Department of Electronics Engineering

B. Tech. IV Electronics and Communication Engineering

(Effective from 2023-24)

Scheme

SEMESTER – VII

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				
					Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	Core-15 – Microwave Engineering	EC 401	3-1-2	05	100	25	25	25	175
2.	Core-16 – VLSI Design	EC 403	3-1-2	05	100	25	25	25	175
3.	Core-17 – Deep Learning	EC 405	3-0-2	04	100	-	25	25	150
4.	Project	EC 407	0-0-6	03	-	-	75	75	150
5.	Core Elective-IV	EC 4XX	3-0-0	03	100	-	-	-	100
6.	Core Elective-V	EC 4XX	3-0-0	03	100	-	-	-	100
7.	Core Elective-VI	EC 4XX	3-0-0	03	100	-	-	-	100
		Total	**18-2-12=32**	**26**	**600**	**50**	**150**	**150**	**950**

List of Subjects for Core Elective IV

Sr. No.	Subject	Code
1.	Optical Wireless Communication	EC 421
2.	Ad-Hoc Networks	EC 423
3.	Adaptive Signal Processing	EC 425
4.	Fundamentals of Nanoelectronics	EC 427
5.	Processor Architecture	EC 429

List of Subjects for Core Elective V

Sr. No.	Subject	Code
1.	Error Control Coding	EC 431
2.	EM Interference and Compatibility	EC 433
3.	Global Navigation Satellite System	EC 435
4.	Real Time Systems	EC 437
5.	Advanced Electronic Circuits	EC 439

List of Subjects for Core Elective VI

Sr. No.	Subject	Code
1.	MIMO Communication systems	EC 441
2.	Visible Light Communication	EC 443
3.	Estimation and Detection Theory	EC 445
4.	Speech Processing and Human-Machine Communication	EC 447
5.	Robotics	EC 449

SEMESTER – VIII
(Effective from 2023-24)

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				
					Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	Internship training in Industry / Research Organization/ Academic Institute	EC 402	0-0-20	10	-	-	120	180	300
		Total	**0-0-20=20**	**10**	**-**	**-**	**120**	**180**	**300**

Course	Semester	Credit
B. Tech. – I	Semester – I	24
	Semester – II	25
B. Tech. – II	Semester – III	22
	Semester – IV	23
B. Tech. – III	Semester – V	26
	Semester – VI	25
B. Tech. – IV	Semester – VII	26
	Semester – VIII	10
	Total UG Credit	**181**

Credit Range: 180-186

MICROWAVE ENGINEERING

L	T	P	Credit
3	1	2	05

EC 401 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	**Explain** the working principle of waveguide based and microstrip based components, sources and their applications.
CO2	**Apply** the knowledge of transmission line theory to waveguide components, microstrip components and antennas.
CO3	**Analyze** the electric and magnetic field modes in microstrip based and waveguide based components in association with the communication systems.
CO4	**Evaluate** the different parameters of microwave communication system.
CO5	**Design** the matching networks, microstrip filters of different orders, waveguide based hybrid circuits and Microwave integrated circuits.

2. **Syllabus:**

- **INTRODUCTION** **(02 Hours)**
  Circuit-Field Relations, RF Behavior of Passive Components, Chip Components.

- **MICROWAVE WAVEGUIDES AND COMPONENTS** **(08 Hours)**
  Introduction, Rectangular Waveguides, Rectangular Cavity Resonators, Circular Waveguides, Microwave Hybrid Circuits: Waveguides Tees, Magic Tees, Directional Couplers, radiation from rectangular and circular apertures, Radiation from sectoral and pyramidal horns.

- **MICROWAVE NETWORK ANALYSIS AND IMPEDANCE MATCHING** **(06 Hours)**
  Basic Definitions, Interconnecting Networks, Network Properties And Application, ABCD and Scattering Parameters, Impedance Matching using Discrete Components, Microstrip Line Matching Networks.

- **POWER DIVIDERS AND DIRECTIONAL COUPLERS** **(07 Hours)**
  The T Junction Power Divider, The Wilkinson Power Divider, The Quadrature (90°) Hybrid, Coupled Line Directional Couplers, Ratrace and Hybrid Ring.

- **MICROWAVE FILTERS** **(06 Hours)**
  Basic Resonator and Filter Configurations, Periodic Structures, Filter Design by the Image Parameter Method, Special Filter Realizations, Stepped-Impedance Low-Pass Filters, Coupled Line Filters.

- **MICROWAVE DIODES AND TUBES** **(06 Hours)**
  GaAs FET, HEMT, Varactor diodes, PIN diodes, IMPATT, TRAPATT and BARITT, Microwave Tunnel Diodes, Gunn Diodes, Schottky Diodes and Detectors, Microwave Unipolar and Bipolar Transistor: physical structure, principle of operation, characteristics, Klystrons, Magnetrons and TWT.

- **MICROWAVE ANTENNAS** **(04 hours)**
  Fundamentals of Antenna, Antenna Arrays, Microstrip, Helical, Yagi-Uda, Log-Periodic and Reflector Antennas.

- **MICROWAVE COMMUNICATION SYSTEMS AND OTHER APPLICATIONS** **(03 hours)**
  Overview of Radar, Cellular Communication, Satellite Communication

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. Practicals:

1. Introduction to Microwave Bench.
2. To determine the frequency & wavelength in a rectangular wave-guide working on TE10 mode
3. To obtain characteristics of Attenuator (Fixed and Variable type)
4. To verify properties of Magic Tee
5. To verify properties of Directional Coupler.
6. To obtain characteristics of Microstrip Band Pass and Band Stop Filters.
7. To obtain characteristics of Microstrip Power Divider.
8. To plot Mode Characteristics of Reflex Klystron.
9. To plot of V-I characteristics of Gunn Diode
10. To verify properties of Resonant Cavity
11. Study and analysis of EMI and EMC standards.
12. Experiments on Microwave Measurements :
    Power measurements: Calorimeter method, Bolometer bridge method
    Measurement of Cavity Q, Measurement of S parameters of a Network.

4. Books Recommended:

1. Ludwig Reinhold and Bretchko Pavel, "RF Circuits Design: Theory and Applications", 1st Ed., Pearson Education, Low Price ed., 2000.
2. Liao Samuel Y., "Microwave Devices and Circuits", 3rd Ed., PHI, 2nd Reprint, 2006.
3. Pozar M. David, "Microwave Engineering", John Wiley & Sons, Inc., 1999.
4. C. A. Balanis, "Antenna Theory and Design", 4th Ed., John Wiley & Sons, 2016.
5. Annapurna Das, Sisir K Das, "Microwave Engineering", 3rd Ed., Mc Graw Hill, Reprint 2017.

5. Reference Book:

1. Kumar A., "Microwave Techniques: Transmission Line", 1st Ed., New Age International, 1998.

VLSI DESIGN

L	T	P	Credit
3	1	2	05

EC 403 Scheme

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	**Describe** VLSI Design flow and circuit characterization for performance estimation.
CO2	**Demonstrate** dynamic Logic circuits.
CO3	**Compare** different semiconductor memories.
CO4	**Evaluate** the circuit performance using Logical efforts.
CO5	**Design** arithmetic building blocks (data-path) from the system's perspective along with the design of FSM (Control-path).

2. **Syllabus:**

- **INTRODUCTION OF VLSI DESIGN (06 Hours)**

  Historical Perspective, Design Hierarchy, Concepts of Regularity, Modularity and Locality, VLSI Design Styles, VLSI Design Flow, Semi Custom- Full Custom IC Design Flow, Data Path, Control Path Programmable Logic Array, CMOS and Bipolar Transistor Gate Arrays and Their Limitations, Standard Cells, FPGA/CPLD Architecture.

