Smart Agriculture Automation using Tru-IoT setup AIM: to measure the soil moisture and use a solenoid valve is controlling water flow for irrigation.
12.	Distance based servo motor control using Tru-IoT setup. AIM1: use the Ultrasonic Sensor to detect an object and based on the distance of the recognized object, rotate the Servo Motor.

Text Books:

1. J.G.Proakis and D.G.Manolakis"Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Prentice Hall, 2007. (T1)

2. N. J. Fliege, "Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets", 1st Edition, John Wiley and Sons Ltd, 1999.

Reference Books:

1- Tru-IoT Reference manual

COURSE INFORMATION SHEET
Optoelectronic Instrumentation

Course Code: **EC567**
Course Title: Optoelectronic Instrumentation
Pre-requisite(s): Fiber Optics Communication, Electronics Measurement
Co-requisite(s):
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Instrumentation

Name of Teacher:

Course Objectives:
This course enables the students:

A.	To provide knowledge about the optical sources and Detectors
B	To provide Knowledge about Fiber Optic Instrumentation and its application for various measurements
C.	To provide Knowledge about LASER and its different types with their industrial and medical application
D.	To provide Knowledge about the Holography and its applications.

Course Outcomes:
After the completion of this course, students will be:

CO1	Use optical sources and Detectors
CO2	Design optical interferometers, Photo-emissive cells
CO3	Gain Knowledge about Fiber Optic Instrumentation and its application for various measurements
CO4	Gain Knowledge about LASER and its different types with their industrial and medical applications
CO5	Gain Knowledge about the Holography and its applications.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module -1: Overview of Gaussian optics, Physical Optics, Fourier optics, optical sources, Heterojunction LED's and LASERS, semiconductor Lasers Optical interferometers, Mono-chromators, Photon detectors, Photo-emissive cells, LDR, Light Activated SCR, Heterostructure solar cell, noise statistics and accuracy of measurements, Statistical approach to measurements, inaccuracy of indirect measurements.	**8**
Module -2: Fiber optic instrumentation, Optocoupler, optoelectronic Isolator, Fiber-optic Pressure and flow sensors, optical current sensor, Fiber-optic Displacement sensor, Interferometric Fiber optic sensors, Mach-Zehnder, Michelson, Fabry-Perot sensor, fiber Bragg grating sensors for strain and temperature measurements, Distributed sensors based on Raleigh, Raman, Brillouin, Optical spectrum Analyser, Fiber-optic Endoscope.	**8**
Module -3: Principles of operation of Mode locking and Q switching in Lasers, Tunable lasers, Laser for Velocity Measurement. Angular Rotation Rate, Measurement of Product Dimension Measurement of Surface Finish Profile and Surface Position Measurement, Particle Diameter Measurement, Strain and Vibration Measurement, Defect Detection	**8**
Module -4: Laser Doppler Anemometry, Laser microscope, Raman Spectroscopy in Medicine, Laser Doppler vibrometer, Heterodyne measurements of Air drums, Laser Lithotripsy, Laser induces thermos therapy of brain cancer, Atmospheric measurements of Lidar, Medical Applications of Lasers: Laser and Tissue Interaction, Laser Instruments for Surgery	**8**
Module -5: Holographic recording and Reconstruction, Holography for Non–destructive Testing, Holographic Interferometry and applications, Double exposer Holography, Real time holography, Holographic vibrational Analysis, Morie pattern, Speckle pattern, Measurement of in plane and out of plane deformations,	**8**

Text Books:

3. Amar K. Ganguly., "Optical and optoelectronic Instrumentation" , Narosa Press, 2010
4. Dr. M N Avadhanulu & Dr. R S Hemne, An Introduction to Lasers- Theory and Applications, S. Chand.

Reference Book:

4. John F. Read, Industrial Applications of Lasers, Academic Press.
5. Keiser G., Optical Fiber Communication, McGraw-Hill.
6. John and Harry, Industrial Lasers and their Applications, Mc-Graw Hill, 1974.
7. Monte Ross, Laser Applications, McGraw-Hill

COURSE INFORMATION SHEET

Introduction to Internet of Things

Course Code: **EC568**
Course Title: Introduction to Internet of Things
Pre-requisite(s): Knowledge in Sensors, Microcontrollers, Communication Networks
Co-requisite(s):
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/ V
Branch: ECE
Specialization: Instrumentation/ VLSI Design & Embedded System

Name of Teacher:

Course Objectives:

1	To know the roles of IoT
2	To understand communication protocols for IoT
3	To know Data and Analytics for IoT
4	To learn programming for IoT
5	To know various applications of IoT

Course Outcomes:

At the end of the course, a student should be able

CO1	To use sensors and actuators in IoT
CO2	To implement communication protocols for IoT
CO3	To create or process data and analytics for IoT
CO4	To write programming for IoT
CO5	To implement IoT for various applications

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1: Introduction: What is IoT, Impact of IoT, IoT Challenges, Things in IoT, IoT Enabling Technologies: Sensors, Actuators and Smart Objects, Communications: RFID and NFC, Bluetooth Low Energy (BLE), Li-Fi, 6LowPAN, ZigBee, Z-Wave, LoRa, Protocols: HTTP, WebSocket, MQTT, CoAP, XMPP, Node-RED.	**8**
Module 2: Communicating smart objects: Communication criteria, IoT access technologies- IEEE 802.15.4, IEEE 802.15.4e, IEEE 802.11ah, IEEE 1901.2a, NB-IoT. IoT Network Layer: IP as IoT network layer, 6LoWPAN, 6Lo, 6TiSCH, RPL. IoT Application Layer: IoT application transport methods, CoAP, MQTT.	**8**
Module 3: Data and Analytics for IoT: IoT Middleware, Data analytics for IoT, Big Data analytics tools and technology. Structured and unstructured data, NoSQL Databases, Hadoop, trend and seasonality analysis, missing value in data, prediction, estimation, and forecasting.	**8**
Module 4: Interoperability in IoT: Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi.	**8**
Module 5: IoT application case study: Smart City, Smart Grid, Smart Transportation, Smart Manufacturing, Smart Healthcare. Activity Monitoring. Arm Mbed Ethernet based IoT Devices, LCD/ LED, Joystick, Potentiometers, Speaker, Accelerometer, Temperature Sensor, LED, IoT applications in Temperature Monitoring over the Internet, Smart Lighting, Voice-Controlled Door Access, RFID Reader. Cloud based IoT systems	**8**

Text Books:

1. D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, J. Henry; IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, 1st Edition, Pearson India Pvt. Ltd., 2018.
2. Perry Xiao, "Designing Embedded Systems and Internet of Things (IoT) with ARM Mbed" John Wiley and Sons, 2018.
3. A. Bahga, V. Madisetti; Internet of Things: A Hands-on Approach, 1st Edition, Universities Press (India) Pvt. Ltd., 2015.

Reference Books:

1. Y. Kanetkar, S. Korde; 21 Internet of Things (IOT) Experiments: Learn IoT, the programmer's way, 1st Edition, BPB Publications, 2018.
2. Research Articles

COURSE INFORMATION SHEET

Digital Image Processing Techniques

Course Code: **EC569**
Course Title: Digital Image Processing Techniques
Pre-requisite(s): Signal Processing Techniques, Probability and Random Process
Co-requisite(s):
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: Instrumentation
Name of Teacher:

Course Objectives:

This course enables the students:

1	To gain understanding on digital image formation, characteristics and its processing steps.
2	To demonstrate the use of different spatial and frequency domain processing techniques to improve the image quality.
3	To apply various segmentation techniques of an image.
4	To introduce various object recognition and analysis methods for computer vision applications.

Course Outcomes

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

CO1	Develop an understanding on the image formation, pixel characteristics and processing step.
CO2	Have an ability to analyze the image quality using transformed and spatial domain filters.
CO3	Have an ability to segment and represent the image for computer vision tasks.
CO4	Have an ability for Object Recognition and Interpretation
CO5	Develop an ability to create and apply the image processing techniques in various applications in many areas.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1 Fundamental steps in Digital Image Processing, Components of an Image processing system, Digital Image Representation, Basic relationship between pixels, Basic Arithmetic/Logic operations on image: Image subtraction, Image averaging, Color image processing fundamentals: Color Modules, RGB, HIS, Lab colormodules, Convolution and Correlation theorems.	**8**
Module 2 Image Enhancement in Spatial and Frequency Domain: Grey Level Transformations, Histogram Processing, Smoothing and Sharpening with Spatial Domain Filters, Fourier Transform, Fast Fourier Transform, Discrete Cosine Transform, Wavelet Transforms, Smoothing and Sharpening with Frequency Domain filters, Homomorphic filtering, Pseudo Color Image Enhancement.	**8**
Module 3 Image Restoration: Noise Models, Restoration in the presence of Noise-Only Spatial filtering, Mean filters, Adaptive filters Periodic Noise Reduction by Frequency Domain filtering, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Geometric Mean Filter.	**8**
Module 4 Image Segmentation and Representation: Detection of Discontinuities, Point Detection, Line detection, Edge Detection, Thresholding, Optimal Global and Adaptive thresholding, Region-based Segmentation, Textural Images, Textural Feature extraction from Co-occurrence matrices, Chain codes, Signatures, Boundary Segments, Skeletons, Boundary Descriptors, Regional Descriptors.	**8**
Module 5 Object Recognition and Interpretation: Elements of Image analysis, Pattern Classifier, Minimum distance classifier, Baye's Classifier, Neural Network algorithm, Fuzzy classifier, structural methods.	**8**

Text Books:

1. Digital Image Processing. 2/E by Rafael C. Gonzalez and Richard E. Woods. Pearson Education
2. Digital Image Processing and Analysis. by B. Chanda and D. Dutta Mujumdar PHI

Reference Book:

1. Fundamentals of Digital Image Processing. By Anil K. Jain, PHI Publication
2. Image Processing, Analysis and Machine Vision. Milan Sonka and Vaclav Hlavac,

COURSE INFORMATION SHEET

Speech Processing & Recognition

Course Code: **EC570**
Course Title: Speech Processing Techniques
Pre-requisite(s): **Signal Processing Techniques**
Co-requisite(s):
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: 01
Branch: ECE
SPECIALIZATION: Instrumentation
Name of Teacher:

Course Objectives

This course enables the students:

1	To explain fundamentals of speech production, its perception and inherent features.
2	To develop an ability to analyse parameter estimation and feature representations of speech signals.
3	To develop an ability to evaluate the pattern comparison and design issues of speech recognition.
4	To develop the concept and utilization of statistical and pattern recognition models. To develop the ability to apply the speech analysis and recognition methods for different real life applications.

Course Outcomes

After the completion of this course, students will be able to:

CO1	Demonstrate the understanding on the speech production, its perception and features.
CO2	Analyse various components of parameter estimation and feature representations of speech signals.
CO3	Illustrate various models for speech synthesis and automatic recognition.
CO4	Analyse the speech recognition and implementation issues.
CO5	Develop an ability to create and apply the speech recognition techniques in various applications in different areas.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module-I **Speech Production**: Introduction, Speech Production Process, Representing Speech in Time and Frequency domains, Speech Sounds and Features, Statistical pattern recognition approach to speech recognition.	**8**
Module-II **Signal Processing and Analysis Method for Speech Recognition**: Introduction, Linear predictive coding model for Speech Recognition, LPC model, LPC analysis equations, Autocorrelation method, Covariance method, LPC processor for speech recognition, MFCC, Vector quantization: Elements of VQ, VQ training set, Similarity or Distance Measure, Clustering, Vector classification procedure.	**8**
Module-III **Pattern comparison techniques**: Introduction, Speech Detection, Distortion Measures, Spectral-Distortion Measures :Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Liftering, Likelihood Distortion, Variance of Likelihood distortion, Time Alignment and Normalization.	**8**
Module-IV **Hidden Markov Models :** Introduction, Discrete-Time Markov Process, Extensions to HMM, Three Basic Problems for HMM, Types of HMM, Implementation issues for HMMs, HMM System for Isolated Word Recognition, Gaussian Mixture Model, HMM-GMM for isolated word recognition.	**8**
Module-V **Applications of Automatic Speech Recognition and Support Vector Machine**: Introduction, Support Vector Machines: Linear and Non-linear classifications, Computing the SVM classifier, Properties, Speech-Recognizer Performance Scores, Characteristic of Speech- Recognition Applications, Broad classes of Speech-Recognition Applications, Command and Control Applications, Projections for Speech Recognition, Applications of Speech Recognition in Mobile Phones.	**8**

Text Book:

1. L.R. Rabiner, B.H. Juang and B. Yegnanarayana, "Fundamentals of Speech Recognition", Pearson, Education 2011.
2. Cristianini Nello and Shawe-Taylor, "An introduction to Support Vector Machines and other kernel based learning methods", Cambridge University Press, 2000.

Reference Book:

1. L.R. Rabiner and R.W. Schafer, "Digital Processing of Speech Signals", Pearson Education, 2006.

COURSE INFORMATION SHEET
Biomedical Signal Processing

Course Code: **EC571**
Course Title: Biomedical Signal Processing
Pre-requisite(s): Digital Signal Processing
Co-requisite(s):
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: (Instrumentation)

Name of Teacher:

Course Objectives
This course enables the students:

1	Understand the fundamentals of Digital Signal Processing and Biomedical Signal Processing.
2	Grasp the concept of stochastic processes to develop advanced Biomedical signal processing concept.
3	Comprehend Digital Signal Processing and Biomedical Signal Processing.
4	Grasp how to integrate the concept of matrix algebra, probability models, random processes and linear algebra to Separate information Source using Spatial filters.

