**Open Electives** ( Subjects offered by ECE Dept. for the students other than ECE)

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| **OE0501** | **Communication Systems** | **L-T-P: 3-0-0; Total 42 Lectures** |

**Prerequisite**

* Elements of Electronics Engineering

**COURSE OBJECTIVE**

* This course is intended to make students familiar with different types of modulation schemes and communication techniques used in communication system and networks.

**COURSE CONTENT**

**Unit-I: Introduction to Communication Systems:**

Fourier Transform and Fourier Series – Basic properties of Fourier Transform and Fourier Series, Power and Energy Signals, Block diagrams of different types of communication systems, like, Wired, Wireless, Optical, etc.

[7 Lectures]

**Unit-II: Analog Communication System I:**

Amplitude Modulation System: Need for modulation, Conventional AM - Representations in time and frequency domain and their Modulation and Demodulation methods, Modulation index, Double Sideband Supressed Carrier AM - Representations in time and frequency domain and their Modulation and Demodulation methods, Single Sideband AM - Representations in time and frequency domain and their Modulation and Demodulation methods. [8 Lectures]

**Unit-III:** **Analog Communication System II:**

 Angle Modulation System: Concept of Frequency and Phase modulation, Representation of FM and PM signals, Frequency deviation and Modulation index, Carson’s Rule, Narrowband FM and its generation, Generation of Wideband FM - Armstrong method, Demodulation of FM signal. [5 Lectures]

**Unit-IV:** **Discrete Time Modulation System:** Sampling Theorem – Low pass and Band pass, Quantization, Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM) and their generation and detection. [4 Lectures]

**Unit-V:** **Digital Communication System:** Advantages of Digital communication over Analog communication, Pulse Code Modulation, Differential PCM, Delta Modulation, Introduction of Digital modulation schemes – ASK, FSK, PSK, etc. [7 Lectures]

**Unit-VI:** **Optical Communication System:**

Introduction to Fiber Optics, Types of Optical Fibers - step index and graded index, multimode and single mode; Signal Distortion in Optical Fiber Communication, Introduction of Optical Sources and Optical Detectors. [6 Lectures]

**Unit-VII: Wireless Communication System**

 Introduction to Wireless Communication and types of Wireless Communication, Frequencies used and Ranges, Basic Challenges and Requirements, Different Generations of Wireless Communications, Basic Propagation methods, Concept of Cellular Communications and Frequency reuse, Handoffs. [5 Lectures]

**Text Books**

1. J. G. Prokias, and M. Salehi, ‘Fundamentals of Communication Systems’, Fifteenth Impression, Pearson Education Inc., India, 2013.

2. J. M. Senior, ‘Optical Fiber Communications: Principles and Practices’ 3rd Edition, Pearson Education Inc., India, 2013.

3. T. S. Rapport, ‘Wireless Communications: Principles and Practices’, 2nd Edition, Pearson Education Inc., India, 2011.

**Reference Books**

1. B.P. Lathi, and Zhi Ding, Modern Digital and Analog Communication Systems, 4th Edition, Oxford University Press, 2017.
2. G. Kennedy, and B. Davis, ‘Electronic Communication Systems’, 4th Edition, TMH Publishing Company Limited, India, 2010.
3. G. Keiser, ‘Optical Fiber Communications’, 5th Edition, McGraw Hill Education (India) Pvt. Ltd., India, 2013.
4. H. Taub, D. L. Schilling, G. Saha, ‘Principles of Communication Systems’, 3rd Edition, TMH Publishing Company Limited, India, 2008.

**COURSE OUTCOMES**

Students would be able to –

CO1: Understand the principle of Analog modulation schemes, such as Amplitude modulation, Frequency modulation, etc. along with the Analog Communication Systems.

CO2: Understand the principle of Sampling Theorem and Pulse modulation approaches.

CO3: Understand the principle of Digital Communication System and some important Digital Modulation schemes, such as ASK, PSK, QAM, etc.

CO4: Understand the different varieties of Optical Fiber, Optical Sources and Optical Detectors used in Optical Fiber Communication System.

CO5: Understand the different types of Wireless communication systems, concept of cellular system design, and Handoff strategies.