- **DYNAMIC LOGIC CIRCUITS (06 Hours)**

  Voltage Bootstrapping, Synchronous Dynamic Circuit Techniques, Dynamic and High Performance Dynamic CMOS Circuit, Dynamic Latches and Registers.

- **CIRCUIT CHARACTERIZATION FOR PERFORMANCE ESTIMATION (07 Hours)**

  Interconnect, Estimation of Interconnect Parasites, Delay Estimation, Logical Efforts and Transistor Sizing, Power Dissipation, Design Margin, Reliability.

- **SEMICONDUCTOR MEMORIES (08 Hours)**

  Type of Memories, design and analysis of ROM Cells, Static and Dynamic Read - Write Memories, Memory Peripheral Circuits, Power Dissipation in Memory, Flash Memory.

- **DESIGN OF ARITHMETIC BUILDING BLOCKS (10 Hours)**

  Data Path Operations: Adders, Shifter, Multiplier, Power and Speed Trade-off in Data-path Structures, Control Path and FSM.

- **INPUT-OUTPUT CIRCUITS (05 Hours)**

  ESD Protection, Input Circuits, Output Circuits, Pad Drivers and Protection Circuit, On-Chip Clock Generation/Distribution, Latch-up and its Prevention.

- **TUTORIALS (14 Hours)**

(Total Contact Hours: 56)

3. **Practical:**

1. Introduction to Verilog HDL and FPGA.
2. Implementation and Simulation of Logic Gate using Verilog HDL on FPGA
3. Design and Implementation of Half adder and Full Adder using Verilog HDL on FPGA.
4. Design and Implementation of Half subtractor and Full Subtractor using Verilog HDL on FPGA.
5. Design and Implementation of Ripple Carry Adder using Verilog HDL on FPGA.
6. Design and Implementation of Multiplexer using Verilog HDL on FPGA.
7. Design and Implementation of Flip-Flops using Verilog HDL on FPGA.
8. Design and Implementation of Registers using Verilog HDL on FPGA.
9. Design and Implementation of Four Bit Up-Down Counter using Verilog HDL on FPGA.
10. Design and Implementation of Array Building Blocks.

4. BOOKS RECOMMENDED:

1. Sung-Mo Kang and Leblebici Y., “CMOS Digital Integrated Circuits: Analysis and Design”, 3rd Ed., Tata McGraw-Hill, 2003.
2. Rabaey Jan, Chandrakasan Anantha and Borivoje Nikolic, “Digital Integrated Circuits”: A Design Perspective, Pearson Education, 2nd Ed., Second Impression, 2008.
3. Weste Neil H.E, Harris D. and Banerjee A., “CMOS VLSI Design: A Circuits and Systems Perspective”, 3rd Ed., Pearson Education, 2002.
4. Samir Palnitkar, “Verilog Hdl”– 2nd Ed., Pearson, 2003.
5. Bhasker J., “A Verilog Hdl Primer”, 3rd Ed., BS Publication, 2008.

5. Reference Book:

1. Pucknell D.A. and Eshraghian K., “Basic VLSI Design, 3rd Ed., Prentice Hall of India”, 2003.

DEEP LEARNING

L	T	P	Credit
3	0	2	04

EC 405 **Scheme**

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Describe** basic concepts of pattern classification , Neuron and Neural Network, and to analyze ANN learning.
CO2	**Demonstrate** different single layer/multiple layer Perception learning algorithms.
CO3	**Examine** concept of deep learning algorithms for various applications.
CO4	**Evaluate** the concept of optimizer and Network training.
CO5	**Design** of another class of layered networks using deep learning principles.

2. Syllabus:

- **INTRODUCTION** **(12 Hours)**
  Feature Descriptor, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss, Support Vector Machine, Multiclass support Vector Machine, Maximum margin hyper planes: Rationale for Maximum Margin, Linear SVM: Separable Case: Linear Decision Boundary, Margin of a Linear Classifier, learning a Linear SVM model, Linear SVM: Non-separable Case, Nonlinear SVM: Attribute Transformation, Learning a Nonlinear SVM, Kernel Trick, Characteristics of SVM.

- **NEURAL NETWORK** **(08 Hours)**
  Multilayer Perceptron, Feed forward Neural networks, Gradient descent and the back propagation algorithm, Example of Back Propagation Learning, Non-Linear Functions, Unsupervised Learning with Deep Network, Autoencoder, Autoencoder vs PCA.

- **CONVOLUTIONAL NEURAL NETWORK (CNN)** **(08 Hours)**
  Convolution, Cross correlation, building blocks of CNN, MLP vs CNN, Different CNN architectures, Popular CNN model, Transfer Learning, Vanishing and Exploding Gradient, Recurrent Neural Networks.

- **OPTIMISER** **(03 Hours)**
  Gradient Descent, Batch Optimization, Mini-Batch Optimization, Momentum Optimizer, Momentum and Nesterov Accelerated Gradient (NAG) Optimiser, RMSProp, Adam.

- **REGULARIZATION FOR DEEP LEARNING** **(03 Hours)**
  Parameter norm penalties, Effective training in Deep Net-early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization, Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc.

- **APPLICATIONS AND EXAMPLES** **(08 Hours)**
  Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection, Image generation with Generative adversarial networks, video to text with LSTM models.

(Total Contact Hours:42)

3. Practicals:

1. Introduction to Python for machine learning.
2. To learn data handling, visualization and preprocessing in Python.
3. Implement naïve Bayes classifier.
4. Implement decision tree.
5. Implement SVM for binary and multiclass classification considering linear and non-linear kernal.
6. Implement gradient descent for linear regression.
7. Implement gradient descent for logistic regression.
8. Implement and compare various optimization techniques (RMSprop, Adam, Adagrad)
9. Implement multilayer perceptron using back propagation for classification.
10. Implement principal component analysis (PCA) for dimensionality reduction of the given data.
11. Implement Autoencoder for image compression/denoising.
12. Implement CNN for binary and multiclass classification and adjust hyper parameters to improve the classification accuracy.
13. Implement CNN for classification and apply different regularization techniques to improve the classification accuracy.
14. Implement recurrent neural network for time series prediction.

4. Books Recommended:

1. Ian Goodfellow, YoshuaBenjio, Aaron Courville, “Deep Learning”, The MIT Press, 2017.
2. Eugene Charniak , “Introduction to Deep Learning”, The MIT Press, Hardcover, 2019.
3. Richard O. Duda, Peter E. Hart, David G. Stork ,Pattern Classification-, 2nd Ed., John Wiley & Sons Inc.Wiley; 2007.
4. Simon Haykins “Neural Network- A Comprehensive Foundation”, 2nd Ed., Pearson Prentice Hall.
5. Zurada and Jacek M, “Introduction to Artificial Neural Systems”, West Publishing Company.

5. Reference Book:

1. Christopher M. Bishop, **“**Pattern Recognition and Machine Learning”, Springer; 2nd Ed., 2011.

OPTICAL WIRELESS COMMUNICATION

L	T	P	Credit
3	0	0	03

EC 421 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** atmospheric channels for the intended terrestrial free space optical link.
CO2	**Apply** the concepts of OWC to calculate the system performance under background noise effects.
CO3	**Analyze** various modulation/demodulation techniques in designing of transmitter/receiver for OWC system.
CO4	**Evaluate** various detection techniques under various atmospheric conditions
CO5	**Design** the OWC system under different weather conditions.

2. **Syllabus:**

- **INTRODUCTION** **(06 Hours)**
  General introduction, optical channel - Beam divergence, atmospheric losses, weather condition influence, atmospheric turbulence effects viz., scintillation, beam wander, beam spreading, etc.