Course Outcomes
After the completion of this course, students will be able to:

CO1.	Distinguish Digital Signal Processing and Biomedical Signal Processing.
CO2.	Use the concept of stochastic processes to develop advanced Biomedical signal processing concept.
CO3.	Analyse Biomedical signals using PCA, BSS and ICA to separate or decorrelate the Multichannel Biomedical Signal.
CO4.	Integrate the concept of matrix algebra, probability models, random processes and linear algebra to develop Spatial filters for pattern classification.
CO5	Implement machine learning technique for biomedical signal processing.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module-1 Acquisition, Generation of Bio-signals, Origin of bio-signals, Types of bio-signals, Study of diagnostically significant bio-signal parameters, Electrodes for bio-physiological sensing and conditioning, Electrode-electrolyte interface, polarization, electrode skin interface and motion artefact, biomaterial used for electrode, Types of electrodes (body surface, internal, array of electrodes, microelectrodes), Practical aspects of using electrodes, Acquisition of bio-signals (signal conditioning) and Signal conversion (ADC's DAC's) Processing, Digital filtering	**8**
Module-2 Biomedical signal processing by Fourier analysis, Biomedical signal processing by wavelet (time frequency) analysis, Analysis (Computation of signal parameters that are diagnostically significant)	**8**
Module-3 Classification of signals and noise, Spectral analysis of deterministic, stationary random signals and non-stationary signals, Coherent treatment of various biomedical signal processing methods and applications.	**8**
Module-4 Principal component analysis, Correlation and regression, Analysis of chaotic signals Application areas of Bio–Signals analysis Multiresolution analysis (MRA) and wavelets, Principal component analysis (PCA), Independent component analysis (ICA)	**8**
Module-5 Pattern classification–supervised and unsupervised classification, Neural networks, Support vector Machines, Hidden Markov models. Examples of biomedical signal classification examples.	**8**

References:

1. W. J. Tompkins, "Biomedical Digital Signal Processing", Prentice Hall, 1993.
2. Eugene N Bruce, "Biomedical Signal Processing and Signal Modeling", John Wiley & Son's _publication, 2001.
3. Myer Kutz, "Biomedical Engineering and Design Handbook, Volume I", McGraw Hill, 2009._
4. D C Reddy, "Biomedical Signal Processing", McGraw Hill, 2005.
5. Katarzyn J. Blinowska, Jaroslaw Zygierewicz, "Practical Biomedical Signal Analysis Using MATLAB", 1st Edition, CRC Press, 2011.

COURSE INFORMATION SHEET

Photonic Integrated Circuits

Course Code: **EC572**
Course title: Photonic Integrated Circuits
Pre-requisite(s): Electronics Devices, Electromagnetic Fields and Waves
Co- requisite(s):
Credits: L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/ V
SPECIALIZATION: Instrumentation

Name of Teacher:

Course Objectives:
This course enables the students to:

A.	Understand the light-guiding properties in optical waveguides.
B	Understand the operating principle of waveguide devices.
C.	Understand the methods for fabrication of optical waveguides in silicon.
D.	Understand the system on-chip perspective and applications of Photonic Integrated circuits in different fields.

Course Outcomes:
After the completion of this course, students will be able to :

CO1	Explain the key properties of Optical Waveguides.
CO2	Design various optical waveguide devices.
CO3	Explain the characteristics of silicon waveguide devices.
CO4	Design and integrate complex systems with SoC (System on Chip)
CO5	Apply the photonic integrated circuits in various applications.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module -1: Light propagation in optical waveguide, symmetrical planar waveguide, Asymmetrical planar waveguide, Ideal slave waveguide, 3D optical waveguide, Analysis of guided modes, Loss mechanisms in waveguides, Coupling to optical circuit.	**8**
Module -2: Waveguide devices, Directional couplers, Phase-matched and non-phase-matched couplers, Distributed Bragg reflectors, Mach- Zehnder Interferometers, Optical phase modulator, Variable optical attenuators, Arrayed Waveguide Grating (AWG), PHASER-based devices, Silicon-on-Insulator (SOI).	**8**
Module -3: Fabrication of silicon waveguide devices, SOI substrate design, waveguide integration, Photolithography, Oxidation, Formation of submicron waveguides, Silicon doping, Metallization, Design verification and device models, Design and testing infrastructure.	**8**
Module -4: System on-chip perspective, On-chip communication, SoC Integration Issues, On-chip optical interconnect, PICMOS, WADIMOS, High speed performance of Stand-Alone-Silicon MZM, Performance of standalone MUX/ DEMUX, High speed performance of silicon PIC.	**8**
Module -5: Green Integrated Photonics, Non-linear optical losses in integrated Photonics, Two-Photon Photovoltaic effect, Non-linear Photovoltaic effect, Silicon photonic in Biosensing, Bioreceptors, Surface chemistry and passivation for biosensing, Optical reflectors Transducers in Porous Silicon, Photoluminescence Transducers, MOEMS, Photonic bandgap structures.	**8**

Text Books:

1. Graham T. Reed, Silicon Photonics: An Introduction, John Willey & Sons.
2. M. JAMAL DEEN & P. K. BASU, Silicon Photonics Fundamentals and Devices, Willey.

Reference Book:

1. Sasan Fathpour & Bahram Jalali., Silcon Photonics for Telecommunications and biomedicine, CRC Press.
2. David J. Lockwood & Lorenzo Pavesi, Silicon Photonics II: Components and Integration, Springer.
3. L.A.Coldren, S.W.Corzine & M.L.Masanovic, Diode Lasers and Photonic Integrated Circuits, Willey.
4. Marco Pisco, Andrea Cusano and Antonello Cutolo, Photonic Bandgap Structures, Bentham Science Publishers.

COURSE INFORMATION SHEET

Brain Computer Interfacing

Course Code: EC573
Course Title: Brain Computer Interfacing
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: X/X
Branch: ECE
SPECIALIZATION:

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Understand the concept of human commuter interaction
2.	Interpret different kinds of brain signal
3.	Understand the human-machine interaction using Brain signal
4.	Learn about Brain Computer interface
5.	Develop the BCI system.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Explain the concept of human commuter interaction
CO2	Identify and interpret different kinds of brain signal
CO3	Develop human-machine interaction using Brain signal
CO4	Integrate BCI system using different kind of Biomedical Signals
CO5	To develop the real time BCI inference and decision system

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Brain Structures and Scalp Potentials, Neural Activities, Measuring Electric Activity in the brain EEG, MEG and SSVEP, Wearable and Wireless EEG Monitoring, Brain Rhythms. Event-Related Potentials, Detection, Separation, Localization, and Classification of P300 Signals.	**8**
Module – II 10-20 Electrode Placement System, EEG Recording and Measurement, Wireless multi-channel EEG Recording System, Artifact identification from EEG and MEG, ERD and ERS, Laplacian Referencing, Common Average Referencing.	**8**
Module-III Cognitive State Estimation Problem, Spatial filters, Common Spatial Pattern, CSP based Cognitive State Estimation. EEG source localization, General Approaches to Source Localization, ICA Method, MUSIC Algorithm, RAP MUSIC, FOCUSS Algorithm, Determination of the Number of Sources.	**8**
Module – IV Instantaneous BSS, BSS based EEG Signal Analysis, Validity of the basic ICA model, Artifact removal from EEG and MEG, Topography Mapping of Independent Components.	**8**
Module – V Wearable and Wireless EEG based Brain-Computer Interface, Wireless Electroencephalogram, Information System using WLAN, BCI performance Evaluation parameters, Feature Extraction, Thought Recognition, Linear classification.	**8**

Textbooks:

1. Saied Sanei and J.A. Chambers, EEG Signal Processing, John Wiley & Sons Ltd., 2007.

2. Guido Dornhege, Jos´e del R. Mill´an Thilo Hinterberger, Dennis J. McFarland, KlausRobert Muller, Toward Brain-Computer Interfacing, MIT Press Cambridge, 2007.

3. Rangaraj M. Rangayyan, Biomedical Signal Analysis- A case-study approach, IEEE Press, 2005.

4. D.C. Reddy, Biomedical Signal Processing – principles and techniques, Tata McGrawHill, New Delhi, 2009.

Reference books:

1. “Neural Networks: A comprehensive Foundation” – Simon Haykin, Pearson education

COURSE INFORMATION SHEET

Analog VLSI Design

Course Code: EC581
Course Title: Analog VLSI Design
Pre-requisite(s): Electronic Devices (ED), Analog Circuit
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System
Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	To comprehend CMOS amplifiers.
2.	To grasp Analog CMOS Subcircuits.
3.	To apprehend Frequency Response of CMOS Amplifiers.
4.	To perceive CMOS Differential Amplifier.
5.	To understand CMOS Operational-Transconductance Amplifier.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Apply different biasing styles to CMOS amplifier circuits.
CO2	Design basic building blocks like current sources, current sinks, current mirrors, voltage references up to layout level.
CO3	Appraise Frequency Response of CMOS Amplifiers.
CO4	Design and analyze CMOS differential amplifier and op amp.
CO5	Design and analyze CMOS op-amp.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Design and Analysis of CMOS Amplifiers:** Review of MOS Large-Signal Model, Small-Signal Model, MOS Transconductance, Determination of the small-signal resistances of diode-connected NMOS and PMOS. MOS Amplifier Topologies, Biasing, Realization of Current Sources; Common-Source Stage: CS Core, CS stage with Current-Source Load, CS stage with Diode-Connected Load, CS Stage with Degeneration, CS Core with Biasing; Common-Gate Stage: CG Stage with Biasing; Source Follower: Source Follower Core, Source Follower with Biasing.	**8**

Module – II **Design and Analysis of Analog CMOS Subcircuits:** Analog CMOS subcircuits: MOS Diode/ Active resistor, Current Sink and Sources, Impractical biasing of MOS current sources, Current Mirrors, Application of Current Mirror as Current Steering Circuit, illustration of NMOS and PMOS current mirrors in a typical circuit, Current and Voltage Reference, Bandgap Reference; NMOS cascode current source and its equivalent circuit, PMOS cascode current source, Cascode Stage as an Amplifier, CMOS Cascode Amplifier;	**8**
Module – III **Frequency Response of CMOS Amplifiers:** General Considerations: Relationship Between Transfer Function and Frequency Response, Bode Rules, Association of Poles with Nodes, Miller's Theorem; High-Frequency Model of Transistor: High-Frequency Model of MOSFET, Transit Frequency; Frequency Response of Common Source Stage: Use of Miller's Theorem, Direct Analysis, Input Impedance; Frequency Response of Common Gate Stage, Frequency Response of Source Follower: Input and Output Impedances, Frequency Response of Cascode Stage: Input and Output Impedances.	**8**
Module – IV **Design and Analysis of CMOS Differential Amplifier:** General Considerations: Initial Thoughts, Differential Signals, Differential Pair; MOS Differential Pair: Qualitative Analysis, Large-Signal Analysis, Small-Signal Analysis; Cascode Differential Amplifiers, Common-Mode Rejection, Differential Pair with Active Load: Qualitative Analysis, Quantitative Analysis; Frequency Response of Differential Pairs. Variability and Mismatch: Systematic Variations Including Proximity Effects, Process Variations, Random Variations and Mismatch; Analog Layout Considerations: Transistor Layouts, Capacitor Matching, Resistor Layout, Noise Considerations.	**8**
Module – V **Design and Analysis of CMOS Operational-Transconductance Amplifier:** Performance Analysis of Current-sink CMOS inverting Amplifier, building blocks an CMOS operational-transconductance amplifier and Voltage Operational Amplifier, block diagram a general CMOS Operational-Transconductance Amplifier and Voltage Operational Amplifier, General Characteristics of the ideal CMOS Operational-Transconductance Amplifier, Division of a two-stage uncompensated CMOS Operational-Transconductance Amplifier into voltage-to-current and current-to-voltage stages, Functions of different stages, Characterization of two-stage CMOS Operational-Transconductance Amplifier: Slew Rate, CMRR, Design guidelines of two-stage CMOS Operational-Transconductance Amplifier based on given boundary conditions.	**8**

Textbooks:

[1] Behzad Razavi, Fundamentals of Microelectronics, Wiley, 2009.
[2] Phillip E. Allen & Douglas R. Holberg, CMOS Analog Circuit Design, 3/e, Oxford University Press, 2012.

Reference books:

[1] Tony Chan Carusone, David A. Johns and Kenneth W. Martin, Analogue Integrated Circuit Design, 2/e, John Wiley & Sons, 2012.
[2] Paul R. Gray, Paul J. Hurst, Stephen H. Lewis and Roberst G. Meyer, Analysis and Design of Analog Integrated Circuits, 5/e, Wiley, 2009

COURSE INFORMATION SHEET

VLSI Design Lab

Course code: EC582
Course Title: VLSI Design Lab
Pre-requisite(s): Basics of Electronics Engineering (BEE) Lab, Electronic Devices (ED) Lab
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class periods per week: 04
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: M.Tech. in VLSI Design and Embedded System

Name of Teacher:
Course Objectives
This course enables the students to:

1.	Understand Nanoscale MOSFET's short-channel effects
2.	Appraise CS stage with resistive, diode-Connected Load and Current-Source Load
3.	Apprehend cascaded CS, CD differential amplifier and 2-stage OP AMP
4.	Understand combinational and sequential circuits design with SPICE and System Verilog HDL
5.	Understand various fabrication process steps

Course Outcomes:

After the completion of this course, students will be able to:

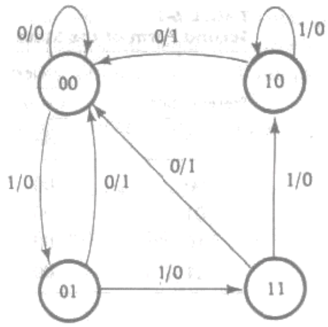
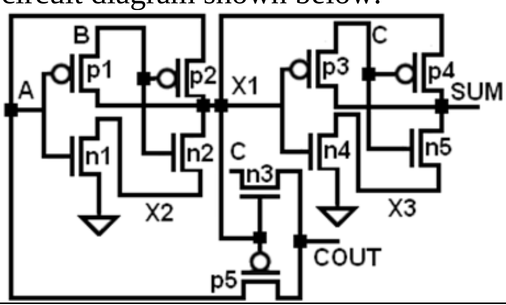
CO1	Study Nanoscale MOSFET's short-channel effects.
CO2	Design CS stage with resistive, diode-Connected Load and Current-Source Load using current mirror bias circuit.
CO3	Design cascaded CS, CD differential amplifier and 2-stage OP AMP.
CO4	Design combinational and sequential circuits with SPICE and System Verilog HDL.
CO5	Design a nanoscale MOSFET using virtual fabrication processes.

Syllabus

Hands-on experiments related to the course:

Experiment No.	Name of the Experiments
1.	**Calculation of MOSFET parameters and observation of short Channel effects** AIM1: Study of region of operation of MOSFET and find MOSFET parameters: K_n, K_p, V_{thn}, V_{thp}, Lambda.