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| **OE0502** | **Electronics Technology** | **L-T-P: 3-0-0; Total 42 Lectures** |

**Prerequisite:** Engineering Physics

**Course Objectives:**

* To give students a comprehensive overview of electronics system in general.
* To give basic idea about different semiconductor devices

**UNIT I (6 Lectures)**

**Introduction:** Semiconductor; Discrete Components: resistor, capacitor, inductor, diode, transistor, LED, etc.; Multimeter, CRO, bread board, printed circuit board and its design; Working principle of diode, diode characteristics; Brief introduction to PNP & NPN BJT; Introduction to the concept of Integrated circuit (IC) and VLSI.

**UNIT II (7 Lectures)**

**Analog Electronics:** Application of diode e.g. rectifier; Application of BJT as amplifier and switch; OpAmp and its advantages; Application of OpAmp: Inverting and non-inverting amplifier, adder, subtractor, IC741.

**UNIT III (6 Lectures)**

**Digital Electronics:** Logic gates; Multiplexer; De-multiplexer; Flip-Flop; Shift Register; Counter; A/D and D/A converter.

**UNIT IV (6 Lectures)**

**Microcontroller & Computer Architecture:** Basic block diagram of a typical computer architecture; Basic working principle of ALU and control unit; processor instruction format; Introduction to I/O operation. Example of industrial application of microcontroller.

**UNIT V (7 Lectures)**

**Radio Technology:** Electromagnetic spectrum; Applications of radio technology in domains like wireless communication, RADAR, broadcasting, remote sensing, navigation, etc.; Block diagram of a typical wireless communication system; Block diagram of a typical radio transmitter and receiver; The need of modulation in communication system; Frequency translation; Brief introduction to analog modulation: AM, FM, PM; Advantages of digital communication over analog communication; Cellular Communication System: Introduction to the cell structure, frequency reuse, and hand off.

**UNIT VI (4 Lectures)**

**Consumer Electronics:** Working principle of the following: DVD, DVD player, LCD TV, Plasma TV, LED TV, 3D TV, Microwave oven, GPS, and HDTV System.

**UNIT VII (6 Lectures)**

**Industrial Control:** Introduction to Laplace Transform; Transfer function; Stable and unstable system; Introduction to feedback control; Advantage of closed loop control over open loop control; Introduction to sensors, transducers and actuators with practical examples; Introduction to Programmable logic controller (PLC) with example.

**Text Books:**

1. Electronics Explained, Lou Frenzel, Elsevier, 2010.

**Reference Books:**

1. Electronics Technology Handbook, Neil Sclater, McGraw Hill, 1999.

**Course Outcome:**

Upon completion of the course, students should posse the following knowledge and skills:

* An understanding of a machine's instruction set architecture including basic instruction fetch and execute cycles, instruction formats, control flow, and operand addressing modes.

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| **OE0504** | **Digital Image Processing** | **L-T-P: 3-0-0; Credit: 3; Total 42 Lectures** |

*Prerequisites:* (i) Digital Signal Processing, (ii) Signals and Systemsand (iii) Linear Algebra

*Objectives:* 1. To introduce the origin and formation of digital imaging.

2. To develop the understanding of different types of imaging techniques for different purposes.

3. To equip the students with various possible applications of the image analysis.

*Course Outcome:* 1. Ability to enhance image in spatial and frequency domain.

2. Ability to implement various aspects of image segmentation and compression.

*Topics Covered:*

1. **Digital Image Fundamentals:** Image modeling, Sampling and Quantization, Imaging Geometry, Digital Geometry, Image Acquisition Systems, Different types of digital images.

2. **Bi-level Image Processing:** Basic concepts of digital distances, distance transform, medial axis transform, component labeling, Histogram of grey level images, Optimal thresh holding.

3. **Images Enhancement:** Point processing, enhancement in spatial domain, enhancement in frequency domain.

4. **Detection of edges and lines in 2D images:** First order and second order edge operators, multi-scale edge detection, Canny's edge detection algorithm, Hough transform for detecting lines and curves.

5. **Color Image Processing:**Color Representation, Laws of color matching, chromaticity diagram, color enhancement, color image segmentation, color edge detection.

6. **Image compression:**Lossy and lossless compression schemes, prediction based compression schemes, vector quantization, sub-band encoding schemes, JPEG compression standard.

7. **Segmentation:** Segmentation of grey level images, Watershed algorithm for segmenting grey level image.

8. **Morphology:** Dilation, erosion, opening, closing, hit and miss transform, thinning, extension to grey scale morphology.

9. **Feature Detection:** Fourier descriptors, shape features, object matching/features.