- **CHANNEL MODELLING** **(07 Hours)**
  Linear time invariant model, channel transfer function, optical transfer function, models of turbulence induced fading viz., lognormal, exponential, K distribution, I- distribution, gamma-gamma distribution, Optical wave models - Plane, spherical and Gaussian, range equation, transmitting and receiving antenna gains.

- **BACKGROUND NOISE EFFECTS** **(07 Hours)**
  Background noise source, detector FOV, diffraction limited FOV, spatial modes, background noise power calculation.

- **MODULATION TECHNIQUES** **(07 Hours)**
  Power efficiency, BW efficiency, bit versus symbol error rates, error rate evaluation for isochronous modulation schemes viz., M-PPM, OOK, mxnPAPM schemes, subcarrier modulation, an isochronous modulation schemes - DPPM, DHPIM, DAPPM, psd and bandwidth requirement.

- **DETECTION TECHNIQUES** **(08 Hours)**
  Photon counter, PIN/APD, PMT, coherent techniques viz., homodyne and heterodyne, bit error rate evaluation in presence of atmospheric turbulence, concept of adaptive threshold.

- **WEATHER IMPAIRMENTS** **(07 Hours)**
  Effect of turbulence and weather conditions viz., drizzle, haze fog on error performance and channel capacity, link availability.

(Total Contact Hours: 42)

3. <u>Books Recommended:</u>

1. Z. Ghassemlooy, W. Popoola, S. Rajbhandari, “Optical Wireless Communications”, 1st Ed., CRC Press, 2013.
2. L. C. Andrews, R.L.Phillips, “Laser Beam Propagation through Random Media”, 2nd Ed., SPIE Press, USA, 2005.
3. J. H. Franz, V. K. Jain, “Optical Communications: Components and Systems”, 1st Ed., Narosa Publishing House, 2000.
4. D. Chadha, “Terrestrial Wireless Optical Communication”, 1st Ed., Tata McGraw-Hill, 2012.
5. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks A Practical Perspective", Elsevier, 3rd Ed., Morgan Kaufmann Publishers, 2009.

AD-HOC NETWORKS

L	T	P	Credit
3	0	0	03

EC 423 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the basic knowledge of architecture, issues, protocols of Mobile Adhoc Networks and the standard Adhoc networks-Bluetooth, WiFi, WiMAX, WSN etc.
CO2	**Apply** protocols and techniques in MANETs, developing algorithms for recent standard Adhoc networks overcoming the constraints
CO3	**Analyze** Wireless Sensor Network Architecture.
CO4	**Evaluate** various techniques and protocols/algorithms, case study and problem solving as per given data.
CO5	**Design** of Wireless Sensor Network for IoT application.

2. **Syllabus:**

- **INTRODUCTION** **(04 Hours)**
  Introduction To Generations In Wireless Systems, Introduction To Mobile Ad-Hoc Networks (MANETS), Classification Of Mobile Data Networks, MANET issues, Wireless Channel Related Issues

- **MAC LAYER ISSUES OF ADHOC NETWORKS** **(04 Hours)**
  CSMA with Hidden and Exposed Terminal Issues, MACA and MACAW protocols

- **NETWORK LAYER ISSUES IN ADHOC NETWORKS** **(06 Hours)**
  Challenges, Proactive and Reactive Algorithms, Limitations of Bellman Ford Algorithm, DSDV, WRP, CGSR protocols, DSR, AODV, Location aided, hybrid protocols, multicast protocols

- **TRANSPORT LAYER ISSUES** **(06 Hours)**
  Challenges, data flow control mechanisms, congestion control protocols, security aspects

- **BLUETOOTH** **(04 Hours)**
  Bluetooth Network Structure: Piconet&Scatternet, Bluetooth Specifications, Bluetooth Protocol Stack, Bluetooth Media Access Control Consideration, Asynchronous Connectionless And Synchronous Connection Oriented Communication Link, Modified Bluetooth

- **WIFI - IEEE802.11 STANDARDS** **(04 Hours)**
  Various 802.11 Protocols (a to s), WiFi Architecture, Security Enhancement, QoS Enhancement, Physical & MAC Layer Aspects Of 802.11 a,b,g,n; WiFi MAC: Point Coordinate Function, Distributed Coordinate Function, Hybrid Coordinate Function

- **WiMAX - IEEE802.16 STANDARDS** **(04 Hours)**

Various 802.16 (a to e) Protocols, WiMAX Air Interface / Physical Layer, WiMAX Architecture, WiMAX Protocol Architecture, WiMAX And WiFi Interworking, WiMAX Mode: TDD And FDD, QoS In WiMAX

- **WIRELESS SENSOR NETWORK** **(06 Hours)**
  Sensor node architecture, Sensor Network architecture, Zigbee IEEE 802.15.4, Mobile Computing Aspects, Introduction to IoT

- **UWB** **(02 Hours)**
  UWB Air Interface

- **IEEE802.20 AND BEYOND** **(02 Hours)**

(Total Contact Hours: 42)

3. <u>Books Recommended:</u>

1. Toh C. K. "Ad-hoc Mobile Wireless Networks-Protocol and Systems", LPE, 2nd Ed., Pearson Education, 2009.
2. William C.Y. Lee, "Wireless& Cellular Telecommunication", 3rd Ed., McGraw-Hill, 2005.
3. Upena Dalal, "Wireless Communication", 1st Ed., Oxford University, 2009.
4. Vijay K. Garg, "Wireless Network Evolution 2G to 3G", 2nd Ed., Pearson Education, 2004.
5. C. Siva Rama Murthy, B. S. manoj, "Adhoc Wireless Networks-Architectures and Protocols", 1st Ed., Pearson, 2007.

ADAPTIVE SIGNAL PROCESSING

L	T	P	Credit
3	0	0	03

EC 425 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Define** the different theory/concepts required for adaptive algorithm
CO2	**Describe** the different algorithms used in adaptive filtering problem
CO3	**Solve** the problem related to different adaptive filtering techniques
CO4	**Analyze** different adaptive filtering techniques
CO5	**Design** different filtering techniques in practical scenario

2. **Syllabus:**

- **INTRODUCTION:** **(06 Hours)**
  Introduction to Filters, Filtering Problem, Linear Optimum Filters, Adaptive Filers, Linear Filter Structures, Different Approaches of Linear Adaptive Filters, Applications

- **RANDOM VARIABLES AND RANDOM PROCESS** **(06 Hours)**
  Random Variables, Probability Density Function and Distribution Function, Joint Random Variable, Random Process, Ensemble Averages, Correlation, Covariance, Power Spectral Density, Ergodicity, Time Averages, Biased & Unbiased Estimators, Consistent Estimators

- **WIENER FILTERING** **(06 Hours)**
  Problem Statement of Optimum Filtering, Orthogonality Principles, Minimum Mean-Square Error, Wiener- Hopf equations and Solutions, Wiener smoothing and prediction filters

- **LINEAR PREDICTION** **(08 Hours)**
  Forward Linear Prediction, Backward Linear Prediction, Prediction Error Filters, Lattice Structure, All-pole Lattice Structure, Pole-Zero Lattice Structure, Adaptive Lattice Structure, Autoregressive modelling, Predictive Modeling of Speech

- **LEAST-MEAN-SQUARE ADAPTIVE FILTERING** **(06 Hours)**
  Steepest-Descent Algorithm, Least-Mean-Square-Adaptation Algorithm (LMS), Canonical Model of the LMS Algorithm, Normalized LMS Adaptation Algorithm, Stability Analysis for Normalized LMS Filter