	AIM2: Study of short channel effects: channel length modulation (CLM), drain-induced barrier lowering (DIBL), *V*t rolloff using Virtuoso Analog Design Environment of Cadence. AIM3: Study of short channel effects: hot carrier injection (HCI), body effect, subthreshold slope of NMOSFET and PMOSFET using Virtuoso Analog Design Environment of Cadence.
2.	**Design of CS amplifier and and current mirror circuit** AIM1: Design of CS stage with resistive and diode-Connected Load. AIM2: Design nMOS input and pMOS input CS stage with Current-Source Load using current mirror bias circuit.
3.	**Design of CS amplifier with Source Degeneration, CD amplifier.** AIM1: Design CS amplifier with Source Degeneration. AIM2: Study Frequency Response of Source Follower / CD amplifier.
4.	**Design of cascaded CS and CD amplifier** AIM1: Study Frequency Response of Common Gate Stage. AIM2: Design cascaded CS and CD amplifier and observe frequency response
5.	**Design of differential amplifier** AIM1: Design an inverting differential amplifier with a gain of at least 3 with respect to ground on the Virtuoso ADE platform of Cadence.
6.	**Design of two-stage Op-Amp** AIM1: Design an Op Amp based square wave generator with a frequency of at least 1 MHz on the Virtuoso ADE platform of Cadence
7.	**Design of 1-bit full adder using Transmission Gate (TG) logic style** AIM1: Draw transistor-level circuit diagram of a 1-bit full adder using Transmission Gate (TG) logic style and write down the circuit-level specification (SPICE deck/ System Verilog code) (using data flow modeling style) for subsequent simulation and analysis.
8.	**Design of Master-Slave Edge-Triggered Register & 4-bit Johnson counter** AIM1: Draw the transistor-level circuit diagram of a Master-Slave Edge-Triggered Register and model the same with SPICE/ System Verilog HDL (using switch-level modeling style) for subsequent simulation and analysis. AIM2: Design a 4-bit Johnson counter using Verilog on Xilinx ISE 10.1i. Synthesize the circuit, download the configuration file to the prototyping board (use Spartan-3E Starter kit) and verify its operation.
9.	**Fabrication (virtual) of nanoscale MOSFET using process simulator** AIM1: Design a nanoscale MOSFET using process simulator (virtual fabrication) AIM2: Simulate the virtually fabricated MOSFET using device simulator.
10.	**Design of carry look ahead adder** AIM1: Design a carry look ahead adder with SPICE/ System Verilog HDL (using structural modeling style). Simulate the same using test bench and ModelSim.

11.	**Design of 8×8 RAM/ROM** AIM1: Design an 8x8 RAM/ROM using SystemVerilog and verify its functionality.
12.	**Design of Mealy machine and simulate/analyze the given circuit** AIM1: Design a Mealy machine with the following state transition diagram using Verilog and VHDL on Active HDL/Xilinx ISE platform.  **State diagram (Mealy machine)** AIM2: Provide circuit/switch-level model using SPICE/System Verilog of the circuit diagram shown below. 

List of Optional experiments (Analog):

1. Study of transfer characteristics of NMOSFET and PMOSFET as a function of temperature using Virtuoso Analog Design Environment of Cadence.
2. Design Push-pull inverting amplifier and find out its design metrics.
3. Design a square wave generator using differential amplifier.
4. Design a triangular wave generator using differential amplifier.
5. Design an active filter using differential amplifier.
6. Design a variable gain amplifier.
7. Design instrumentation amplifier.
8. Draw the layout of Active PMOS load inverting amplifier, perform post-layout analysis and compare the results with pre-layout results.
9. Draw the layout of Current source load inverting amplifier, perform post-layout analysis and compare the results with pre-layout results.
10. Draw the layout of Current Sink CMOS inverting amplifier, perform post-layout analysis and compare the results with pre-layout results.
11. Draw the layout of Differential Amplifier, perform post-layout analysis and compare the results with pre-layout results.
12. Draw the layout of Push-pull inverting amplifier, perform post-layout analysis and compare the results with pre-layout results.
13. Draw the layout of CMOS Cascode Amplifier, perform post-layout analysis and compare the results with pre-layout results.

List of Optional experiments (Digital):

14. Draw layout of inverter, perform post-layout analysis and compare the results with pre-layout results.
15. Draw layout of 2-input NAND, perform post-layout analysis and compare the results with pre-layout results.
16. Draw layout of 2-input NOR, perform post-layout analysis and compare the results with pre-layout results.
17. Draw the transistor-level circuit diagram of a 2-input NOR gate and implement the same in Verilog HDL using switch-level modeling style.
18. Draw the logic diagram of a 2-to-1 MUX using a NOT and two transmission-gates (TGs) and implement the same in Verilog HDL using Verilog primitive such as not and cmos switches.
19. Draw the transistor-level circuit diagram of a 2-to-1 MUX and provide switch-level model using Verilog nmos, pmos and cmos switches.
20. Draw the transistor-level circuit diagram of Co (carry out) function Co= A.B+Ci(B+A), where Ci is the input carry to a 1-bit full adder and provide the switch-level model using Verilog nmos and pmos switches.
21. Write down the circuit-level specification (SPICE deck) of an inverter along with its transistor-level circuit diagram.
22. Write down the circuit-level specification (SPICE deck) of a 2-input NOR gate along with its transistor-level circuit diagram.
23. Draw the transistor-level circuit diagram of Co (carry out) function Co= A.B+Ci(A+B), where Ci is the input carry to a 1-bit full adder and provide the circuit-level specification (SPICE deck).

Textbooks:

1. Behzad Razavi, Fundamentals of Microelectronics, Wiley, 2009.
2. Phillip E. Allen & Douglas R. Holberg, CMOS Analog Circuit Design, 3/e, Oxford University Press, 2012.
3. J. Rabaey, A. Chandrakasan, B. Nikolic, "Digital Integrated Circuits: A Design Perspective", 2nd ed., Prentice Hall, 2003.
4. Neil H. E. Weste, David Money Harris, "CMOS VLSI Design – A Circuits and Systems Perspective," 4th ed., Addison Wesley, 2011.
5. Neil H. E. Weste, David Money Harris, "CMOS VLSI Design – A Circuits and Systems Perspective," 3rd ed., Pearson Education, 2006.

Reference Books:

1. Tony Chan Carusone, David A. Johns and Kenneth W. Martin, Analogue Integrated Circuit Design, 2/e, John Wiley & Sons, 2012.
2. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis and Roberst G. Meyer, Analysis and Design of Analog Integrated Circuits, 5/e, Wiley, 2009.
3. Samir Palnitkar, "Verilog HDL: A guide to Digital Design and Synthesis," SunSoft Press, 1996.
4. Stuart Sutherland, Simon Davidmann, Peter Flake, "SystemVerilog Design - A Guide to Using SystemVerilog for Hardware Design and Modeling," 2nd ed., Springer, 2006.

COURSE INFORMATION SHEET

Digital VLSI Design

Course Code: EC583
Course Title: Digital VLSI Design
Pre-requisite(s): Electronic Devices (ED), Basics of Electronics Engineering (BEE)
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System
Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	To apprehend Design technique of Combinational Logic Circuits in CMOS
2.	To perceive Design technique of Sequential Logic Circuits in CMOS
3.	To grasp CMOS Fabrication Process and Manufacturing Issues.
4.	To comprehend memory and control structure design techniques.
5.	To comprehend memory and control structure design techniques.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Design and analyze Combinational Logic Circuits in CMOS with given design specification such as propagation delay, power dissipation, PDP and EDP.
CO2	Design and analyze Sequential Logic Circuits in CMOS with given design specification.
CO3	Appraise CMOS Fabrication Process and Manufacturing Issues.
CO4	Design and analyze datapath circuits and model them using SPICE/ System Verilog.
CO5	Design and analyze semiconductor memory and control unit and model them using SPICE/ System Verilog.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Design of Combinational Logic Circuits in CMOS:** Static and Dynamic Behaviour of CMOS Inverter: Switching Threshold, Noise Margin formulation, computing capacitance, Propagation Delay, Power, Delay, Power-Delay Product, Energy-Delay Product. Design of CMOS Combinational Logic Circuits: Static CMOS Design: Complementary CMOS, Ratioed Logic, Pass-Transistor Logic, TG Logic; Dynamic CMOS Design: Basic Principles of Dynamic Logic, Speed and Power Dissipation of Dynamic Logic, Signal Integrity Issues in	**8**

Dynamic Design Cascading Dynamic Gates. Introduction to the SPICE/ System Verilog with Design examples of inverter, NAND and NOR gates.	
Module – II **Design of Sequential Logic Circuits in CMOS:** Timing Metrics for sequential Circuits, Static Latches and Registers: Bistability Principle, Multiplexer-Based Latches, Master-Slave Edge-Triggered Register, Low-Voltage Static Latches; Dynamic Latches and Registers; Alternative Register Styles, Pipelining, Nonbistable Sequential Circuits: The Schmitt Trigger; Design examples of latch, flip-flop and register using SPICE/ System Verilog HDL.	**8**
Module – III **CMOS Fabrication Process and Manufacturing Issues:** CMOS Technologies, Layout Design Rules, CMOS Process Enhancements, Design Rule Checking (DRC), Inverter cross-section, Layout of CMOS Inverter, Layout of 2-input NAND gate, Layout of 2-input NOR gate, Layout of Complex logic gate, Layout of Domino AND gate, Stick Diagrams, Design Partitioning, Floor Planning; **Estimation of parasitic**: diffusion capacitance and interconnect parasitic, package parasitic, impact of parasitic on circuit performance. **Manufacturing Issues:** Antenna Rules, Layer Density Rules, Resolution Enhancement Rules, Metal Slotting Rules, Interconnect Wearout: Electromigration, Self-heating, Yield Enhancement Guidelines.	**8**
Module – IV **Design of Datapath in CMOS:** **Data operators:** single-bit addition, carry-propagate addition, subtraction, multi-input addition, One/Zero detectors, magnitude comparators, equality comparators, counters, Boolean logic operators, Funnel shifters, Barrel Shifter, Array multiplier, Wallace tree multiplier; **Power and Speed Trade-off's in Datapath Structures:** Design Time Power-Reduction Techniques, Run-Time Power Management, Reducing the Power in Standby (or Sleep) Mode. Design examples of Datapath using SPICE/ System Verilog HDL.	**8**
Module – V **Design of Memory and Control in CMOS:** **Semiconductor Memory:** SRAM, DRAM, ROM, Flash memory; **Control Structure Design**: Mealy and Moore FSM, state-transition diagram, state reduction technique, control logic implementation, Design examples of control unit (Mealy and Moore FSM) using SPICE/ System Verilog HDL.	**8**

Textbooks:

[1] J. M. Rabaey, A. Chandrakasan, B. Nikolic, "Digital Integrated Circuits – A Design Perspective," 2nd ed., Upper Saddle River, New Jersey, USA: PHI, 2003.
[2] N. H. E. Weste and D. M. Harris, "CMOS VLSI Design – A Circuits and Systems Perspective," 4th ed., Boylston Street, Boston, USA: PHI, 2011.
[3] S. Palnitkar, "Verilog HDL: A guide to Digital Design and Synthesis," 1st ed., SunSoft Press, 1996.

Reference books:

[3] C D. L. Perry, "VHDL Programming," 4th ed., Tata McGraw Hill, 2012.
[4] Stuart Sutherland, Simon Davidmann, Peter Flake, System Verilog Design - A Guide to Using SystemVerilog for Hardware Design and Modeling, 2/e, Springer, 2006.

COURSE INFORMATION SHEET

Embedded Systems

Course code: EC585
Course title: Embedded Systems
Pre-requisite(s): EC203 Digital System Design, EC303 Microprocessors & Microcontrollers
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
Name of Teacher:
Course Objectives
This course enables the students to:

1.	Understand and explain the Fundamentals of Embedded Computing System.
2.	Gain knowledge on the hardware connections and 8051 programming techniques and apply the same.
3.	Appraise and analyse the custom input /output peripheral interfacing examples.
4.	Assess and evaluate the real-world interfacing of sensors and converters.
5.	Create the real-world control device interfacing for FPGA-based embedded system.

Course Outcomes
After the completion of this course, students will be able to:

CO1	Describe and illustrate the fundamentals of embedded system and 8051.
CO2	Sketch and explain the hardware connections and 8051 programming techniques.
CO3	Analyze and illustrate custom input /output peripheral interfacing.
CO4	Develop and schematize real-world interface with sensors and converters and evaluate its performance.
CO5	Design/develop and schematize real-world control device Interface and justify its applications.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Fundamentals of Embedded System and 8051:** Basics of Embedded systems, Design challenges, Common design metrics, Time-to-market design metric, Design Methodologies: Basic Design Methodologies, Embedded Systems Design Flows, Design Verification and Validation; Reliability, Safety, and Security, Why Reliable Embedded Systems? Basics of 8051.	**8**

Module – II **8051 programming techniques and Hardware Description Languages:** Hardware connection and Intel hex file, pin description, explaining the Intel hex file, programming timers and counters, serial port programming, interrupts, Programming timer interrupts, Programming external hardware interrupts, Programming the serial communication interrupt, Interrupt priority, Basics of Hardware Description Languages, Basics of FPGA architecture.	**8**
Module – III **Custom Input/Output Interfacing:** Optical Display Interfacing, Buzzer Control, Liquid Crystal Display Interfacing, General-Purpose Switch Interfacing, Dual-Tone Multifrequency Decoder, Sensor (Optical, Wind-Speed) Interfacing.	**8**
Module – IV **Interfacing Digital Logic to the Real World: Sensors, ADC and DAC:** Basics of Signal Conditioning for Sensor Interfacing, Principles of Sensor Interfacing and Measurement Techniques, Multichannel Data Logging, Pseudorandom Binary Sequence Generator, Signal Generator Design and Interfacing.	**8**
Module – V **Real-World Control Device Interfacing with aid to IoT:** Relay, Solenoid Valve, Opto-Isolator, and Direct Current Motor Interfacing and Control, Servo and BLDC Motor Interfacing and Control, Stepper Motor Control, Introduction to IoT, NFC, RFID, LiFi, ZigBee, Applications of IoT: Digital and Analog I/Os, Digital Interfaces, Networking and Communication protocols.	**8**

Books recommended:

Textbooks:

1. Wolf Wayne, "High-Performance Embedded Computing - Architectures, Applications, and Methodologies", Morgan Kaufmann Publishers, 2006.
2. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems Using Assembly and C", 2nd edition, Pearson, 2006.
3. A. Arockia Bazil Raj, "FPGA based embedded system developer's guide", Taylor & Francis, CRC Press, 2018.
4. Perry Xiao, "Designing Embedded Systems and Internet of Things (IoT) with ARM Mbed" John Wiley and Sons, 2018.