**Texts Books:**

1. R. C. Gonzalez and R. E. Woods, Digital Image Processing, Pearson Education, 2008.

2. A. K. Jain, Fundamentals of Digital Image processing, Pearson Education, 2009.

**References Books:**

1. W. K. Pratt, Digital Image Processing, John Wiley & Sons, 2006.

 2. S.J. Solari, Digital Video and Audio Compression, McGraw-Hill, 1997

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| **OE0506** | **Embedded System design** | **L-T-P: 3-0-0; Credit: 3; Total 42 Lectures** |

***Prerequisites****:* **(i)** Digital Electronics (ECI 1 1)

*Objectives:* This course concerns with Embedded systems basic knowledge: embedded architectures: Architectures and programming of microcontrollers: embedded system applications..

***Course Outcome*:** Upon successful completion of this course, students should be able to understand the following:

(1) Introduction to Microcontroller Organization and Architecture **(ARM.**8051)

(2) Data Representation and Memory Usage

(3) Problem Solving and Algorithm Development

(4) Assembling/Compiling and Execution

(5) Assembly and C Programming

(6) Analysis of timing and memory requirements.

(7) Embedded system applications

Course Detail

**UNIT –I: Introduction to Embedded Systems**

Definition of Embedded System. Embedded Systems Vs General Computing Systems. History of Embedded Systems.Classification, Major Application Areas. Purpose of Embedded Systems,Characteristics and Quality Attributes of Embedded Systems

**Typical Embedded System:**

Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs,Commercial Off-The-Shelf Components (COTS), Memory: ROM. RAM. Memory according to thetype of Interface.Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators. Communication Interface: Onboard and External Communication Interfaces.

**UNIT- II: Programming Embedded Systems in C**

Introduction .What is an embedded system. Which processor should you use. Which programming language should you use. Which operating system should you use. How do you develop embedded software,

**UNIT- III: Embedded Firmware:**

Reset Circuit. Brown-out Protection Circuit. Oscillator Unit. Real lime Clock. Watchdog Timer, Embedded firmware Design Approaches and Development Languages.

**UNIT- IV: RTOS Based Embedded System Design:**

Operating System Basics, Types of Operating Systems, Tasks. Process and Threads. Multiprocessing and Multitasking, Task Scheduling.

**Task Communication:** Shared Memory. Message Passing. Remote Procedure Call and Sockets. Task Synchronization: Task Communication/Synchronization Issues. Task Synchronization Techniques, Device Drivers, How to Choose an RTOS.

**UNIT –V: ARM Architecture**

ARM Design Philosophy, Registers, Program Status Register. Instruction Pipeline Interrupts and Vector Table. Architecture Revision, ARM Processor Families. ARM Programming Model – I: Instruction Set: Data Processing Instructions. Addressing Modes. Branch. Load. Store Instructions, PSR Instructions. Conditional Instructions.

**UNIT –VI: ARM Programming Model - II:**

Thumb Instruction Set: Register Usage, Other Branch Instructions. Data Processing Instructions. Single-Register and Multi Register Load-Store Instructions. Stack. Software Interrupt Instructions

**UNIT –VII: ARM Programming:**

Simple C Programs using Function Calls, Pointers, Structures, Integer and Floating Point Arithmetic, Assembly Code using Instruction Scheduling, Register Allocation. Conditional Execution and Loops

**Text Book:**

1. Embedded System Design - Frank Vahid, Tony Givargis, John Wiley..

2. Embedded C - Michael J. Pont, 2nd Ed., Pearson Education, 2008.

3. ARM Systems Developer's Guides- Designing & Optimizing System Software Andrew N.

4. Sloss. Dominic Symes. Chris Wright, 2008. Elsevier

**Reference Books**

1. Introduction to Embedded Systems - Shibu K.V, McGraw Hill.

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| **OE0507** | **Information Theory and Coding** | **L-T-P: 3-0-0; Credit: 3; Total 42 Lectures** |

***Prerequisites****:* i) Probability Theory ii) Analog and Digital Communication Engineering

***Objective****:* To expose to students some concepts in information theory, and the performance characteristics of an ideal communications system. To expose to students fundamentals in coding and its applications.