- **METHOD OF LEAST-SQUARES AND RECURSIVE** **(06 Hours)**
- **LEAST-SQUARES**
  Linear Least-Squares Estimation Problem, Orthogonality principles, Normal Equations and Least-Squares Filters, Singular Value Decomposition, Matrix Inversion Lemma, Recursive Least-Squares Algorithm

- **KALMAN FILTERING** **(04 Hours)**
  Statement of the Kalman Filtering Problem, The Innovation Process, Estimation of State using the Innovation Process, Kalman Filtering

(Total Contact Hours : 42)

3. **Books Recommended:**

1. Simon Haykin "Adaptive filter theory", Pearson Education India, 2003.
2. Bernard Widrow and Samuel Stearns, "Adaptive Signal Processing", Pearson Education, 1985
3. Ali H. Sayed, "Fundamentals of adaptive filtering" John Wiley & Sons, 2003.
4. Behrouz Farhang-Boroujeny, "Adaptive filters: theory and applications" John Wiley & Sons, 2013.
5. Tülay Adali and Simon Haykin, "Adaptive signal processing: next generation solutions" Vol. 55. John Wiley & Sons, 2010.

FUNDAMENTALS OF NANOELECTRONICS

L	T	P	Credit
3	0	0	03

EC 427 **Scheme**

1. Course Outcomes (COs):

At the end of the course, students will be able to:

CO1	**Describe** various carrier transport mechanisms, properties of semiconductor materials, and novel devices using mathematical equations.
CO2	**Demonstrate** physics needed for special classes of nanoelectronic devices and their applications.
CO3	**Analyze** nanoelectronic devices and their suitability in the semiconductor industry.
CO4	**Evaluate** the technological, economical and social impact of nanostructuring processes, small devices and systems.
CO5	**Develop** novel devices, processes and applications based on them.

2. Syllabus:

- **FUNDAMENTALS OF NANOSCALE PHYSICS** **(12 Hours)**
  Top-Down and Bottom-Up Approach, Potential of Nanotechnology and Nanoelectronics, Classical Particles, Quantum Mechanics of Electrons, Free and Confined Electrons, Quantum Structures

- **BAND THEORY OF SOLIDS** **(08 Hours)**
  Electrons in Periodic Potential, Kronig-Penney Model of Band Structure, Band Theory of Solids, Graphene and Carbon Nanotubes.

- **SINGLE, FEW AND MANY ELECTRONS PHENOMENA** **(11 Hours)**
  Tunnel Junctions, Applications of Tunneling, Coulomb Blockade and Single Electron Transistor, Particle Statistics, Density of States.

- **QUANTUM STRUCTURES** **(11 Hours)**
  Quantum Wells, Quantum Wires and Quantum Dots, Ballistic Transport and Spin Transport.

(Total Contact Hours: 42)

3. Books Recommended:

1. Hanson, G. W., "Fundamentals of Nanoelectronics", 1st Ed., Pearson Education, 2009.
2. Rogers, Pennathur and Adams, "Nanotechnology: Understanding Small Systems", CRC Press, Tayler and Francis Group, 2008.
3. Mahalik N. P., "Micromanufacturing and Nanotechnology", Springer, 2006.
4. Kohler and Fritzsche, "Nanotechnology: An Introduction To Nanostructuring Techniques", 1st Edition, 1st Reprint, Wiley-VCH, 2004.
5. Fahrner W. R. (Ed),"Nanotechnology And Nanoelectronics: Materials, Devices, Measurement Techniques", Springer Publications, 2005.

4. Reference Book:

1. Kumar Vijay, "Nanosilicon", 1st Ed., Elsevier Ltd., 2008.

PROCESSOR ARCHITECTURE

L	T	P	Credit
3	0	0	03

EC 429 Scheme

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Discuss** different processor architectures and system-level design processes.
CO2	**Demonstrate** the components and operation of a memory hierarchy and the range of performance issues influencing its design.
CO3	**Analyze** the organization and operation of current generation parallel computer systems, including multiprocessor and multicore systems.
CO4	**Evaluate** the principles of I/O in computer systems, including viable mechanisms for I/O and secondary storage organization.
CO5	**Develop** systems programming skills in the content of computer system design and organization.

2. **Syllabus:**

- **COMPUTER ABSTRACTIONS AND TECHNOLOGY (04 Hours)**
  Technologies for building processors and memory, Performance, Power wall, the switch from uniprocessors to Multiprocessors.

- **INSTRUCTION SET ARCHITECTURE OF 64-BIT RISC-V (08 Hours)**
  RISC-V addressing modes, instruction types, logical operations, instructions for making decisions, supporting procedures, RISC-V addressing for Wide Immediate and addresses, parallelism and instructions, comparison with MIPS and x86 Architectures.

- **PIPELINING (10 Hours)**
  An overview of pipelining, pipelined data-path and control, Data hazards: Forwarding versus Control, Control hazards, Exceptions, Parallelism via instructions, Real stuff: ARM Cortex-A53 and Intel Core i7 Pipelines, Case study: ILP and matrix multiply.

- **PARALLEL PROCESSORS (12 Hours)**
  Parallel programs, Flynn’s taxonomy, Hardware multithreading, multicore and shared memory multiprocessors, Graphics processing units, Clusters and message passing multiprocessors, Multiprocessor networks, Benchmarking of Intel Core i7 960 and NVIDA Tesla GPU, Case study: Multiprocessors and matrix multiply, Cache coherence, Advanced Cache optimizations, Real stuff: The ARM Cortex-A53 and Intel Core i7 memory hierarchy, Case study: Cache blocking and matrix multiply.

- **STORAGE AND INTERCONNECTION** **(08 Hours)**
  The basic principles of interconnection network design, On-Chip Interconnection Network, Router Architecture, Network interface design, Case Study: NoC

(Total Contact Hours: 42)

3. <u>Books Recommended:</u>

1. David A. Patterson, John L. Hennessy, "Computer Organization and Design: The Hardware Software Interface [RISC-V Edition]", The Morgan Kaufmann Series in Computer Architecture and Design, 2017
2. John L Hennessy, "Computer architecture: a quantitative approach", 6^{th} Ed., Morgan Kaufmann Publishers, 2019
3. Leander Seidlitz, "RISC-V ISA Extension for Control Flow Integrity", Technische Universität München, 2019
4. Andrew Waterman, KrsteAsanović, The RISC-V Instruction Set Manual: Volume I: User-Level ISA, riscv.org, 2017
5. Andrew Waterman, KrsteAsanović, The RISC-V Instruction Set Manual: Volume II: Privileged Architecture, riscv.org, 2017

4. <u>Reference Book:</u>

1. William James Dally, Brian Patrick Towles, "Principles and Practices of Interconnection Networks", Morgan Kaufmann, Year: 2004

ERROR CONTROL CODING

L	T	P	Credit
3	0	0	03

EC 431 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Explain** various mathematical tools: groups and finite fields, Linear algebra in the development of codes and sequences.
CO2	**Demonstrate** various codes and application in Communication for error correction
CO3	**Compare** the strengths and weaknesses of various errors correcting code for a given application.
CO4	**Evaluate** the different error correcting codes in digital communication system.
CO5	**Develop** and model different error correcting codes for appraise of reaching data rate to Shannon limit.

2. **Syllabus:**

- **CHANNEL CAPACITY AND CODING** **(06 Hours)**
  Introduction, Channel Models, Channel Capacity, Channel Coding, Information Capacity Theorem, The Shannon Limit, Random Selection of Codes, Hamming Distance, Few Points Of Information Theory.