Reference books:

1. Vahid G Frank and Givargis Tony, "Embedded System Design: A Unified Hardware/Software Introduction", John Wiley & Sons, 2001.
2. Wolf Wayne, "Computers as Components - Principles of Embedded Computing System Design, 2nd Edition, Morgan Kaufmann Publishers, 2008.
3. Ronald Sass, Andrew G. Schmidt, "Embedded Systems Design with Platform FPGAs - Principles and Practices, Morgan Kaufmann Publishers, 2010.

COURSE INFORMATION SHEET

Embedded Systems Lab

Course code: EC586
Course title: Embedded Systems Lab
Pre-requisite(s): Digital System Design, Microprocessors & Microcontrollers.
Co- requisite(s): Embedded System Design
Credits: L: 0 T: 0 P: 4 C: 2
Class schedule per week: 4
Class: M. Tech.
Semester / Level: II/05
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the programmable hardware and its programming.
2.	Apply their understanding to write 8051 based assembly language/C programs.
3.	Analyse programs for designing components of embedded system for on-chip applications with other components.
4.	Evaluate and test programs for designing components of embedded system for on-chip commercial applications.
5.	Create/develop programs for designing components of embedded system for consumer electronics applications after integration of all necessary components.

Course Outcomes

After the completion of this course, students will be able to:

CO1	Translate their theoretical knowledge to write assembly language/C programs and burn into flash ROM of AT89S51 or AT89S52 Microcontroller for its application on wish-board.
CO2	Write assembly language/C programs and burn into flash ROM of AT89S51 or AT89S52 Microcontroller and simulate/ the same and experiment on wish-board.
CO3	Outline and write the Verilog/VHDL program for designing a component of an embedded system and simulate/test the same using Xilinx ISE 8.1i and experiment on prototyping board such as **Xilinx XC9572 CPLD in Milman VLSI Trainer** kit after downloading the configuration file.
CO4	Write the Verilog/VHDL program for designing a component of an embedded system and simulate/evaluate the same using Xilinx ISE 10.1i and test for verification on prototyping board such as **Xilinx Spartan-3E Starter kit** after downloading the configuration file.
CO5	Write the Verilog/VHDL program for designing a component of an embedded system and simulate/validate the same using Xilinx ISE 10.1i and test for verification on prototyping board such as **Xilinx Spartan-3E Starter kit** after downloading the configuration file.

SYLLABUS

Experiment No.	Name of the Experiments
1.	**Write an assembly language/C program to test port pins (P1.2 and P2.3)** AIM1: Write an assembly language/C programs and assemble/compile the same to find error, if any; generate Intel HEX file and burn into flash ROM of AT89S51 or AT89S52 Microcontroller to perform the following: (a) Keep monitoring the P1.2 bit until it becomes high (b) When P1.2 becomes high, write value 45H to port 0 (c) Send a high-to-low (H-to-L) pulse to P2.3. Use wish-board of ANALOG AND DIGITAL TRAINER to show the result.
2.	**Write an assembly language/C program to turn a buzzer ON through P2.3.** AIM1: Assume that bit P2.3 is an input and represents the condition of an oven. If it goes high, it means that the oven is hot. Monitor the bit continuously. Whenever it goes high, send a high-to-low pulse to port P1.5 to turn on a buzzer. Write an assembly language/C program and assemble/compile the same to find error, if any; generate Intel HEX file and burn into flash ROM of AT89S51 or AT89S52 Microcontroller. Use wish-board of ANALOG AND DIGITAL TRAINER to show the result.
3.	**Write an assembly language/C program to toggle the bits of PORT 1** AIM1: Write an assembly language/C program to toggle the bits of PORT 1 and assemble/compile the same to find error, if any; generate Intel HEX file and burn into flash ROM of AT89S51 or AT89S52 Microcontroller. Use wish-board of ANALOG AND DIGITAL TRAINER to show the result.
4.	**Write an assembly language to get the status of a switch connected to P1.0 through an LED** AIM1: A switch is connected to P1.0 and an LED to pin P2.7. Write an assembly language/C program to get the status of the switch through the LED; assemble/compile the same to find error, if any; generate Intel HEX file and burn into flash ROM of AT89S51 or AT89S52 Microcontroller. Use wish-board of ANALOG AND DIGITAL TRAINER to show the result.
5.	**Write an assembly language to generate a square wave of 50% duty cycle** AIM1: Write an assembly language/C program to generate a square wave of 50% duty cycle on bit 0 of port 1; assemble/compile the same to find error, if any; generate Intel HEX file and burn into flash ROM of AT89S51 or AT89S52 Microcontroller. Use wish-board of ANALOG AND DIGITAL TRAINER to show the result.
6.	**Write a program to read data from P1 whiling writing the same to P2 and transferring serially** AIM1: Write an assembly language/C program to read data from P1 and write the read data to P2 continuously while giving a copy of it to the serial COM port to be transferred serially; assemble/compile the same to find error, if any; generate Intel

	HEX file and burn into flash ROM of AT89S51 or AT89S52 Microcontroller. Use wish-board of ANALOG AND DIGITAL TRAINER to show the result.
7.	**Write a VHDL/Verilog code for designing an ALU** AIM1: Outline and write a VHDL/Verilog code for designing an ALU using IP core on Xilinx ISE. Test your VHDL/Verilog code by simulating it, find error, if any; synthesize the error free RTL code; experiment your design downloading the configuration file into the Xilinx XC9572 CPLD in Milman VLSI Trainer kit /Spartan-3E Starter kit and test its operation.
8.	**Write a VHDL/Verilog code for displaying your name** AIM1: Outline and write a VHDL/Verilog code for designing a FPGA-based digital system to display your name. Test your VHDL/Verilog code by simulating it, find error, if any; synthesize the error free RTL code; experiment your design downloading the configuration file into the Xilinx XC9572 CPLD in Milman VLSI Trainer kit /Spartan-3E Starter kit and show your name on LCD.
9.	**Write a VHDL/Verilog code for rotating your name** AIM1: Outline and write a VHDL/Verilog code for designing a FPGA-based digital system to rotate your name. Test your VHDL/Verilog code by simulating it, find error, if any; synthesize the error free RTL code; experiment your design downloading the configuration file into the Xilinx XC9572 CPLD in Milman VLSI Trainer kit /Spartan-3E Starter kit and show your rotating name on LCD.
10.	**Write a VHDL/Verilog code for designing a 2-bit adder** AIM1: Outline and write a VHDL/Verilog code for designing a 2-bit adder using System Generator. Test your VHDL/Verilog code by simulating it, find error, if any; synthesize the error free RTL code; experiment your design downloading the configuration file into the Xilinx XC9572 CPLD in Milman VLSI Trainer kit /Spartan-3E Starter kit and verify its operation without Chip Scope Pro.
11.	**Write a VHDL/Verilog code for glowing Sixteen LEDs in specified pattern.** AIM1: Sixteen LEDs are connected to the FPGA in common cathode configuration. Develop VHDL/Verilog code to make the first eight LEDS glow in a downward direction while the other eight LEDs glow in an upward direction. This has to happen five times; then all the LEDs have to blink two times. Simulate your VHDL/Verilog code, find error, if any; synthesize the error free RTL code; experiment your design downloading the configuration file into the Xilinx XC9572 CPLD in Milman VLSI Trainer kit and show the results.
12.	**Write a VHDL/Verilog code to drive a buzzer at different duty cycles** AIM1: Develop a digital system in FPGA to drive a buzzer at different duty cycles 0%, 40%, 80%, and 100% whenever the input (data_in) is ($0 \leq data\_in \leq 10$), ($10 < data\_in \leq 100$), ($100 < data\_in \leq 200$) and ($200 < data\_in$), respectively. Assume that the inputs are given via a port of eight bits. Simulate your VHDL/Verilog code, find error, if any; synthesize the error free RTL code; experiment your design downloading the configuration file into the Xilinx XC9572 CPLD in Milman VLSI Trainer kit and show the results.

List of Optional Experiments

Part – I:

1. Assume that the INT1 pin (external hardware interrupt) is connected to a switch that is normally high. Whenever it goes low, it should turn on an LED. The LED is connected to P1.3 and is normally off. When it is turned on it should stay on for a fraction of a second. As long as the switch is pressed low, the LED should stay on. Write an assembly language program to show the result in hardware by burning the program into flash ROM (use AT89S51 or AT89S52, burner kit, wish-board, necessary hardware and tester).
2. Assume that pin 3.3 (INT1) is connected to a pulse generator, write a program in which the falling edge of the pulse will send a high to P1.3, which is connected to an LED (or buzzer). In other words, the LED is turned on and off at the same rate as the pulses are applied to the INT1 pin. Write an assembly language program to show the result in hardware by burning the program into flash ROM (use AT89S51 or AT89S52, burner kit, wish-board, necessary hardware and tester).
3. Write the assembly code for Intelligent Traffic Light Controllers QTLC) at Zebra Crossing.
4. Design an Auto Toll Billing System
5. Design a microcontroller based embedded system for agricultural surveillance.
6. Design a system using AT89S5l, ADC0848, LM34135, LM336 & POT l0K for reading the output of temperature sensor.
7. Design a microcontroller based embedded system for smart power grids.
8. Write a assemble program to generate saw tooth wave & triangular wave using DAC.
9. Develop a simple hardware/software partitioning tool that accepts as input a task graph and the execution times of the software implementations of the tasks. Allocate processes to hardware or software and generate a feasible system schedule.
10. Develop a tool that allows you to quickly estimate the performance and area of an accelerator, given a hardware description.

Part – II:

1. Design a 2-bit adder using System Generator on Xilinx ISE 10.1i. Synthesize the circuit, download the configuration file to the prototyping board (use use Spartan-3E Starter kit) and verify its operation with Chip Scope Pro.
2. Design a 4-bit Johnson counter using Verilog on Xilinx ISE 10.1i. Synthesize the circuit, download the configuration file to the prototyping board (use Xilinx XC9572 CPLD in Milman VLSI Trainer kit) and verify its operation.
3. Design a circuit to implement GCD (greatest common divisor) algorithm using Verilog on Xilinx ISE 8.1i. Synthesize the circuit, download the configuration file to the prototyping board (use Spartan-3E Starter kit) and verify its operation.
4. Develop a digital system to display "DIAT" on a multi-segment LED display panel. The scrolling of the word has to be in the right-to-left direction. Assume each segment of the LED display panel has eight rows and eight columns.
5. Develop a digital system to display digital pulses on pages 1 and 6 of a GLCD. Use both segments and display two cycles in each page. Use the onboard DIP switch for resetting the GLCD.
6. Develop a digital system in the FPGA to control appliances from a remote station using DTMF (Dual-Tone Multifrequency Decoder) tones as per the following requirements.
    a) There are nine electrical appliances that have to be controlled.

b) DTMF tone "0" has to be used to switch off all the appliances.
c) DTMF tone data (1–9) have to be used to select a particular appliance.
d) "*" and "#", that is, A ("1010") and C ("1100"), have to be used to switch the appliances "on" and "off", respectively.

7. Develop a FPGA-based digital system to continuously monitor and automatically fill the chemical fluid in a tank. A proximity sensor is placed inside the tank so as to get IR radiation reflected back to the phototransistor from the chemical fluid surface. The output of the phototransistor is given to an 8-bit A/D convertor. Hence, the fluid level is measured by A/D and given to the FPGA via 8-bit data. The system has to indicate the fluid level in the first row of an LCD and switch on the fluid inlet motor if the level goes below "00001111".

Books recommended:

Textbooks:

5. Wolf Wayne, "High-Performance Embedded Computing - Architectures, Applications, and Methodologies", Morgan Kaufmann Publishers, 2006.
6. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems Using Assembly and C", 2nd edition, Pearson, 2006.
7. A. Arockia Bazil Raj, "FPGA based embedded system developer's guide", Taylor & Francis, CRC Press, 2018.

Reference books:

4. Vahid G Frank and Givargis Tony, "Embedded System Design: A Unified Hardware/Software Introduction", John Wiley & Sons, 2001.
5. Wolf Wayne, "Computers as Components - Principles of Embedded Computing System Design, 2nd Edition, Morgan Kaufmann Publishers, 2008.
6. Ronald Sass, Andrew G. Schmidt, "Embedded Systems Design with Platform FPGAs - Principles and Practices, Morgan Kaufmann Publishers, 2010.

COURSE INFORMATION SHEET
IC Technology

Course Code: EC587
Course Title: IC Technology
Pre-requisite(s): Electronic Devices (ED)
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	To understand Clean Room and Wafer Cleaning Technology.
2.	To grasp Crystal Growth Techniques and Epitaxy.
3.	To perceive Film Formation Methods.
4.	To apprehend Impurity Incorporation Techniques.
5.	To comprehend Lithography and Etching Methods.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Appraise importance of Clean Room and Wafer Cleaning Technology.
CO2	Apply Crystal Growth Techniques and Epitaxy.
CO3	Apply Film Formation Methods.
CO4	Apply Impurity Incorporation Techniques
CO5	Apply Lithography and Etching Methods.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Clean Room and Wafer Cleaning Technology**: Environment for VLSI Technology: Clean room classification, Clean room design concept, clean Room Performance Criteria, Clean room installation, Clean room operations, automation, related facility systems, safety requirements. Basic concepts of Wafer cleaning: Wet-Cleaning Technology, Dry-Cleaning Technology, Future Trends	**8**
Module – II **Crystal Growth Techniques and Epitaxy:** Process Flow, Silicon Crystal Growth from the Melt: Starting Material, The Czochralski Technique, Distribution of Dopant, Effective Segregation Coefficient; Silicon Float-Zone Process; GaAs Crystal-Growth Techniques: Starting Materials, Crystal-Growth Techniques; Material Characterization: Wafer Shaping, Crystal Characterization, Crystal Defects, Material Properties; Epitaxial-Growth Techniques: Chemical-Vapor Deposition, CVD for Silicon, CVD for GaAs, Metalorganic CVD, Molecular-Beam Epitaxy; Structures And Defects In Epitaxial Layers: Lattice-Matched and Strained-Layer Epitaxy, Defects in Epitaxial Layers	**8**
Module – III **Film Formation Methods:** Thermal Oxidation, Kinetics of Silicon dioxide growth, Thin Oxide Growth, Dielectric Deposition, Silicon Dioxide: Deposition Methods, Properties of Silicon Dioxide, Step Coverage, P-Glass Flow; Silicon Nitride: Low-Dielectric-Constant Materials, High-Dielectric-Constant Materials; Polysilicon Deposition, Metallization: Physical-Vapor Deposition, Chemical-Vapor Deposition, CVD-W, CVD TiN; Aluminum Metallization: Junction Spiking, Electromigration; Copper Metallization: Damascene technology; Chemical-Mechanical Polishing, Silicide.	**8**
Module – IV **Impurity incorporation Techniques**: Basic Diffusion Process, Diffusion Equation, Diffusion Profiles, Evaluation of Diffused Layers, Extrinsic Diffusion, Concentration-Dependent Diffusivity, Diffusion in Silicon, Zinc Diffusion in Gallium Arsenide, Lateral Diffusion, Impurity Redistribution During Oxidation. Ion Implantation: Range of implanted ions, Ion Distribution, Ion Stopping, Ion Channeling, Implant Damage, Annealing: Conventional Annealing B and P, Rapid Thermal Annealing, Multiple Implantation and Masking, Tilt-Angle Ion Implantation, High-Energy and High-current Implantation.	**8**
Module – V **Lithography and Etching Methods**: Optical Lithography, Masks, Photoresist, Pattern Transfer, Resolution Enhancement Techniques; Next-Generation Lithographic Methods: Electron-Beam Lithography, The Proximity Effect, Extreme-Ultraviolet Lithography, X-Ray Lithography, Ion-Beam Lithography; Wet Chemical Etching: Silicon Etching, Silicon Dioxide Etching, Silicon Nitride and Polysilicon Etching, Aluminum Etching, Gallium Arsenide Etching, Dry Etching, Plasma Fundamentals; Etch	**8**

Mechanism, Plasma Diagnostics, and End-Point Control, Reactive Plasma-Etching Techniques, Clustered Plasma Processing; Reactive Plasma-Etching Applications, Microelectromechanical Systems: Bulk Micromachining, Surface Micromachining, LIGA Process, Process integration for NMOS, CMOS and Bipolar circuits, Advanced MOS technologies	

Textbooks:

[1] S. M. Sze, and C. Y. Chang, ULSI Technology, McGraw Hill Companies Inc, 1996.
[2] S. M. Zee, Semiconductor Devices: Physics and Technology, 2e, John Wiley Inc., New York, reprint 2002.