***Course Outcome****:* Upon successful completion of this course, students should be able to:

Have understood the notion of information in the quantitative sense

Have understood how the quantity of information could be measure

Have understood the concept and properties of entropy and mutual information as it applied to information

Have understood, and be able to prove, the noiseless coding theorem (Shannon's First Theorem)

Be able to construct compact and non-compact codes for a given data ensemble

Have understood the notions of channels, different classes of channel, and channel capacity

Have understood the fundamental coding theorem for noisy channels (Shannon's Second Theorem), and its implications

Have understood simple methods for construction of error correction codes

Topics Covered

**Unit 1: Introduction to Information Theory Lectures-7**

Introduction to Information Theory and Coding; Definition of Information Measure and Entropy, Relative Entropy, Extension of An Information Source and Markov Source, Adjoint of An Information Source, Joint and Conditional Information Measure, Properties of Joint and Conditional Information Measures and A Morkov Source, Asymptotic Properties of Entropy and Problem Solving in Entropy, Estimation of Probability Density and Probability Mass Functions, Expectation-Maximization algorithm, Maximum Entropy Principle, Jensen’s Inequality; Fano’s Inequality; Data Processing Inequality.

**Unit 2: Source Coding Lectures-6**

Introduction to Lossless Coding; Block Code and its Properties, Instantaneous Code and Its Properties, Kraft-Mcmillan Equality and Compact Codes, Shannon’s Source Coding Theorem, Source coding techniques including Shannon Fano, Huffman, LZW algorithms.

**Unit 3: Channel Capacity and Coding Lectures-8**

Introduction to Discrete Information Channels, Equivocation and Mutual Information, Properties of Different Information Channels, Reduction of Information Channels, Noiseless Channel, Properties of Mutual Information and Introduction to Channel Capacity, Calculation of Channel Capacity for Different Information Channels, Shannon’s Channel Coding Theorem, Bandwidth-S/N Trade-Off, Channel Capacity Theorem, Discussion On Error Free Communication Over Noisy Channel, Error Free Communication Over A Binary Symmetric Channel and Introduction to Continuous Sources and Channels, Differential Entropy and Evaluation of Mutual Information for Continuous Sources and Channels, Channel Capacity of A Band-Limited Continuous Channel.

**Unit 4: Linear Block and Cyclic Error-Correction Coding Lectures-9**

Definition of Terms – Redundancy, Code Efficiency, Systematic Codes, Hamming Distance, Hamming Weight, Hamming Bound; Types of Codes – Parity Check Codes, Hamming Codes, BCH Codes, Reed-Solomon Codes, Concatenated Codes; Linear Block Codes, Generator and Parity Check Matrix, Syndrome Decoding; Cyclic Codes, Generation and Detection; Coding for Reliable Communication, Coding Gain, Bandwidth Expansion Ratio; Comparison of Coded and Un-coded systems.

**Unit 5: Convolutional Code Lectures-8**

Burst Error Detecting and Correcting Codes; Convolutional Codes; Time Domain and Frequency Domain Approaches; Code Tree, Trellis and State Diagram; Decoding of Convolutional Codes, Transfer Function and Distance Properties of Convolutional Codes; Bound on the Bit Error Rate; Coding gain.

**Unit 6: Coded Modulation Lectures-4**

Coding for Bandwidth Constrained Channels -- Combined Coding and Modulation, Trellis Coded Modulation (TCM), Set-partitioning, Encoder and Decoder Design for TCM, Decoding of TCM Codes using the Viterbi Algorithm.

**Books:**

1. T. M. Cover and J. A. Thomas, ‘Elements of Information Theory’, 2nd Edition, Wiley India Pvt. Ltd, 2013.

2. I. Csiszar and J. Korner, ‘Infromation Theory: Coding Theorems for Discrete Memoryless Systems’, 2nd Edition, Cambridge University Press, 2011.

3. R. G. Gallager, ‘Information Theory and Reliable Communication’, JohnWiley& Sons, 1969.

4. R. E. Blahut, ‘Algebraic Codes for Data Transmission’, 1st Edistion, Cmabridge University Press, 2003.

5. Digital Communications Systems, Simon Haykin, John Wiley & Sons, Inc., 2013.

**Other useful references:**

1. C.E. Shannon, “A Mathematical Theory of Communications”, Bell System Tech. Journal, Vol. 27, July and Oct. 1998.

2. G. Forney and D. Costello, B., “Channel coding: The road to channel capacity”, Proc. IEEE, vol. 95, no. 6, pp. 1150–1177, Jun. 2007.

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| **OE0508** | **Digital Signal Processing** | **L-T-P: 3-0-0; Credit: 3; Total 42 Lectures** |

***Prerequisites:* (i)** Signals and System Analysis

***Objectives:*** This course concerns with different concepts of Digital Signal Processing and it's need for different real world applications.