- **BLOCK CODES** **(05 Hours)**
  The Digital Communication Channel, Introduction to Block Codes, Single Parity Check Codes, Product Codes, Repetition Codes, Hamming Codes, Minimum Distance Of Block Codes, Soft - Decision Decoding, Automatic Repeat Request Schemes.

- **LINEAR CODES** **(05 Hours)**
  Definition of Linear Codes, Generator Matrices, The Standard Array, Parity - Check Matrices, Error Syndromes, Error Detection And Correction, Shortened And Extended Linear Codes.

- **CYCLIC CODES** **(06 Hours)**
  Definition Of Cyclic Codes, Polynomials, Generator Polynomials, Encoding Cyclic Codes, Decoding Cyclic Codes, Factors Of x^n+1, Parity-Check Polynomials, Dual Cyclic Codes, Generator And Parity-Check Matrices Of Cyclic Codes, Design of cyclic coder using LFSR.

- **BCH CODES** **(05 Hours)**
  Linear Algebra, Galois Field, Definition and Construction of Binary BCH Codes, Error Syndromes In Finite Fields, Decoding SEC and DEC, Reed-Solomon Codes.

- **CONVOLUTION CODES** **(06 Hours)**
  Convolution, Encoding Convolutional Codes, Generator Matrices for Convolutional Codes, Generator Polynomials For Convolutional Codes, Graphical Representation Of Convolutional Codes, The Viterbi Decoder, Minimum distance.

- **ADVANCE ERROR CONTROL CODING** **(09 Hours)**
  Concept Of Puncturing, Interlever, Turbocode, Trellis Coded Modulation (TCM), LDPC Codes, Applications of Error Control Coding.

(Total Contact Hours:42)

3. <u>Books Recommended:</u>

1. Gravano Salvatore, "Introduction to Error Control Codes", 1st Ed., Oxford University Press, 2007.
2. Shulin/ Daniel J.Costello Jr., "Error Control Coding, Prentice Hall series in computer applications in electrical engineering" 2nd Ed., Series, 2005.
3. Bose Ranjan, "Information Theory, Coding and Cryptography", 1st Ed., Tata McGraw-Hill, 2007.
4. Moon Tood K., "Error Correction Coding - Mathematical Methods and Algorithms", 1st Ed., Wiley- Interscience, 2006.
5. SklarBernard, "Digital Communications - Fundamentals and Applications", 2nd Ed., Pearson Education-LPE, 2009.

EM INTERFERENCE AND COMPATIBILITY

L	T	P	Credit
3	0	0	03

EC 433 **Scheme**

1. **Course Outcomes (COs):**

At the end of the students will be able to:

CO1	**Classify** the different standards for EMC.
CO2	**Implement** the environments of radiation and conduction interference and methods to counter it.
CO3	**Analyze** the hazards of cross talk interference and model the methods to avoid it.
CO4	**Evaluate** the utility of different EMC methods in different environments.
CO5	**Design** a system for EMC.

2. **Syllabus:**

- **INTRODUCTION** **(04 Hours)**
  History of EMI/EMC, Analysis of EMI, Types of noise and interference, Electromagnetic Compatibility, Benefits of good EMC design, EMC regulations (Government, Commercial And Military), Examples of EMC related problems.

- **EMC REQUIREMENTS FOR ELECTRONIC SYSTEMS** **(05 Hours)**
  Radiated emission limits for Class A, Class B, FCC And CISPR, Measurement Of Emissions for Verification of Compliance, Radiated Emission and Susceptibility, Conducted Emissions and Susceptibility, Typical Product Emissions, Additional Product Requirements, Design Constraints for Products, Advantages of EMC Design.

- **CONDUCTED EMISSION AND SUSCEPTIBILITY** **(07 Hours)**
  Measurement Of Conducted Emission: LISN, Common and Differential Mode Currents, Power Supply Filters, Basic Properties of Filters, a Generic Topology, Effect of Filter Elements on Common and Differential Mode Currents, Separation of Conducted Emissions In to 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.

- **RADIATED EMISSION AND SUSCEPTIBILITY** **(07 Hours)**
  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.

- **CROSS TALK** **(10 Hours)**

  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, Inductive and Capacitive Coupling, Effect of Shield Grounding, Effect of Pigtails, Effects of Multiple Shields, MTL Model Predictions, Twisted Wires, Inductive and Capacitive Coupling, Effects of Twist, Effects of Balancing.

- **SHIELDING** **(05 Hours)**

  Shielding Effectiveness, Far Field Sources, Exact Solution, Approximate Solution, Near Field Sources: Near Field versus Far Field, Electric Sources, Magnetic Sources, Low Frequency, Magnetic Fielding Shielding, Effect of Apertures.

- **SYSTEM DESIGN FOR EMC** **(04 Hours)**

  Shielding and Grounding, PCB Design, System Configuration and Design, Electrostatic Discharge, Diagnostic Tools.

3. <u>Books Recommended:</u>

1. Paul Clayton, Introduction to Electromagnetic Compatibility, 2^{nd} Ed., Wiley Interscience, 2006.
2. Ott H. W., Noise Reduction Techniques in Electronic Systems, 2^{nd} Ed., Wiley Interscience, 1988.
3. Goedbloed, Electromagnetic Compatibility, 1^{st} English Language Ed., Prentice Hall, 1993.
4. Kaiser K. L., Electromagnetic Shielding, 1^{st} Ed., CRC Press, 2006.
5. V. Prasad Kodali, Engineering Electromagnetic Compatibility, Principles, Measurement and Technologies, IEEE Press, 1996.

4. <u>Reference Book:</u>

1. Michel Mardiguian,"EMI Troubleshooting Techniques", 1^{st} Ed., McGraw-Hill Professional, 1999.

GLOBAL NAVIGATION SATELLITE SYSTEM

L	T	P	Credit
3	0	0	03

EC 435 **Scheme**

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Classify** global as well regional navigation systems.
CO2	**Apply** knowledge of different signal structures of diverse navigation systems.
CO3	**Analyze** position of GNSS receiver using acquisition and tracking.
CO4	**Evaluate** various GNSS positioning techniques.
CO5	**Design** societal application using GNSS.

2. Syllabus:

- **GNSS OVERVIEW** **(04 Hours)**
  Introduction to GNSS systems, GNSS Architecture, Augmentation System

- **SATELLITE NAVIGATION SYSTEMS** **(08 Hours)**
  Global Navigation systems: GPS, GLONASS, GALILEO, Beidou Regional Navigation systems : QZSS, IRNSS/NavIC

- **SATELLITE SIGNAL CHARACTERISTICS: GPS/GNSS** **(08 Hours)**
  Common components of any GNSS Signal, Modulation Techniques, Multiple Accessing Techniques , CDMA-Code Division Multiple Access, FDMA-Frequency Division Multiple Access, Signal structure of different GNSS systems

- **SATELLITE SIGNAL ACQUISITION, TRACKING AND DATA DEMODULATION** **(08 Hours)**
  Introduction of Acquisition, Acquisition Methods, Serial Search in time domain, Parallel Search in frequency domain, Tracking, Navigation Data Decoding

- **GNSS POSITIONING TECHNIQUES** **(10 Hours)**
  code based positioning, phase based positioning , Single Point Positioning, Differential positioning, Precise Point Positioning, RTK

- **APPLICATIONS OF GNSS** **(04 Hours)**
  Aviation Ground-based Augmentation, Marine Navigation, Space Navigation, Vehicle Navigation, Precision Agriculture, Military Applications, Geodesy, Surveying and Mapping, Atmospheric and Ionospheric Science

(Total Contact Hours: 42)

3. Books Recommended:

1. Elliott_D._Kaplan, “Christopher_Hegarty Understanding GPS Principles and Applications”, 3rd Ed., Archtech House, Artech House, 2017.
2. Pratap Misra, “Per Enge - Global Positioning System_ Signals, Measurements, and Performance”, 1st Ed., Ganga-Jamuna Press, 2006.
3. Kai Borre,_Dennis M. Akos, Nicolaj Bertelsen, “A Software-Defined GPS and Galileo Receiver: A Single-Frequency Approach”, 1st Ed., Peterson, 2007.
4. Scott Madry, “Global Navigation Satellite Systems and Their Applications”, Springer series 10058, 2015.
5. Teunissen, Montenbruck, “Handbook of Global Navigation Satellite Systems”, 1st Ed., Springer-Verlag, 2017.