Reference books:

[1] James D. Plummer, Michael D. Deal, Peter B. Griffin, Silicon VLSI Technology - Fundamentals, Practice and Modeling, Prentice Hall, 2000.
[2] Sorab K. Ghandhi, VLSI Fabrication Principles – Silicon and Gallium Arsenide, John Wiley Inc., New York, 1994.
[3] S. M. Sze, VLSI Technology, 2e, McGraw-Hill, reprint 2008.

COURSE INFORMATION SHEET

Deep Submicron CMOS IC Design

Course Code: EC588
Course Title: Deep Submicron CMOS IC Design
Pre-requisite(s): Electronic Devices (ED)
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	To apprehend Technology Scaling and its impact on device and circuit performance.
2.	To grasp Pitfalls in CMOS Circuit Design in Advanced CMOS Technologies.
3.	To perceive Variability and Reliability Issues.
4.	To comprehend Sources of Variation and Variation Prevention Techniques.
5.	To understand advantages and pitfalls of Silicon-on-Insulator Technology.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Infer impact of technology scaling and their impact on device and circuit parameters.
CO2	Explain the Pitfalls in CMOS Circuit Design in Advanced CMOS Technologies.
CO3	Appraise Variability and Reliability Issues in advanced CMOS technologies and apply variability reduction techniques.
CO4	Discuss Sources of Variation and Variation Prevention Techniques.
CO5	Apprehend the Silicon-on-Insulator Technology

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Technology Scaling and its impact on device and circuit performance:** Transistor Scaling, Dennard's Scaling theory, Industry practice, Interconnect Scaling, International Technology Roadmap for Semiconductors; Impacts of Technology Scaling on Design: Improved Performance and Cost, Interconnect, Power, Variability, Productivity; Physical Limits of Technology Scaling: Subthreshold leakage at low VDD and Vt, Tunnelling current through thin oxides, Poor I-V characteristics due to short-channel effects such as mobility degradation and velocity saturation, channel length modulation, threshold voltage effects, substrate current-induced body effect (SCBE), drain-induced barrier lowering (DIBL), short-channel effects (SCE); hot carrier injection (HCI), Dynamic power dissipation, Lithography limitations, Exponentially increasing costs of fabrication facilities and mask sets, Electromigration, Interconnect delay.	**8**
Module – II **Pitfalls in CMOS Circuit Design in Advanced CMOS Technologies:** Threshold drops, Ratio failures, Leakage: Gate Leakage, Subthreshold Leakage, Junction Leakage, Gate-Induced Drain Leakage, leakage prevention techniques; Charge sharing, Power supply noise, Hot spots, Minority carrier injection, Back-gate coupling, Diffusion input noise sensitivity, Process sensitivity, Domino Noise Budgets: Charge leakage, Charge sharing, Capacitive coupling, Noise feedthrough, Process corner effects, Soft errors; Manufacturing Issues: Antenna Rules, Layer Density Rules, Resolution Enhancement Rules, Metal Slotting Rules, Yield Enhancement Guidelines.	**8**
Module – III **Variability and Reliability Issues:** Variability: Process variation, Supply voltage, Operating temperature, Design Corners; Reliability: Reliability Terminology, Oxide Wearout, Hot Carriers, Negative bias temperature instability (NBTI), Time-dependent dielectric breakdown (TDDB); Interconnect Wearout: Electromigration, Self-Heating, Soft Errors, Overvoltage Failure, Latchup and its prevention technique.	**8**
Module – IV **Sources of Variation and Variation Prevention Techniques:** Channel Length Variation, linewidth variation, line edge roughness, proximity effect, orientation Effect, topography effect, Threshold voltage variation, random dopant fluctuations (RDF), Oxide Thickness variation, Layout Effects, across-chip mobility variation; Impact of variation on Device and Circuit Performance: Fundamentals of Yield, variation in ON and OFF Currents, Variation in Delay, Variation in Power, Variation in Energy, Malfunctioning Device and Circuits, Matched Delays, Variation-Tolerant Design: Adaptive Control, Fault Tolerance.	**8**

Module – V **Advantages and pitfalls of Silicon-on-Insulator Technology:** Types of Silicon-on-Insulator Devices, Partially depleted Silicon-on-Insulator device, Fully-depleted Silicon-on-Insulator device, pitfalls of Partially depleted Silicon-on-Insulator device: history effect, pass-gate leakage, Self-heating, implications for circuit styles in Partially-depleted Silicon-on-Insulator devices, advantages of Silicon-on-Insulator CMOS process.	**8**

Textbooks:

[1] Neil H. E. Weste and David Harris, "CMOS VLSI Design: A Circuits and Systems Perspective," 4th International Edition, Pearson Education, Inc., 2011.

[2] Y. Taur and T.H. Ning, "Fundamentals of Modern VLSI Devices," 2nd ed., Cambridge University Press, NY, USA, reprint 2016.

Reference books:

[1] J.M. Rabaey, A. Chandrakasan, B. Nikolic, Digital Integrated Circuits: A Design Perspective, 2/e, Pearson Education, 2016.

[2] Alice Wang, Benton H. Calhoun, A. P. Chandrakasan "Sub-threshold Design for Ultra Low-Power Systems", Springer, 2006, ISBN-13: 978-0387335155.

COURSE INFORMATION SHEET

Low Power VLSI Design

Course Code: EC589

Course Title: Low Power VLSI Design

Pre-requisite(s): Basics of Electronics Engineering (BEE), Electronic Devices (ED)
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/V
Branch: ECE
SPECIALIZATION: M.Tech. in VLSI Design and Embedded System

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	To understand power and energy basics.
2.	To grasp power optimization technique @ design time at architecture and system level.
3.	To perceive power optimization technique @ design time for interconnect and clock.
4.	To infer power optimization technique @ standby for Memory.
5.	To understand power optimization technique @ runtime on low power design methodologies.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Appraise power and energy basics.
CO2	Apply the power optimization technique @ design time at architecture and system level.
CO3	Make use of the power optimization technique @ design time for interconnect and clock.
CO4	Apply power optimization technique @ Standby on Memory.
CO5	Apply low power design methodologies @ Runtime.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Power and Energy Basics:** Digital design metrics – power, delay and energy metrics, power-delay and energy–delay trade-offs, dynamic power, short-circuit power, static power, sources of static power dissipation, optimizing power at design time.	**8**
Module – II **Optimizing Power @ Design Time: Architecture, Algorithms, and Systems:** The architecture/system trade-off space, concurrency improves energy-efficiency, exploring alternative topologies, removing inefficiency, and the cost of flexibility.	**8**
Module – III **Optimizing Power @ Design Time: Interconnect and Clocks** Interconnect basics – capacitive parasitics, Dealing with Capacitive Cross Talk, Circuit Fabrics with Predictable Wire Delay, Capacitive Load and Performance, Resistive Parasitics, Electromigration – an issue in interconnect, Inductive Parasitics, ITRS projection on interconnect and clock, Increasing Impact of Interconnect, Novel interconnect media, Lower Bounds on Interconnect Energy, Reducing Interconnect Power/Energy, Wire Energy–Delay Trade-off.	**8**
Module – IV **Optimizing Power @ Standby: Memory:** New memory technologies, memory in standby, voltage scaling, data retention voltage (DRV) and transistor sizes, impact of process variations on DRV, how to approach the DRV safely, body biasing.	**8**
Module – V **Optimizing Power @ Runtime: Low Power Design Methodologies and Flows:** **Low Power Design Methodology**: Minimize power, Minimize time, Minimize effort, System-Phase Analysis Methodology, Design-Phase Analysis Methodology, Clock Gating, Data Gating; **Power Gating**: Physical Design, Switch Sizing, Additional Issues, Multi-V_{DD}, Multi-V_{DD} Issues, Multi-V_{DD} Flow, Power Integrity Methodologies, Power Integrity Verification Flow, Dynamic Voltage Drop Impact.	**8**

Textbooks:

1. Jan M. Rabaey, “Low power essentials”, First Edition, Springer, 2009, ISBN 978-0-387-71712-8.
2. Alice Wang, Benton H. Calhoun, A. P. Chandrakasan “Sub-threshold Design for Ultra Low-Power Systems”, Springer, 2006, ISBN-13: 978-0387335155.

Reference books:

1. Kaushik Roy, Sharat Prasad, “Low power CMOS VLSI circuit design”, John Wiley sons Inc., 2000.
2. Jan M. Rabaey, “Digital Integrated Circuits - A Design Perspective”, 2nd Edition, Prentice Hall, 2003.

COURSE INFORMATION SHEET

Digital Signal Processing Algorithms and Architecture

Course code: EC590
Course title: Digital Signal Processing Algorithms and Architecture
Pre-requisite(s): Digital Signal Processing, Signal and System
Co- requisite(s):
Credits: L: 3 T: 0 P: 0
Class schedule per week: 3 L
Class: M. Tech.
Semester / Level: II/ V
Branch: ECE
Specialization: VLSI Design & Embedded System

Name of Teacher:
Course Objectives

This course enables the students to:

A.	Demonstrate the digital signal processing concepts.
B.	Appraise the DSP architecture design and circuits.
C.	Understand the operation of programmable DSP devices and processors.
D.	Understand the DSP module synthesis and its operations.
E.	Demonstrate the interfacing and application of DSP processor.

Course Outcomes

After the completion of this course, students will be able to:

1.	Identify the specific computation feature of Digital signal processor and its accuracy issues.
2.	Architect programmable DSP devices.
3.	Implement basic DSP algorithm
4.	Interface peripheral devices to program DSP processor.
5	Develop DSP based application using DSP processors.

Syllabus

MODULE	(NO. OF LECTURE HOURS)
Module – I **Introduction to DSP:** The sampling process, discrete time sequences, Digital signal processor, major feature of programmable digital signal processor, Discrete Fourier transformation (DFT) and fast Fourier transformation (FFT), Digital filter: FIR, IIR, Decimation and Interpolation.	**8**
Module – II **Computational Accuracy in DSP Implementations**: Number formats for signals and coefficients in DSP system, Dynamic range and precision, Source of error in DSP implementation, AD conversion error, and DA conversion error. DSP representations (data-flow, control-flow, and signal-flow graphs, block diagrams), fixed-point DSP design (A/D precision, coefficient quantization, round-off and scaling).	**8**
Module – III **Architecture for programmable DSP Devices:** DSP computation building blocks, bus architecture and memory, Data addressing capabilities, Address Generation Unit, Programmable and program execution, speed issues, Features for External Interfacing. Fast filtering algorithms (Winograd's, FFT, short- length FIR), retiming and pipelining, block processing, folding, distributed arithmetic architectures, performance measures: area, power, and speed.	**8**
Module – IV **Development Tools for DSP implementation:** DSP development tools, The DSP system design kit (DSK), The Assembler and assembly source file, compiler, the linker and memory allocation, the code compressor studio. Architecture of C6x Processor: Commercial digital signal processing device, Introduction TMS320 C6x architecture, Data addressing modes, Linear and circular addressing modes, functional units, fetch and execute packets, pipe lining, registers, memory space.	**8**
Module – V **Interfacing and Applications of DSP Processors:** Introduction to DSP/BIOS, RTDX, Interface between PC and DSK. Applications: Implementation of speech recognition, image enhancement, filtering in DSP processor.	**8**

Recommended Books:

1. Digital Signal Processors: Architectures, Implementations, and Applications Sen M.Kuo , Woon-Seng S. Gan, Prentice Hall 2004
2. Architectures for Digital Signal Processing, Pirsch, John Wiley and Sons, 1998.
3. "Architectures for Digital Signal Processing", Peter Pirsch John Weily, 2008
4. Digital signal processing and applications with C6713 and C6416 DSK by Rulph Chassaing, Wiley publication.