***Course Outcom****e:* Upon successful completion of this course, students should be able to understand the following:

Representation of discrete time signals in temporal and spectral domain.

Processing of the Discrete-time signals in temporal and spectral domain.

Analysis and design of different Infinite Impulse Response (IIR) filters and Finite Impulse Response (IIR) filters.

Realization of digital filters.

The concepts of Multirate digital signal processing and it's need for signal processing task.

The applications of digital signals processing for different real world applications.

**Course Detail**

**UNIT –I: Review of z-transform and DTFT-**Review of z-transform and DTFT.

**UNIT –II: Discrete Fourier Transform (DFT)-**Frequency domain sampling (Sampling of DTFT), DFT and its inverse, zero padding, DFT as a linear transformation (matrix method), properties. Spectrum analysis using DFT. Filtering of long data sequences using DFT: overlap save method, overlap add method.

**UNIT –III: Fast Fourier Transform (FFT): Radix-2 FFT algorithms-**Decimation-in-time (DIT-FFT) algorithm, Decimation-in-frequency (DIF-FFT) algorithm. Inverse DFT using FFT algorithms.Goertzel algorithm, Chirp-z transform algorithm.

**UNIT –IV: Filter Concepts-**Frequency response and filter characteristics, phase delay and group delay, zero-phase filter, linear-phase filter, Simple FIR filters, Simple IIR filters, All pass filter, Minimum-phase system, Averaging filter, Comb filter, Digital resonator, Notch filter, Digital sinusoidal oscillator.

**UNIT –V: FIR Digital Filter-**Desirability of linear-phase filters, Frequency response of linear phase FIR filters, Filter specifications: absolute specifications, relative specifications, analog filter specifications. Design techniques: windowing, frequency sampling method, digital Hilbert transformer.

**UNIT –VI : IIR Digital Filter-**Analog filters, Butterworth and Chebyshev approximation. Bilinear transformation method, warping effect.Spectral transformation. Design of low pass ,high pass, band pass and band elimination filter

**UNIT –VII: Realizations of Digital Filters-**FIR filter structures: direct form, cascade form, linear-phase form, FIR Lattice structure. IIR filter structures: direct form-I, direct form-II, cascade form, parallel form, All pole lattice structure, lattice-ladder (pole-zero) lattice structure.

**UNIT –VIII: Multirate Signal Processing-**Decimation, Interpolation, The polyphase decomposition, Digital filter banks, Nyquist filters, Two-channel QMF.

***Text Book:***

1. Digital Signal Processing by Alan V. Oppenheim, Ronald W. Schafer , PHI

***Reference Book****:*

1. S K Mitra, Digital Signal Processing-A Computer Based Approach, Tata McGraw Hill.
2. Digital Signal Processing by John G. Proakis, Dimitris K Manolakis, Pearson.

***Course Outcom****e:* Upon successful completion of this course, students should be able to understand the following:

1. Representation of discrete time signals in temporal and spectral domain.
2. Processing of the Discrete-time signals in temporal and spectral domain.
3. Analysis and design of different Infinite Impulse Response (IIR) filters and Finite Impulse Response (IIR) filters.
4. Realization of digital filters.
5. The concepts of Multi-rate digital signal processing and it's need for signal processing task.
6. The applications of digital signals processing for different real world applications.

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| **OE0509** | **Remote Sensing** | **L-T-P: 3-0-0; Total 42 Lectures** |

*Prerequisites:*(i) Digital Signal Processing, (ii) Signals and Systems

*Objectives:* 1. To introduce the origin and formation of satellite imaging.

2. To develop the understanding of different types of satellite imaging techniques for differentpurposes.

3. To equip the students with various possible remote sensing applications

*Course Outcome:*1. Ability to enhance the satellite image in spatial and frequency domain.

2. Ability to implement various aspects of remote sensing image for different applications.

*Topics Covered:*

**Unit-1:Introduction and Basic Concepts:**Basic Concepts of Remote Sensing, EMR Spectrum, Energy Interactions in the Atmosphere,Energy Interactions with Earth Surface Features,Spectral Reflectance Curves.

**Unit-2:Remote Sensing Systems:**Satellites and Orbits, Spatial and Spectral Resolutions,Radiometric and Temporal Resolutions,Multispectral, Thermal and Hyperspectral Remote Sensing, Features of the Remote Sensing Satellites.