REAL TIME SYSTEMS

L	T	P	Credit
3	0	0	03

EC 437 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the foundation for programming languages developed for real time programming.
CO2	**Apply** real time operating systems and their functions.
CO3	**Analyze** the real time network.
CO4	**Evaluate** the real time systems with regard to keeping time and resource restrictions.
CO5	**Design** real time applications with RTOS.

2. **Syllabus:**

- **INTRODUCTION TO REAL-TIME SYSTEMS** **(10 Hours)**
  Hard Versus Soft Real Time Systems, Reference Models of Real Time Systems, Operating System Services, I/O Subsystems, Network Operations Systems, Real Time Embedded Systems, Operating Systems Interrupt Routines in RTOS Environments, RTOS Task Scheduling Models, Interrupt Latency And Response Time, Standardization Of RTOS

- **REAL-TIME SCHEDULING AND SCHEDULABILITY ANALYSIS** **(09 Hours)**
  Task, Process And Threads, Commonly Used Approaches To Real Time Scheduling, Clock-Driven Scheduling, Priority Driven Scheduling Of Periodic Tasks, Hybrid Schedules, Event Driven Schedules, Earliest Dead Line First (EDF) Scheduling, Rate Monotonic Algorithm (RMA), Real Time Embedded Operating Systems: Standard & Perspective, Real Time Operating Systems: Scheduling Resource Management Aspects,Quasi-Static Determining Bounds On Execution Times

- **INTER-PROCESS COMMUNICATION AND SYNCHRONIZATION OF PROCESSES,TASKS AND THREADS** **(05 Hours)**
  Multiple Process in An Application, Data Sharing By Multiple Tasks And Routines Inter Process Communication

- **REAL-TIME OPERATING SYSTEMS** **(12 Hours)**
  Handling Resources Sharing and Dependencies Among Real Time Tasks, Resource Sharing Among real Time tasks, Priority Inversion, Priority Inheritance Protocol (PIP), Highest Locker Protocol (HLP), Priority Ceiling Protocol (PCP), Different Types of Priority Inversion Under PCP, Important Features of PCP, Handling Task Dependencies, Real time communication, Real time systems for multiprocessor systems, Real-time databases.

- **COMMERCIAL REAL TIME OPERATING SYSTEMS** **(06 Hours)**
  Time Services, Unix As Real Time OS, Non-Primitive Kernel, Dynamic Priority Levels, Unix Based Real Time OS, Extension to the Traditional Unix Kernal, Host Target Approach, Preemption Point Approach, RT Linux, Windows CE as Real Time OS, Real Time POSIX Standard, MC/OS-II

(Total Contact Hours: 42)

3. <u>Books Recommended:</u>

1. Rajib Mall, "Real Time Systems Theory and Practice", 1st Ed., Pearson Education, 2007.
2. Wayne Wolf, "Computers as Components: Principles of Embedded Computing System Design", 2nd Ed., Morgan Kaufman, 2008.
3. Liu Jane, "Real-time Systems", 1st Ed., PHI, 2000.
4. Albert M. K. Cheng, "REAL-TIME SYSTEMS Scheduling, Analysis, and Verification", 1st Ed., Wiley Interscience, 2002.
5. Richard Zurawski, "Embedded Systems Handbook", 1st Ed., CRC Taylor Francis, 2006.

ADVANCED ELECTRONIC CIRCUITS

L	T	P	Credit
3	0	0	03

EC 439 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** the fundamental principles and applications of Linear and Switch Mode Power Supplies
CO2	**Discuss** the effect of static op-amp limitations and Illustrate its impact on various circuits.
CO3	**Implement** various waveform generation techniques
CO4	**Analyze** the concept of Switched capacitor and its applications in various circuit designs.
CO5	**Evaluate** analog multiplier circuit and its applications.
CO6	**Design** Linear and switching regulators according to specifications.

2. Syllabus:

- **LINEAR VOLTAGE REGULATOR** **(08 Hours)**
  Voltage References, Characteristics of Voltage Regulators, Line and Load Regulation, Series and Shunt Voltage Regulators, Protection Circuits, Low Dropout (LDO) Voltage Regulators, Adjustable Voltage Regulators, Voltage Regulator IC.

- **SWITCHING REGULATOR** **(10 Hours)**
  Choice of Switching Frequency, Operation and Design of Different types of Switching Regulators, Buck type, Boost type and Buck-Boost Type, Continuous and Discontinuous Mode, Study of PWM IC, Isolated Multi-Winding Switching Regulator, Push-Pull Configuration, Merits and Demerits of Switching Regulator.

- **STATIC OP-AMP LIMITATION** **(08 Hours)**
  Input Bias and Offset Currents, Low-Input-Bias-Current Op Amps, Input Offset Voltage, Low-Input-Offset-Voltage Op Amps, Input Offset Error and Compensation Techniques, Input Voltage Range/Output Voltage Swing, Maximum Ratings, Effect of offset voltage and bias current on various op-amp based circuits, Stability and compensation of Op-Amps.

- **FUNCTION GENERATORS** **(05 Hours)**
  Transfer Curve Synthesizer, Sine Wave Generation using an analog MUX, Waveform generation Techniques, PLL.

- **ANALOG MULTIPLIER** **(05 Hours)**
  Simple Multiplier using an Emitter Coupled Transistor Pair, Gilbert Multiplier Set, Complete Four Quadrants Analog Multiplier, IC Multiplier, Application of Analog Multiplier, Logarithmic and Antilog Amplifiers, Design issue with Log Amplifier.

- **SWITCHED CAPACITOR FILTER** **(06 Hours)**

  Switched Capacitor using a MOSFET, SC Integrator, Practical Limitation of SC Integrator, Switch Capacitor Filters, Universal SC Filters, and Gyrator Circuit.

(Total Contact Hours: 42)

3. <u>Books Recommended:</u>

1. Pressman Abraham I., "Switching Power Supply Design", McGraw-Hill, 2nd Ed., 2015.
2. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", McGraw-Hill, 4th Ed., Published: May 11, 2016.
3. K R Botkar, “Integrated Circuits”, Khanna Publisher, 10th Ed., 1987
4. Flynn Whittington, “Switched Mode Power Supplies” Universities Press; 2nd Ed. 2009.
5. Salivahanan S., "Linear Integrated Circuits", Fourth Reprint, McGraw-Hill, 2010.