COURSE INFORMATION SHEET

Embedded Computing Systems and Interfacing

Course code: EC591
Course title: Embedded Computing Systems and Interfacing
Pre-requisite(s): Microprocessors and Microcontrollers
Co- requisite(s):
Credits: L:3 T:0 P:0
Class schedule per week: 03
Class: M. TECH
Semester / Level: II/ V
Branch: ECE
Specialization: VLSI Design & Embedded System

Course Objectives

This course enables the students:

1	To learn about basics of embedded computing and system design flow
2	To realise the hardware fundamentals involved in embedded system circuit design
3	To understand the bus architectures and component interfacing
4	To appraise the real-time operating systems
5	To understand the variation of instruction sets for ARM and PIC microcontrollers

Course Outcomes

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

1.	Identify the application areas of microprocessors, design a hardware platform with I/O devices that can support the required tasks and its processing
2.	Read the schematic diagrams and develop ability to write basic level embedded system-software
3.	Design and optimize the bus-based embedded systems
4.	Build complex applications using microprocessors such as a Digital Telephone Answering machine
5.	Perform programming-based projects based on ARM or PIC microcontrollers

Syllabus

MODULE	(NO. OF LECTURE HOURS)
Module – I **General system design:** Embedded Computing: Introduction, Complex Systems and Microprocessor, The Embedded System Design Process, Formalisms for System Design, Design Examples.	**8**

Module – II **Advanced hardware fundamentals:** Gates, Timing diagrams, Memory, Buses, Direct Memory Access, Microprocessor architecture, Interrupts: Basics, Shared-data problem, Interrupt latency, Round-robin with interrupts.	**8**
Module – III **Bus-based systems:** Bus architectures and transactions, Serial interconnects, CPU Bus: Bus protocols, DMA, I2C bus, CAN bus, AMBA bus, System bus configurations, Component interfacing, Designs based on microprocessor and their performance analysis, Design Example-Elevator Controller, Alarm clock.	**8**
Module – IV **Processes and Real-time Operating Systems:** Multiple Tasks and Multiple Processes, Preemptive Real-Time Operating Systems: Preemption, Priorities, Processes and Context, Processes and Object-Oriented Design, Scheduling based concepts, Interprocess Communication Mechanisms, Operating System Performance evaluation, Process optimization for power reduction, A design example: Telephone Answering machine.	**8**
Module – V **Design and programming with microcontrollers:** **ARM:** Introduction to processor design-architecture and organization, Abstraction in hardware design, Instruction set design, Processor design trade-offs, RISC. Overview of ARM architecture, ARM Instruction Set, ARM memory interface, AMBA, ARM reference peripheral specifications, JTAG, ARM processor cores. **Programming with PIC**: Assembly Language Programming, Hex File Format, Code-Protect Features, Programming, PIC Emulators.	**8**

Recommended Books:

1. Wayne Wolf, “Computers as Components: Principles of Embedded Computing System Design”, 3rd Editions, Morgan Kaufman Publishers, 2012.
2. David E. Simon, “An Embedded Software Primer”, Pearson Education Asia, 2005
3. Rajkamal, “Embedded Systems Architecture, Programming and Design”, 3rd Edition, TATA McGraw Hill, 2008.
4. F. Vahid and T. Givargis, Embedded System Design: A Unified Hardware/Software Introduction, Wiley, 2002
5. P. Marwedel, Embedded System Design, Springer, 2006.
6. Steve Heath, Embedded Systems Design 2nd Edition, 2002.
7. Programming and customizing PIC microcontroller- Myke Predko, Mc- Graw Hill.
8. John.B. Peatman, “Design with PIC Micro controller”, Pearson Education, 2003.
9. Steave Furber, “ARM system – on – chip architecture” Addison Wesley, 2000.

COURSE INFORMATION SHEET

Nanoelectronic Devices and Materials

Course Code: EC592
Course Title: Nanoelectronic Devices and Materials
Pre-requisite(s): Electronic Devices (ED)
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Understand the issue in scaling MOSFET in the sub-100 nm regime and the state of the art in the areas of semiconductor device physics to enable the Nanoelectronics.
2.	Apply Fundamental Properties of Carbon Nanotube and its Synthesis techniques.
3.	Analyze how to assemble Carbon Nanotubes toward Practical Applications and Separation of Metallic and Semiconducting Single-Wall Carbon Nanotubes.
4.	Evaluate Electronic Applications of Single-Walled Carbon Nanotubes.
5.	Create Spintronics and Molecular electronics.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Describe and illustrate nonclassical transistors with new device structure.
CO2	Sketch and Explain Fundamental Properties of Carbon Nanotube and its Synthesis techniques.
CO3	Analyze and illustrate with diagram the growth and separation techniques of Single-Walled Carbon Nanotubes.
CO4	Consider and justify the Electronic Applications of Single-Walled Carbon Nanotubes.
CO5	Design and schematize Spintronic and Molecular electronic devices

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Silicon-on-Insulator Devices and Multi-gate gate transistor:** Shrink-down approaches: Introduction, CMOS Scaling, The nanoscale MOSFET, FINFETs, Vertical MOSFETs, limits to scaling, system integration limits (interconnect issues etc.), SOI CMOS: Partially Depleted SOI MOSFETs, floating body voltage of PD SOI MOSFET, Drawbacks of PD SOI CMOS process, implications for circuit styles in PD SOI devices, Fully Depleted SOl MOSFETs, Double-Gate MOSFETs: An Analytic Drain Current Model for Symmetric DG MOSFETs, the Scale Length of Double-Gate MOSFETs, Fabrication Requirements and Challenges of DG MOSFETs, Multiple-Gate MOSFETs, advantages of SOI CMOS process, Ultrathin body SOI - integration issues, vertical transistors - FinFET and Surround gate FET.	**8**
Module – II **Fundamental Properties of Carbon Nanotube and its Synthesis:** Bonding between Carbon Atoms, Structure of a Single-Wall Carbon Nanotube, Electronic Structure of Single-Wall Carbon Nanotubes, Graphene Electronic Structure, Band Structure of SWCNTs from Graphene; Synthesis: Arc Discharge, Laser Ablation, Chemical Vapor Deposition, Scalable Production of Carbon Nanotubes, Floating catalyst CVD method, Macroscopic Assembly of CNTs, Plasma-Assisted Growth of CNTs, Purification and Sorting of CNTs for Applications,	**8**
Module – III **Assembly of Carbon Nanotubes toward Practical Applications and Separation of Metallic and Semiconducting Single-Wall Carbon Nanotubes:** Necessity of Assembling CNTs, Approaches to CNT Assembly, Synthetic and Post-Synthetic Approaches: Perpendicularly aligned CNTs, Parallel aligned CNTs, Perpendicularly aligned and patterned CNTs, Parallel aligned and patterned CNTs. Separation of Metallic and Semiconducting Single-Wall Carbon Nanotubes: SWCNT Structure and Metallicity, Electric Conductivity, Dielectrophoresis, Chemical Reactivity, Separation Techniques, Metallicity Abundance Evaluation.	**8**
Module – IV **Electronic Applications of Single-Walled Carbon Nanotubes:** Field-Effect Transistors and Logic Circuits, Schottky-Contact CNTFETs, Ohmic-Contact CNTFETs, CNTFET-Based Logic Circuits, Performance Limit of CNTFETs, Single-Electron Transistors and Circuits, SWCNT-Based SETs, other nanoelectronics Devices.	**8**
Module – V **Spintronics and Molecular electronics:** New Memory Technologies: MRAM, RRAM, PCRAM; Atoms-up approaches: Molecular electronics involving single molecules as electronic devices, transport in	**8**

molecular structures, and molecular systems as alternatives to conventional electronics, molecular interconnects,	

Textbooks:

[1] Supriyo Datta, Quantum Transport: Atom to Transistor, Cambridge University Press, 2005.
[2] Qing Zhang, Carbon Nanotubes and Their Applications - Pan Stanford Series on Carbon-Based Nanomaterials, CRC Press, 2012.

Reference books:

[1] Yuan Taur and T H Ning, Fundamentals of Modern VLSI Devices, 2nd Edition, Cambridge, reprint 2016.
[2] George W. Hanson, Fundamentals of Nanoelectronics, Pearson, 2009.
[3] The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge University Press, 1998.
[4] Introduction to Nanotechnology, C. P. Poole Jr., F. J. Owens, Wiley (2003).
[5] Research Papers.

COURSE INFORMATION SHEET

Memory Devices and Technologies

Course Code: EC593
Course Title: Memory Devices and Technologies
Pre-requisite(s): Electronic Devices (ED), Basics of Electronics Engineering (BEE)
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	To appraise semiconductor memory circuits.
2.	To perceive working principle of various kinds of memory cells.
3.	To infer working principle of memory peripheral circuits.
4.	To interpret memory reliability issues and importance of power dissipation in memory.
5.	To apprehend the state-of-the-art memory circuit and chip design techniques.

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Classify semiconductor memory circuits and subsystems.
CO2	Design semiconductor memory core.
CO3	Develop in-depth knowledge on memory peripheral circuitry.
CO4	Appraise memory reliability issues, importance of power dissipation in memories.
CO5	Apply Advanced Memory Technologies

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Classification and organization of semiconductor memory circuits:** Categorization of Memory Array, Size, Timing Parameters, Function, Access Pattern, Input/Output Architecture, Application, Memory Architectures and Building Blocks, Memory Organization Example, Hierarchical Memory Architecture Example.	**8**
Module – II **Memory Core:** Read-Only Memories, ROM Cells – An Overview, Programming the ROM Memory – 4×4 MOS NOR ROM, 4×4 MOS NAND ROM, Voltage Swing in NOR and NAND ROMs, ROM Transient Performance, Word- and Bit Line Parasitics – NOR ROM and NAND ROM, Propagation Delay of NAND ROM, Static Power Dissipation of NOR ROM, Nonvolatile Read-Write Memories, EPROM, EEPROM, SRAM and its design metrics, SRAM Layout, DRAM, 3T DRAM, 1T DRAM, Layout of DRAM, Content-Addressable or Associative Memory (CAM), Application of CAM in Cache.	**8**
Module – III **Memory Peripheral Circuitry:** Address decoders, row decoders, static decoder design, decoder design example, dynamic decoders, column and block decoders, decoders for non-random-access memories, sense amplifier, differential voltage sensing, single-ended sensing, single-to-differential conversion, sensing in 1T DRAM, voltage references, voltage down converters, voltage references, drivers/buffers, timing and control.	**8**
Module – IV **Memory reliability and Power Dissipation in Memories:** Signal-to-noise ratio, Word-Line-to-Bit-Line Coupling, Bit-Line-to-Bit-Line Coupling, Leakage, Critical charge, memory yield, redundancy, error correction, example of error correction using Hamming codes. Radiation Effects, Radiation Hardening Techniques. Process and Design Issues, Radiation Hardened Memory Characteristics, Radiation Hardness Assurance and Testing. Importance of static power dissipation in memory, sources of power dissipation in memories, portioning of the memory, addressing the active power dissipation, SRAM active power reduction, DRAM active power reduction, data retention dissipation, Data retention in SRAM, turning off unused memory blocks, increasing the thresholds by using body biasing, inserting extra resistance in the leakage path, lowering the supply voltage, DRAM retention power.	**8**
Module – V **Advanced Memory Technologies:** New Trends in Nonvolatile Memories, Multilevel Nonvolatile Memories, Floating-Gate Transistor, SONOS Transistor, Flash Memory, FRAM, High Performance volatile and nonvolatile memories, Double data rate synchronous dynamic random-access memory (DDR SDRAM), Magnetic Random Access Memory (MRAM), Resistive Random Access Memory (RRAM), Phase-Change Memory (PC RAM), etc.	**8**

Textbooks:

[3] Neil H. E. Weste and David Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", 3rd International Edition, Pearson Education, Inc., 2005.
[4] Jan M. Rabaey, A. P. Chandrakasan, B. Nikolic, "Digital Integrated Circuits: A Design Perspective", 2nd Edition, Prentice Hall, 2003.
[5] Y. Taur and T.H. Ning. Fundamentals of Modern VLSI Devices. Cambridge University Press, NY, USA, 2/e, reprint 2016.

Reference books:

[5] Ashok K. Sharma, "Advanced Semiconductor Memories: Architectures, Designs, and Applications", IEEE Press, Willey Interscience, A John Willey & Sons, Inc., Publication.
[6] Neil H. E. Weste and David Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", 4th International Edition, Pearson Education, Inc., 2011.
[7] D. A. Hodges, H.G. Jackson, R.A. Saleh, "Analysis and Design of Digital Integrated Circuits", 3rd Edition, McGraw-Hill, 2004.

COURSE INFORMATION SHEET

Testing & Verifications of VLSI Circuits

Course Code: EC594
Course Title: Testing & Verifications of VLSI Circuits
Pre-requisite(s): Electronic Devices (ED), Fundamental knowledge of VLSI Design, Digital Electronics, Fabrication Process & IC Technology.
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Recognize the importance of Testing in VLSI Circuits
2.	Analyze the complex VLSI Circuits Testing techniques
3.	Show the level of testing & its advantages
4.	Design & test the highly secure optimized systems.
5.	Develop the programmable testing setup for complex system testing

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Recognize the importance of Testing in VLSI Circuits
CO2	Recognize the fault detection and correction.
CO3	Develop the robust level testing setup for verifications of ICs before packaging.
CO4	Develop the programmable testing setup for verification of packaged chip.
CO5	Apply Testing & Timing Verification

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Introduction of Testing:** Scope of testing and verification in VLSI design process, Issues in test and verification of complex chips, embedded cores and SOCs; Fundamentals of VLSI testing.	**8**
Module – II **Testing Models:** Fault models, Automatic test pattern generation, Design for testability, Scan design, Test interface and boundary scan.	**8**
Module – III **System Level Testing:** System testing and test for SoCs, Iddq testing, Delay fault testing, BIST for testing of logic and memories.	**8**
Module – IV **Testing Techniques:** Test automation: Design verification techniques based on simulation, analytical and formal approaches, Functional verification.	**8**
Module – V **Testing & Timing Verification:** Timing verification, Formal verification, Basics of equivalence checking and model checking, Hardware emulation.	**8**

Textbooks:

[1] M. Bushnell and V. D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers, 2000.

[2] M. Abramovici, M. A. Breuer and A. D. Friedman, "Digital Systems Testing and Testable Design", IEEE Press, 1990.

Reference books:

[8] T.Kropf, "Introduction to Formal Hardware Verification", Springer Verlag, 2000.

[9] P. Rashinkar, Paterson and L. Singh, "System-on-a-Chip Verification-Methodology and Techniques", Kluwer Academic Publishers, 2001.