MIMO COMMUNICATION SYSTEMS

L	T	P	Credit
3	0	0	03

EC 441 **Scheme**

1. **Course Outcomes (COs):**

At the end of the students will be able to:

CO1	**Describe** basic terminologies associated with multiantenna / MIMO communication systems with perception of capacity, gain, coding and detection techniques.
CO2	**Implement** different MIMO channels analytically for scenarios like CSIR, CSIT etc
CO3	**Analyze** BER, SER performance analysis of MIMO systems, space-time codes with baseband signal processing aspects also to analyze the capacity of various MIMO systems
CO4	**Evaluate** the performances of different space time codes, MIMO detection techniques like ML, ZF, MMSE etc.
CO5	**Develop** new capacity improving technique, Low complexity receiver design for MIMO with better link performance

2. **Syllabus:**

- **INTRODUCTION TO MULTI ANTENNA SYSTEM** **(10 Hours)**
  Introduction to wireless communication systems and wireless Channels, Performance in fading Wireless channels, Classical and generalized fading distributions, Error/Outage Probabilities over fading channels, Need for MIMO Systems, Multiple antennas in wireless Communication, Benefits of MIMO technology, Basic Building Block, Diversity gain, multiplexing gain, A fundamental Trade-off,MIMO in wireless networks, MIMO communication in wireless standards, Analytical MIMO channel models

- **MIMO CHANNEL CAPACITY** **(08 Hours)**
  Power allocation in MIMO system: Uniform power allocation, Adaptive power allocation, Near optimal power allocation,
  Channel Capacity of simplified MIMO channels: capacity of deterministic MIMO channel, capacity of random MIMO channel, Ergodic and outage capacity of i.i.d. Rayleigh fading MIMO channel, separately correlated Rayleigh fading MIMO channel and keyhole Rayleigh fading MIMO channel

- **INTRODUCTION TO SPACE-TIME CODING** **(04 Hours)**
  Sources and types of diversity, analysis under Rayleigh fading, performance of different diversity schemes, Space-Time Coded Systems, Performance Analysis of Space-Time Codes, Space-Time Code Design Criteria

- **SPACE TIME BLOCK AND TRELLIS CODES** **(08 Hours)**
  Alamouti Space-Time Code, SER analysis for Alamouti space time code over fading channels, Space time block codes, space time trellis codes, performance analysis of space time codes over separately correlated MIMO channel, Performance analysis.Space – time codes with no CSI

- **SPACE TIME CODING FOR FREQUENCY SELECTIVE FADING CHANNELS** **(04 Hours)**
  Frequency-selective channels – Capacity and Information rates of MIMO FS fading channels, Space - time coding and Channel detection for MIMO FS channels, MIMO OFDM systems.

- **INTRODUCTION TO MIMO DETECTION TECHNIQUES** **(04 Hours)**
  Maximum likelihood (ML) detector, Linear suboptimal detectors: Zero forcing detector, MMSE detector, Successive Interference Cancellation (SIC), Sphere decoding

- **ADVANCE TOPICS IN MIMO WIRELESS COMMUNICATION** **(04 Hours)**
  Space time block coded spatial modulation, MIMO based cooperative communication, Large scale MIMO systems, MIMO cognitive radios

(Total Contact Hours: 42)

3. Books Recommended:

1. Rakesh Singh Kshetrimayum, “Fundamentals of MIMO Wireless Communications”, 1st Ed., Cambridge University Press 2017.
2. Mohinder Jankiraman, “Space Time Codes and MIMO Systems”, Har/Cdr Ed., Artech house London, Ed. 2004
3. Branka Vucetic, Jinhong Yuan, “Space Time Coding”, 1st Ed., John Wiley & Sons Ltd, 2003
4. Paulraj, R. Nabar and D. Gore, “Introduction to Space-Time Wireless Communications”, 1st Ed., Cambridge University Press 2008
5. Tolga m. Duman, Ali Ghrayeb, “Coding for MIMO Communication Systems”, 1st Ed., John Wiley & Sons Ltd., 2007

VISIBLE LIGHT COMMUNICATION

L	T	P	Credit
3	0	0	03

EC 443 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Classify** performance improvement techniques and light positioning in visible light communication.
CO2	**Demonstrate** the synchronization issues in VLC and the positioning system.
CO3	**Apply** the visible light communication (VLC) with various modulation techniques in Li-Fi systems.
CO4	**Evaluate** VLC link design parameters.
CO5	**Design** an image sensor based VLC system.

2. **Syllabus:**

- **MODULATION TECHNIQUES** **(08 Hours)**
  Introduction – Inverse source coding in dimmable VLC – ISC for NRK-OOK – ISC for M-ary PAM – Comparison with respect to dimming capacity – Multi-level transmission scheme – Asymptotic performance – Colour intensity modulation for muli-coloured VLC – colour space and signal space.

- **PERFORMANCE ENHANCEMENT TECHNIQUES AND LIGHT POSITIOING** **(08 Hours)**
  Introduction - Performance improvement of VLC systems by tilting the receiver plane – performance improvement of VLC systems by arranging LED lamps – Dimming technique and its performance in VLC systems. Indoor positioning and merits of using light – Positioning algorithms – challenges and solutions.

- **VISIBLE LIGHT POSITIONG AND COMMUNICATION AND SYNCHRONIZATION ISSUES IN VLC** **(09 Hours)**
  Introduction – Indoor light positioning systems based on visible light communication and imaging sensors. Outdoor light positioning systems based on LED traffic lights and photodiodes. VLC modulation methods in the time domain – Bit error rate calculation – Effects of synchronization time offset on IPPM BER.

- **IMAGE SENSORS BASED VLC AND STANDARD FOR VLC** **(09 Hours)**
  Overview – Image sensors – Image sensor as a VLC receiver – Design of an image sensor based VLC system – Massively parallel visible light transmission – Accurate sensor pose estimation – Application of Image sensor based communication. Scope of VLC standard – VLC modulation standard – VLC data transmission standard – VLC illumination standard.

- **APPLICATIONS** **(08 Hours)**
  Visible light communication for vehicular networking – Smart phone camera based visible light communication – Li-Fi – High-speed visible light communication - Visible light communication: Opportunities, challenges and path to market.

(Total Contact Hours: 42)

3. Books Recommended:

1. Zabih Ghassemlooy, Luis Nero Alves, Stanislav Zvanovec, Mohammad-Ali Khalighi, “Visible Light Communication: Theory and Applications”, 1st Ed., CRC press, 2017.
2. Shlomi Arnon, “Visible light Communication”, 1st Ed., Cambridge University Press, 2015.
3. H. Franz, V. K.Jain, “Optical Communications: Components and Systems”, Narosa Publishing House, 2000.
4. T. L. Singhal, "Optical Fiber Communications: Principles and Applications", 1st Ed., Cambridge, 2015.
5. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks A Practical Perspective", 3rd Ed., Elsevier, Morgan Kaufmann Publishers, 2009.

ESTIMATION AND DETECTION THEORY

L	T	P	Credit
3	0	0	03

EC 445 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** random variables, random processes and the basic concepts of signal detection and estimation.
CO2	**Apply** detection and estimation algorithms for problems.
CO3	**Analyze** performance of different detection and estimation algorithms.
CO4	**Evaluate** performance of detection and estimation algorithms.
CO5	**Design** detector and estimator for the problems of interest.

2. Syllabus:

- **INTRODUCTION** **(02 Hours)**
  Recap of probability theory, random variable and random process, Summery of important PDFs

- **STATISTICAL DETECTION THEORY** **(04 Hours)**
  Neyman –Pearson Theorem, Receiver Operating Characteristics, Irrelevant Data, Minimum Probability of Error, Bayes Risk, Multiple Hypotheses Testing

- **DETECTION OF DETERMINISTIC SIGNAL** **(05 Hours)**
  Matched Filters, Generalized Matched Filters, Multiple Signals, Linear Model, Signal Processing Example

- **DETECTION OF RANDOM SIGNAL** **(05 Hours)**
  Estimator-Correlator, Linear Model, Estimator-Correlator for Large Data Records, General Gaussian Detection, Signal Processing Example

- **COMPOSITE HYPOTHESES TESTING** **(04 Hours)**
  Approaches: Bayesian Approach, Generalized Likelihood Ratio Test, Performance of GLRT for Large Data Records, Locally Most Powerful Detectors, , Multiple Hypotheses Testing

- **MINIMUM VARIANCE UNBIASED ESTIMATION** **(04 Hours)**
  Unbiased Estimators, Minimum Variance Criteria, Existence of the Minimum Variance Unbiased Estimator, Finding the Minimum Variance Unbiased Estimator, Extension to a Vector Parameter

- **CRAMER-RAO LOWER BOUND** **(06 Hours)**
  Estimator Accuracy Considerations, Cramer-Rao Lower Bound, General CRLB for Signals in White Gaussian Noise, Transformation of Parameters, Extension to a Vector Parameter, Vector Parameter CRLB for Transformations, CRLB for the General Gaussian Case, Signal Processing Examples

- **MAXIMUM LIKELIHOOD ESTIMATION** **(06 Hours)**
  Finding the MLE, Properties of the MLE, MLE for Transformed Parameters, Numerical Determination of the MLE, Extension to a Vector Parameter, Signal Processing Examples

- **LEAST SQUARES** **(06 Hours)**
  The Least Squares Approach, Linear Least Squares, Geometrical Interpretations, Order-Recursive Least Squares, Sequential Least Squares, Constrained Least Squares, Signal Processing Examples

(Total Contact Hours: 42)

3. <u>Books Recommended:</u>

1. Steven M. Key, "Fundamentals of Statistical Signal Processing (Volume II): Detection Theory", 1st Ed., Prentice Hall PTR, 1998.
2. Steven M. Key, "Fundamentals of Statistical Signal Processing (Volume I): Estimation Theory", 1st Ed., Prentice Hall PTR, 1993.
3. H. V. Poor, "An Introduction to Signal Detection and Estimation", 2nd Ed., Springer, 1998.
4. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part I", 2nd Ed., John Wiley, NY, 2016.
5. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part II", 2nd Ed., John Wiley, NY, 2016.

4. <u>Reference Book:</u>

1. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part III", 2nd Ed., John Wiley, NY, 2016.

SPEECH PROCESSING AND HUMAN-MACHINE COMMUNICATION

L	T	P	Credit
3	0	0	03

EC 447 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the fundamentals of speech and the speech production system.
CO2	**Apply** algorithm to extract different speech parameters.
CO3	**Analyze** different TTS models.
CO4	**Evaluate** an appropriate statistical speech model for a given application.
CO5	**Design** a speech recognition system.

2. **Syllabus:**

- **INTRODUCTION** **(04 Hours)**
  Application of speech processing; Speech signal representation and measurement; Stationary and non-stationary analysis of speech

- **SPEECH PRODUCTION AND PERCEPTION** **(06 Hours)**
  Speech production mechanism; Speech production model; Speech perception; Classification of speech sounds: voiced, unvoiced, silence, vowel, semi-vowel, consonants, diphthongs, nasal, fricative, affricative, stops etc.

- **ANALYSIS OF SPEECH SIGNAL** **(10 Hours)**
  Short-term processing, Time domain analysis: short-time energy, short-time autocorrelation, short-time zero crossing; Frequency domain analysis; Short-term Fourier transform (STFT); Filter-bank analysis; Spectrogram analysis; Cepstrum analysis; Pitch estimation: autocorrelation based, cepstrum based and LP analysis based; Formant estimation

- **LINEAR PREDICTION ANALYSIS** **(10 Hours)**
  All pole model; Pole zero model; Autocorrelation and covariance method; Levinson-Durbin algorithm; Inverse filtering; LP residual; Pitch frequency and formant frequency analysis using LP analysis, Comparison of LP model with non-linear speech production models

- **TEXT-TO-SPEECH SYNTHESIS** **(06 Hours)**
  Components of TTS, Speech synthesis methods: Concatenative and waveform based; Intelligibility and naturalness of synthesized speech; Applications and present status; WORLD vocoder

- **AUTOMATIC SPEECH RECOGNITION** **(06 Hours)**
  Statistical and machine learning Approaches; Acoustic models; Language models

(Total Contact Hours: 42)

3. **Books Recommended:**

1. L. R. Rabiner and R. W. Schafer, “Digital Processing of Speech Signals”, 1st Ed., Pearson Education India, 2003.
2. J. Benetsy, M. M. Sondhi and Y. Huang, “Springer Handbook of Speech Processing”, 1st Ed., Springer Verlag, 2008.
3. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis “Discrete-Time Processing of Speech Signals”, Wiley- IEEE Press, IEEE Edition, NY, USA, 1999.
4. D. O’Shaughnessy, “Speech Communications: Human and Machine”, 2nd Ed., University Press, 2005.
5. Thomas F Quatieri, “Discrete-Time Speech Signal Processing – Principles and Practice”, 1st Ed., Pearson Education, 2004.

ROBOTICS

L	T	P	Credit
3	0	0	03

EC 449 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** application and specification of various robots , robot kinematics and control
CO2	**Apply** localization and mapping algorithms for robots.
CO3	**Experiment** mapping and navigation for algorithms robots
CO4	**Evaluate** different planning and navigation for algorithms robots
CO5	**Design** robots for the given specification.

2. Syllabus:

- **INTRODUCTION** **(04 Hours)**
  History of Robotics-Present status and future trends, Needs of Robots, Applications, Examples and Specification of Service, Field, Non Conventional Industrial Robots

- **ROBOT KINEMATICS** **(04 Hours)**
  Fundamentals of Rigid transform, Kinematics of Mechanics, Orientation and Angular velocity, Kinematic models of Sensors, Transform Graphs and Pose networks, Quaternions.

- **ROBOT CONTROL** **(06 Hours)**
  Classical Control, State Space control, Optimal and model predictive control, Intelligent control

- **LOCALIZATION AND MAPPING** **(10 Hours)**
  Introduction, Bayes filter, Kalman Filter, Extended Kalman Filter, Information Filter, Histogram Filter, Particle Filter, Challenges of Localization, Map Representation, Probabilistic Map based Localization, Monte carlo localization, Landmark based navigation, Globally unique localization, Positioning beacon systems, Route based localization Mapping, Metrical maps, Grid maps, Sector maps, Hybrid Maps, SLAM.

- **PLANNING AND NAVIGATION** **(10 Hours)**
  Introduction, Path planning overview, Representation of Search and Global path planning (Sequential motion planning), Real time Global Motion Planning (Depth limited approaches, Anytime approaches, Plan repair approaches-D* Algorithm, Hierarchical planning)

- **MOBILE ROBOTICS** **(08 Hours)**
  Mobile Robot hardware, Non visual/Visual sensors and related algorithms, System Control, Robot collectives, Mobile robots in practise (Flying Robots, Underwater robots, Micro/nano robots, modular robots).

(Total Contact Hours: 42)

3. Books Recommended:

1. Sebastian Thrun, Wolfram Burgard, Dieter Fox, “Probabilistic Robotics”, 1st Ed., MIT Press, 2005.
2. Kevin M. Lynch and Frank C. Park, “Modern Robotics: Mechanics, Planning, and Control”, 1st Ed., Cambridge University Press, 2017.
3. Alonzo Kelly, “Mobile Robotics: Mathematics, Models, and Methods”, 1st Ed., Cambridge University Press, 2013.
4. Bruno Siciliano and Oussama Khatib, eds. “Springer Handbook of Robotics”, 2nd Edition, Springer, 2018
5. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, “Principles of Robot Motion-Theory, Algorithms, and Implementation”, MIT Press, Cambridge, 2005.