COURSE INFORMATION SHEET
VLSI Signal Processing

Course Code: EC595
Course Title: VLSI Signal Processing
Pre-requisite(s): Electronic Devices (ED)
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Analyze the impact of pipelined and parallel processing in DSP
2.	Recognize the Iteration Bound, Retiming, unfolding, algorithmic strength reduction in filters.
3.	Show the optimized processor architecture algorithms
4.	Develop the Programmable digit signal processors.
5.	Understand DSP Optimization Techniques

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Recognize the impact of pipelined and parallel processing in DSP
CO2	Recognize the Iteration Bound, Retiming, unfolding, algorithmic strength reduction in filters.
CO3	Develop the optimized processor architecture algorithms
CO4	Develop the Programmable digit signal processors
CO5	Apply DSP Optimization Techniques

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Digital Signal Processing:** Introduction to DSP systems, Pipelined and parallel processing.	**8**
Module – II **Folding Techniques:** Iteration Bound, Retiming, unfolding, algorithmic strength reduction in filters and Transforms.	**8**
Module – III **Architecture Design:** Systolic architecture design, fast convolution, pipelined and parallel recursive and adaptive filters, Scaling and round off noise.	**8**
Module – IV **Digital Filter Design:** Digital lattice filter structures, bit level arithmetic, architecture, redundant arithmetic.	**8**
Module – V **DSP Optimization Techniques:** Numerical strength reduction, synchronous, wave and asynchronous pipelines, low power design. Programmable digit signal processors.	**8**

Textbooks:

[1] Keshab K. Parthi [A1], VLSI Digital signal processing systems, design, and implementation [A2], Wiley, Inter Science, 1999.

[2] Mohammad Isamail and Terri Fiez, Analog VLSI signal and information processing, McGraw Hill, 1994

Reference books:

[10] S.Y. Kung, H.J. White House, T. Kailath, VLSI and Modern Signal Processing, Prentice Hall, 1985

COURSE INFORMATION SHEET

FPGA & System on Chip Design

Course Code: EC596
Course Title: FPGA & System on Chip Design
Pre-requisite(s): Digital System Design
Co- requisite(s):
Credits: L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/ V
Branch: ECE
Specialization: VLSI Design & Embedded System
Name of Teacher:

Course Objectives

This course envisions imparting to students to:

1.	Recognize the fundamental of Semicustom IC Design
2.	Show the importance of FPGA in Semicustom IC Design
3.	Analyze the combination & sequential processing unit through FPGA
4.	Show the importance of SoC design, analysis, and synthesis of logic circuits
5.	Demonstrate the synthesis, modeling, model optimization and verification of digital circuit with VHDL & Verilog@HDL in the platform of FPGA & SoC

Course Outcomes

After the completion of this course, students will be able to:

CO1	Recognize the importance of SoC & FPGA in Semicustom ICs Design.
CO2	Design the optimize architecture using VHDL & implementation on FPGA
CO3	Develop the combinational & sequential processing unit for customized system using FPGA & SoC.
CO4	Use the SoC & FPGA for the design, analysis, and synthesis of logic circuits
CO5	Develop a digital system using VHDL & Verilog@HDL synthesis, modeling, model optimization, verification and implementation on FPGA & SoC (System on Chip)

SYLLABUS

MODULE	**(NO. OF LECTURE HOURS)**
Module – I **Fundamental of FPGA Design:** Synthesis, simulation, porting ASIC designs, floor-planning and timing closure, design methodologies, performance, area and power optimizations, RTL coding, IP core selection. VHDL Design units and library. Process statement, Signal vs variable assignment, Sequential statements, For loop, While loop, Condition statements, Examples of half adder and full adder, Test bench.	**8**

Module – II **FPGA Design Implementation using CAD Tools**: Data types, Scalar, Composite, Access type, File type; Arrays; Objects, Signal variables, Constants and files, Association lists, Interface lists, Structural description, Examples, Subprogram, Functions, Conversion function, Resolution functions, Procedures.	**8**
Module – III **FPGA based VHDL Packages and Synthesis**: Packages, Package declaration, deferred constants, Subprogram declaration. Simple gate - concurrent assignment, IF control flow statement, Case statement, Asynchronous preset and clear, Complex sequential statements. VHDL Design of Multiplexers, Decoders, Encoder, Code Converter, Flip-flops, Counters, Registers, Memory, Processors.	**8**
Module – IV **System Design Hierarchy & State Machine:** Basics of system hardware design, Hierarchical design using top-down and bottom-up methodology, System partitioning techniques, interfacing between system components. Design of finite state machines, state assignment strategies. Design and optimization of pipelined stages. Use of data flow graphs, Critical path analysis, retiming and scheduling strategies for performance enhancement.	**8**
Module – V **Layout Strategies & Testing:** Layout strategies at IC and board level for local and global signals. Power supply decoupling; Test strategies: Border Scan Built in Self-Test and signature analysis.	**8**

Text Books:

1. FPGA Architecture for the Challenge". *toronto.edu*. University of Toronto.
2. "VHDL" by Douglas Perry, TMH, 1999.
3. VHDL Synthesis by J. Bhasker, BS Publication 2004.
4. Jan M. Rabaey, "Digital Integrated Circuits", Prentice Hall of India, (New Delhi), 1997.
5. M.J.S. Smith, "Application Specific Integrated Circuits", Addison Wesley (Reading, MA), 1999.

Reference Books:

1. "Battle Over the FPGA: VHDL vs Verilog! Who is the True Champ?". *digilentinc.com*. Retrieved 2020-12-16.
2. Fundamental of Digital Logic with VHDL Design, by Stephen Brown I ZvonkoVranesic, The McGraw-Hill Companies.
3. Fundamental of Digital Logic with Verilog Design, by Stephen Brown I ZvonkoVranesic, The McGraw-Hill Companies
4. VERILOG HDL, A Guide to Digital Design and Synthesis, by Prabhu Goel, MULTI-D

COURSE INFORMATION SHEET

RTL Simulation and Synthesis with PLDs

Course Code: EC597
Course Title: RTL Simulation and Synthesis with PLDs
Pre-requisite(s): Electronic Devices (ED), Fundamental knowledge of VLSI Design, Digital Electronics, signals processing, signal conditioning.
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/5
Branch: ECE
SPECIALIZATION: VLSI Design & Embedded System

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Analyze the design strategies of FSM (Finite State Machine).
2.	Write the design entry by Verilog/VHDL/FSM &Verilog AMS
3.	Show the optimized perfect system design and testing by CAD tools
4.	Develop the RTL Source code, Encrypted Source code
5.	Develop the Soft IP & also explain the case studies and speed issues

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Recognize the design strategies of FSM (Finite State Machine)
CO2	Recognize the design entry by Verilog/VHDL/FSM &Verilog AMS
CO3	Apply ASIC Design Flow
CO4	Apply Testing Techniques.
CO5	Understand IP in various forms

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Design Approach:** Top-down approach to design, Design of FSMs (Synchronous and asynchronous), Static timing analysis, Meta-stability, Clock issues, Need and design strategies for multi-clock domain designs.	**8**
Module – II **Design Entry:** Design entry by Verilog/VHDL/FSM, Verilog AMS, Programmable Logic Devices.	**8**
Module – III **ASIC Design Flow:** Introduction to ASIC Design Flow, FPGA, SoC, Floor planning, Placement, Clock tree synthesis, Routing, Physical verification, Power analysis, ESD protection.	**8**
Module – IV **Testing Techniques:** Design for performance, Low power VLSI design techniques. Design for testability, IP and Prototyping.	**8**
Module – V **IP in various forms:** RTL Source code, Encrypted Source code, Soft IP, Netlist, Physical IP, Use of external hard IP during prototyping, Case studies and Speed issues.	**8**

Textbooks:

[1] Richard S. Sandige, “Modern Digital Design”, MGH, International Edit ions.
[2] Donald D Givone, “Digital principles and Design”, TMH
[3] Charles Roth, Jr. and Lizy K John, “Digital System Design using VHDL”, Cengage
[4] Samir Palnitkar, “Verilog HDL, a guide to digital design and synthesis”, Prentice Hall.

Reference books:

[11] Doug Amos, Austin Lesea, Rene Richter, “FPGA based prototyping methodology manual”, Xilinx
[12] Bob Zeidman, “Designing with FPGAs & CPLDs”, CMP Books.

COURSE INFORMATION SHEET

Fundamentals of MEMS

Course code: EC601
Course title: Fundamentals of MEMS
Pre-requisite(s): Any Branch in UG Engg/ Applied Science
Co-requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III/ VI
Branch: ECE
SPECIALIZATION: N/A, Open Elective
Name of Teacher:

Course Objectives: This course enables the students

A.	Introduction to MEMS and micro fabrication to develop an ability, enthusiasm critical thinking in microengineering process, materials and design issues
B.	To study the essential material properties and understanding of microscale physics for use in designing MEMS devices
C.	To study various sensing and transduction technique to develop an ability and understanding of microscale physics for use in designing MEMS devices
D.	To develop an inclination towards electronics system design and manufacturing
E.	To develop the fundamental concepts of MEMS technology& their applications in different areas

Course Outcomes:

After the completion of this course, students will be:

CO1	Demonstrate knowledge on fundamental principles and concepts of MEMS Technology
CO2	Have an ability to analyse various techniques for building micro-devices in silicon, polymer, metal and other materials
CO3	Correlate micro-systems technology for technical feasibility as well as practicality using modern tools and relevant simulation software to perform design and analysis.
CO4	Have an ability to compare physical, chemical, biological, and engineering principles involved in the design and operation of current and future micro-devices
CO5	Be fluent with the design, simulation and development MEMS Devices.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module-1: Introduction The History of MEMS Development, Intrinsic characteristics of MEMS, MEMS sensors and actuators, Sensor noise and Design complexity. Introduction to Microfabrication Essential overview of frequently used micro fabrication processes. Thin film deposition techniques, wafer bonding Silicon Based MEMS processes, MEMS Materials.	**8**
Module-2: Essential Electrical and Mechanical Concepts Crystal planes & orientations, General Scalar relation between Tensile stress and strain, Mechanical properties of silicon and related thin films, Flexural Beam bending Analysis, Dynamic System, Resonant Frequency and quality factor, Electromechanical and Direct Analogy in Electrical and Mechanical domain.	**8**
Module -3: Sensing and Actuation schemes Electrostatic Sensors and Actuators, Thermal sensors and actuators, Piezoresistive Sensors, Piezoelectric Sensors and Actuators, Magnetic Actuators. Comparison of Major Sensing and Actuation Methods and their Applications.	**8**
Module 4: **MEMS Packaging and Integration** Role of MEMS packages. Mechanical support Electrical interface Protection from the environment Thermal considerations Types of MEMS packages Metal packages Ceramic packages Plastic packages 368, Multilayer packages Embedded overlay Wafer-level packaging, Microshielding and self-packaging, Flip-chip assembly Multichip module packaging, Wafer bonding.	**8**
Module 5: **Case studies for selected MEMS Products** Blood Pressure Sensor, Microphone, Accelerometer, Performance and Accuracy.	**8**

TEXTBOOKS:

1.Foundations of MEMS by Chang Liu, Second Edition, Pearson, ISBN 978-81-317-64756.
2.RF MEMS and Their Applications**,** Vijay K.Varadan, K.J.Vinoy and K.A.Jose, Wiley India Pvt Ltd.,Wiley India Edition, ISBN 978-81-265-2991-9.

REFERENCE BOOKS:

1.MarcMadou, Fundamentals of Microfabrication by, CRC Press, 1997.Gregory Kovacs, Micromachined Transducers Sourcebook WCB McGraw-Hill, Boston, 1998.
2.M.-H. Bao, Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes by Elsevier, New York, 2000.
3.RF MEMS and Their Applications,Vijay K. Varadan K.J. Vinoy K.A. Jose Pennsylvania State University, USA, John Wiley & Sons Ltd -2003.

COURSE INFORMATION SHEET

Introduction to Wireless Communication

Course Code: EC603
Course Title: Introduction to Wireless Communication
Pre-requisite(s): None
Co-requisite(s):
Credits: L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III/6
Branch: ECE
Specialization: N/A, Open Elective

Course Objectives:

This course aims to develop

1	An understanding on functioning of various example wireless communication systems, their evolution and standards.
2	An understanding on cellular communication system, architecture, functioning, various standards
3	An understanding on signal propagation in cellular environment
4	An understanding on architecture, functioning, protocols, capabilities and application of various wireless communication networks.

Course Outcomes

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

CO1	Demonstrate an understanding on functioning of various example wireless communication systems, their evolution and standards.
CO2	Demonstrate an understanding on cellular communication system, architecture, functioning, various standards
CO3	Demonstrate an understanding on signal propagation in cellular environment.
CO4	Demonstrate an understanding on architecture, functioning, protocols, capabilities of various wireless communication networks.
CO5	Demonstrate various wireless communication networks.

SYLLABUS

Module	Lecture Hours
Module – I . Wireless Communication System and Standards An overview of wireless communication and future vision. satellite communication system, GPS, paging system, cordless phone, wireless local loop, RFID	**8**
Module – II : The Cellular Fundamentals cellular communication and frequency reuse, general architecture, channel assignment strategies, hand-off in a cellular system. Interference and cellular system capacity, power control, different generations of mobile cellular communication (1G, 2G. 2.5G, 3G, 4G and beyond), typical cellular standards (AMPS, GSM, GPRS, WCDMA, LTE, concept of LTE-advanced).	**8**
Module – III : Signal Propagation in Mobile Communication mobile cellular environment, multipath propagation and fading, free space propagation model, propagation path loss, outdoor propagation models (Okumura model & Hata model), indoor propagation models, power delay profile, channel parameters (delay spread, doppler spread, coherence bandwidth, coherence time, LCR and ADF).	**8**
Module – IV : Wireless Communication Networks Wireless Personal Area Networks (Bluetooth, UWB and ZigBee), Wireless Local Area Networks (IEEE 802.11, network architecture, medium access methods, WLAN standards), Wireless Metropolitan Area Networks (WiMAX), Ad-hoc Wireless Networks.	**8**
Module – V : Multiple Access Schemes Contention based and contention free multiple access schemes, FDMA, TDMA, SDMA, spread spectrum technique and CDMA, OFDMA, ALOHA and CSMA.	**8**

Books recommended:
Text Books:

1. Sanjay Kumar, “Wireless Communication the Fundamental and Advanced Concepts” River Publishers, Denmark, 2015 (Indian reprint).
2. Vijay K Garg, “Wireless Communications and Networks”, Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian reprint)

Reference Books:

1. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005.
2. Iti Saha Misra, “Wireless Communication and Networks : 3G and Beyond”, 2/e, McGraw Hill Education (india) Private Ltd, New Delhi, 2013.

COURSE INFORMATION SHEET

Modern Instrumentation Theory

Course Code: EC605
Course Title: Modern Instrumentation Theory
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III/VI
Branch: ECE
SPECIALIZATION: N/A, Open Elective

Name of Teacher:

Course Objectives:
This course enables the students:

A.	The knowledge about Silicon Sensors and its application for measurement of pressure, level, flow and Temperature. Biosensors
B.	The knowledge about DAS, Controller and Components involved in implementation of Automation system
C.	The knowledge about Distributed Control Systems
D.	The knowledge about Artificial Intelligent Based Systems
E.	The knowledge about microcontroller and Telemetry

Course Outcomes:
After the completion of this course, students will be:

CO1	Gain knowledge of Silicon Sensors and its application for measurement of pressure, level, flow and Temperature. Biosensors
CO2	Gain knowledge of DAS, Controller and Components involved in implementation of Automation system
CO3	Design Distributed Control Systems
CO4	Realize Artificial Intelligent Based Systems
CO5	Gain knowledge of about microcontroller and Telemetry

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – 1: Review of Transducer, Principles of operations and its classification, Characteristics, Technological trends in making transducers, Silicon sensors for the measurement of pressure, level, flow and Temperature. Biosensors, application and types.	**8**
Module – 2: Introduction about Instrumentation system. Types of Instrumentation system. Data acquisition system and its uses in intelligent Instrumentation system. Detail study of each block involved in making of DAS, Signal conditioners as DA, IA, signal converters (ADC), Sample and hold. Designing application for Pressure, Temperature measurement system using DAS. Data logger. Introduction to telemetry, telemetry links.	**8**
Module – 3 : Introduction about Automation system. Concepts of Control Schemes, Types of Controllers. Components involved in implementation of Automation system i.e., DAS, DOS, Converter (I to P) and Actuators: Pneumatic cylinder, Relay, solenoid (Final Control Element), Computer Supervisory Control System (SCADA), Direct Digital Control's Structure and Software. about Distribution Digital Control	**8**
Module – 4 : Introduction about Intelligent controllers, Model based controllers, Predictive control, Artificial Intelligent Based Systems, Experts Controller, Fuzzy Logic System and Controller, Artificial Neural Networks, Neuro-Fuzzy Control system.	**8**
Module –5 : Introduction to microcontroller 8051, its architecture, register, pin descriptions, addressing modes, instruction set and simple programs. Industrial application of micro controller- measurement applications, automation and control applications.	**8**

Text Books:

1. Computer Based Industrial Control – By Krishna Kant, PHI
2. Process Control Instrumentation – By Curtis D. Johnson, Pearson Education

Ref. Books:

1. Electrical & Electronics Measurements and Instrumentation By A.K.Shawhney, Dhanpat Rai & Sons.
2. Electronics instrumentation By H. S. Kalsi [TMH]

COURSE INFORMATION SHEET

Fundamentals of Microwaves

Course code: EC607
Course title: Fundamentals of Microwaves
Pre-requisites:
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 03
Class: M. Tech.
Semester/Level: III/ VI
Branch: ECE
SPECIALIZATION: N/A (Open Elective)
Name of Teacher:

Course Objectives: This course enables the students to

1	Understand important and unique engineering issues at microwave wave frequencies basic concepts of microwave systems.
2	Understand the concept of microwave network theory and the use of scattering matrix
3	Design, analyze and solve problems related to microwave waveguide. transmission lines.
4	Analyze, test and use various passive microwave components for different applications.
5	Design and implement the microwave layouts

Course Outcomes

After the completion of this course, students will be able to:

CO1	To understand about the microwave frequencies and the waveguides that are used in communication.
CO2.	Understand and Analyze various parameters and characteristics of the various waveguide components.
CO3.	Apply Smith chart use for solution of transmission line problems and impedance matching
CO4	Analyze the difference between the conventional tubes and the microwave tubes for the transmission of the EM waves.
CO5	Acquire knowledge about the measurements to be done at microwaves.

Syllabus

MODULE	(NO. OF LECTURE HOURS)
Module 1: Introduction to microwaves Microwave frequencies, advantages of microwaves, Special features and general applications of microwaves.	**6**
Module 2: Microwave transmission lines and wave guides Mathematical model of Microwave Transmission Concept of Mode, Characteristics of TEM, TE and TM Modes, Losses associated with microwave transmission, Concept of Impedance in Microwave Transmission line equations & solutions, reflection and transmission coefficient, standing wave and standing wave ratio, line impedance and admittance, impedance matching, Rectangular and circular waveguides-theory and analysis.	**10**
Module 3: Microwave Network Analysis Network parameters for microwave Circuits, Scattering Parameters. Microwave Passive components: Directional Coupler, Power Divider, Magic Tee, Wave-guide Corners, Bends, Twists, Attenuator, Circulator, Isolator and Resonator.	**9**
Module 4: Microwave sources Tubes and circuits: Limitations of conventional tubes at UHF & Microwave, Klystrons, multicavity klystron, Reflex klystron, travelling wave tube, Magnetron. Solid state devices: Tunnel diode, Varactor diodes, PIN diodes, Gunn diodes, IMPATT and TRAPATT diodes.	**9**
Module 5: Microwave Measurements Power Frequency and impedance measurement at microwave frequency, Network Analyzer and measurement of scattering parameters, spectrum Analyzer and measurement of spectrum of a microwave signal.	**6**

TEXTBOOKS:

1. Samuel Y.Liao, " Microwave Devices and Circuits", 3 rd edition, Pearson education
2. R.E.Collin, "Foundations for microwave Engineering", 2 nd edition, Tata Mc Graw Hill,1992.
3. David Pozar, *Microwave Engineering*, 3rd edition, (Wiley, 2005).

REFERENCE BOOKS:

1.Microwave Technology, Dennis Roddy, PHI

COURSE INFORMATION SHEET

Fiber Optic System and Applications

Course code: EC609
Course title: Fiber Optic System and Applications
Pre-requisite(s): Knowledge of Semiconductor Devices, Electromagnetic Theory
Co-requisite(s): None
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: 06
Branch: ECE
SPECIALIZATION: N/A, Open Elective
Name of Teacher:

Course Objectives

This course enables the students:

1.	To demonstrate the fiber optic link, fiber types, light propagation, the losses, and the dispersion effects in fiber optic systems
2.	To explain optical sources, detectors, and amplifiers
3.	To familiarize with different optical devices
4.	To understand various non-linear effects in fiber optics
5.	To know different application of optical fiber

Course Outcomes

After the completion of this course, students will be able to:

CO1	Identify the elements required to establish the fiber optic link and determine the losses and the dispersion effects in a fiber optic system
CO2	Choose the optical sources, detectors, and amplifiers for a fiber optic system
CO3	Implement different optical devices for WDM systems and other fiber optic systems
CO4	Analyze the various non-linear effects in fiber optics
CO5	Use optical fibers for various applications such as optical networking and fiber-based sensors

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Basics of Optical Fiber** Basic elements of an optical fiber transmission link, Fiber types, materials, Light propagation in SI fiber and GI fiber, Attenuation mechanisms in optical fibers, Dispersion effects in optical fibers. Birefringent fiber, Polarization-maintaining fibers, Photonic Crystal Fibers	**8**

Module – II **Optical Sources, Detectors and Amplifiers** Working LEDs and its different structures, Working of Laser Diodes and its different structures as Fabry Perot, DFB, VCSEL, Quantum Well, DBR Lasers. PIN photodiode, Avalanche photodiode, Responsivity, noise, Optical Receiver operation, BER, Optical amplifiers, Semiconductor optical amplifier (SOA) and Erbium doped fiber amplifier (EDFA)	**8**
Module – III **Optical Devices** WDM & DWDM, Optical couplers, Fiber Coupler, scattering matrix, waveguide coupler, Mach-Zehnder Interferometer Multiplexer, Isolators, Circulators, Fiber Grating Filter, Etalon, Phased Array based devices, Diffraction Grating, MEMS technology-based devices: Variable Optical Attenuator, Tunable Optical Filters, Optical Add /Drop Multiplexer, Polarization Controllers, Chromatic Dispersion Compensators, Tunable Light Sources	**8**
Module – IV **Fiber Non-linearities** Introduction, Self-phase modulation, Cross Phase modulation, Stimulated Raman Scattering, Stimulated Brillouin Scattering, Four Wave Mixing, Wavelength converters, Optical Solitons, Pulse compression, Supercontinuum generation	**8**
Module – V **Optical Fiber Applications** Optical Network Concepts, Fiber Optic LAN, Single & multi-hop networks, SONET. Optical Fiber Sensors, Classification, Fiber-optic displacement, Pressure, Rotation, flow, and current sensor. Interferometric fiber sensors: Mach-Zehnder, Michelson, Fabry Perot sensor. Fiber Bragg grating sensors	**5**

Text books:

1. “Optical Fiber Communications” G.Keiser, 3/e, McGraw Hill
2. “Optical Fiber Communication”,J. M. Senior, PHI,2nd Ed.
3. “Optical Networking and WDM”, Walter Goralski, Tata McGraw-Hill

Ref. Books:

1. “Introduction to Fiber Optics”, Ghatak &Thyagarajan, Cambridge University press.
2. “Optical Communications”, J.H.Franz &V.K.Jain Narosa Publishing House.
3. “Fiber Optics Communication”, Harold Kolimbiris, Pearson Education.
4. “Fundamentals of Fiber optics in telecommunication and sensor systems”, B. P. Pal, New age International (P) Ltd.
5. “Optical Communication Networks”, B.Mukherjee McGraw Hill.

COURSE INFORMATION SHEET

Sensors and Actuators

Course Code: EC611
Course Title: Sensors and Actuators
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III/VI
Branch: ECE
SPECIALIZATION: N/A, Open Elective

Name of Teacher:

Course Objectives

This course envisions to impact to students to:

1.	Find out the characteristics of sensors
2.	Transducer principle
3.	Working of switch as digital transducer
4.	Function of Actuators
5.	IOT based Intelligent sensor

Course Outcomes

After the completion of this course, a student will be able to:

CO1	List the characteristics of a sensor
CO2	Explain the principle of operation of a transducer.
CO3	Differentiate between analog and digital transducer
CO4	Explain the principle of operation of an actuator.
CO5	Develop IOT based intelligent sensor

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Introduction about sensors and transducers, Principles of operation and their classification, Static and dynamic characteristics of sensors, error, types of error, accuracy and precision, statistical analysis.	**8**
Module – II Resistive transducer, Capacitive transducer, Inductive transducer, Electrostatic Transducer, Piezoelectric Transducer, Thermoelectric Transducers, Radiation Sensors.	**8**
Module – III Digital Encoder, Shaft Encoder, Switches: Pressure, Level, Flow, Temperature, Proximity Switches, Limit Switches and its types, Isolators (or Barriers), Recent trends in sensors technology, Fibre Optic Sensors, Silicon sensor, Bio sensor	**8**
Module – IV Introduction to actuators, transducer, Types of actuators, Pneumatic and hydraulic actuators, Pneumatic cylinders, Single acting, Double acting and Rotary cylinders, I to P converter, Electrical actuators: Motors, Servomotors, Stepper motors, Relay, Solenoid valves, Pneumatic Valves	**8**
Module – V Introduction to Intelligent sensor architecture, Smart Transmitters, IoT Sensors and its application, Raspberry pi board, porting Raspbian, sensor interface examples	**8**

Textbooks:

1. Sensors and Transducers, by D. Patranabis. 2nd Edition
2. Elctrical & Electronics Measurements and Instrumentation by A.K Sawhney, Dhanpat Rai & Sons.
3. Transducers and Instrumentation, by Murthy D. V. S., Prentice Hall, 2nd Edition, 2011.
4. Computer Based Industrial Control – By Krishna Kant, PHI
5. Jon. S. Wilson, "Sensor Technology Hand Book", 2011, 1st edition, Elsevier, Netherland.

Reference books:

Process Control Instrumentation – By Curtis D. Johnson, Pearson Education

COURSE INFORMATION SHEET

Fundamentals of VLSI Design

Course Code: EC613
Course Title: Fundamentals of VLSI Design

Pre-requisite(s): Semiconductor Devices
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III/6
Branch: ECE
SPECIALIZATION: N/A, Open Elective

Name of Teacher: Dr. V. Nath

Course Objectives

This course envisions to impact to students to:

1.	To learn the concept of IC Technologies
2.	To understand the concept of CMOS Digital Design
3.	To design the Combinational Circuit using CAD Tools
4.	To design the Sequential Circuit using CAD Tools
5.	To understand the concept of circuit optimization & Basic Layout Design

Course Outcomes

After the completion of this course, a student will be able to:

CO1	Understand the concept of IC fabrications process
CO2	Design CMOS Digital Circuits
CO3	Design the Combinational Circuit using CAD Tools
CO4	Design the Sequential Circuit using CAD Tools
CO5	Design the Layout of Circuit and optimize it using CAD Tools

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Introduction to IC Technologies:** Wafer preparation, Orientation of wafers, Types of Wafers, Oxidations, Photolithography, Etching, Diffusion, Ion-implantation, Deposition, Metallization, CMOS process, n-well process, p-well process, SOI Techniques, Derivation of drain current equation, working operation of transistors.	**8**
Module – II **CMOS Digital Design in Various Logic Styles:** Switching action of transistors, Combinational & Sequential circuit Design using CMOS, Pseudo-nMOS Logic, Dynamic Logic, Domino Logic, Transmission Gate, Complementary Pass Transistor Logic (CPL), C^2MOS Logic.	**8**
Module – III **Combinational Circuit Design:** Combinational Circuit Design using VHDL & Verilog: Multiplexer, Decoder, Encoder, Adder, Subtractor, Comparator, ALU, etc., their CAD tools and FPGA / CPLD implementations.	**8**
Module – IV **Sequential Circuit Design:** Sequential Circuit Design using VHDL & Verilog: Flip-Flops, Counters, Registers, Semiconductor Memories, Design of Finite State Machines using CAD Tools.	**8**
Module – V **Circuit Design & Optimization:** K-map techniques, Design Rules, Layout design techniques, 16-bit multiplexer, 16-bit decoder circuit design using CAD tools, Layout of CMOS INV, NAND and NOR Gates, Fault Detection & Testing.	**8**

Textbooks:

3. Stephen Brown and Zvonko Vranesic, Fundamental of Digital Logic Design with VHDL Design, McGraw Hill
4. Neil H. E. Weste, CMOS VLSI Design: A Circuits and Systems Perspective, Pearson
5. Douglas A Pucknell, Basic VLSI Design, PHI
6. Jmames D. Plummer, M. D. Deal, Silicon VLSI Technologies- Fundamentals, Practice & Modelling, Pearson

Reference books/ E-Learning Sources:

1. Vijay Nath, Developing Suitable Pedagogical Methods for Various Classes Intellectual Calibres and Research in e-Learning
   http://www.ide.iitkgp.ac.in/Pedagogy_view/example.jsp?USER_ID=210