**Unit-3: Digital Image Processing:**Image modeling, Sampling and Quantization, Imaging Geometry, Digital Geometry, Image Acquisition Systems, Different types of digital images, Geometric Corrections, Atmospheric Corrections, Concept of Color and Color Composites, Contrast Stretching,Filtering and Edge Enhancement, Density Slicing, Thresholding, Point processing, enhancement in spatial domain, enhancement in frequency domain, Segmentation of grey level images, Watershed algorithm for segmenting grey level image.

**Unit-4: Satellite Image Processing-Information Extraction Module:** Supervised Classification, Unsupervised Classification, Fuzzy Classification, Image Transformation,Principal Component Analysis

**Unit-5:** Remote Sensing Applications: Watershed Management, Rainfall-Runoff Modelling,Irrigation Management,Flood Mapping, Drought Assessment, Environmental Monitoring,Other Applications in Engineering

**Reference Books:**

 1. Schowengerdt, R. A. (2006). *Remote sensing: models and methods for image processing*. Elsevier.

2. R. C. Gonzalez and R. E. Woods, Digital Image Processing, Pearson Education, 2008.

3. Bhatta, B. (2008). *Remote sensing and GIS*. Oxford University Press, USA.

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| **OE0510** | **Pattern Recognition** | **L-T-P: 3-0-0; Total 42 Lectures** |

*Prerequisites:*(i) Digital Signal Processing, (ii) Signals and Systems and (iii) Linear Algebra

*Objectives:* 1. To familiarize with the mathematical and statistical techniques used in pattern recognition.

2. To understand and differentiate among various pattern recognition techniques.

*Course Outcome:*1. Ability to formulate high dimensional feature vectors from observations.

2. Ability to select an appropriate pattern analysis tool for analysing data in a given feature space.

3. Abilityto apply pattern analysis tools to practical applications and detect patterns in the data.

*Topics Covered:*

**1. Introduction:** Definitions, data sets for Pattern Recognition, Different Paradigms of Pattern Recognition

**2. Bayes Decision Theory:** Bayes decision rule, Minimum error rate classification, Normal density and discriminant functions, Bayesian networks

**3. Generative Methods:** Maximum Likelihood and Bayesian Parameter Estimation, Nonparametric techniques

**4. Discriminative Methods:** Distance-based methods, Linear Discriminant Functions, Artificial Neural Networks, Support Vector Machines

**5. Clustering:** k-means clustering, Gaussian Mixture Modeling, EM-algorithm

**6. Principal Component Analysis:** PCA, Kernel PCA, Probabilistic PCA

**7. Combining Classifiers:** Bagging and Boosting, Adaboost, Bayesian Model Averaging

**Reference Books**

1. Duda, R. O., Hart, P. E. and Stork, D., (2002), Pattern Classification, Wiley

2. Bishop, C., (2006), Pattern Recognition and Machine Learning, Springer

3. Cristianini, N. & Taylor, J. S., (2000), An Introduction to Support Vector Machines, Cambridge University Press

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| **ECOE0512** | **VLSI Design** | **L-T-P: 3-1-0; Total 42 Lectures** |

**Pre-requisite:** Basic device electronics, MOSFET properties, and logic circuits.

**Objectives:**This course is intended to impart in-depth knowledge about analog and digital CMOS circuits.The focus is on CMOS technology. Issues to be covered include deep submicron design, clocking, power dissipation, CAD tools and algorithms, simulation, verification, testing, and design methodology. This course also dealt with design analysis techniques for the static and dynamic evaluation of CMOS circuits and memory elements including flip-flops, SRAM, and DRAM.

**Outcomes:** After completion of course Student should be able to explain the modeling aspects and physics of semiconductor, E-k diagram and fermi energy level, leakage mechanism in gate oxide of devices, junction effect, tunneling and scaling in MOS.

**Topics Covered**

**Unit I:Introduction to VLSI design:** Introduction to VLSI Design; Moore’s Law; Scale of Integration; Types of VLSI Chips; Design principles (Digital VLSI); Design Domains(Y-Chart), Challenges of VLSI design- power, timing area, noise, testability reliability, and yield; CAD tools for VLSI design. [6L]

**Introduction to VLSI Technology:**VLSI Technology-An Overview-Wafer Processing, Oxidation, Epitaxial Deposition, Ion-implantation and Diffusion; The Silicon Gate Process- Basic CMOS Technology; basic n-well CMOS process, p-well CMOS process; Twin tub process, Silicon on insulator; CMOS process enhancement-Interconnect; circuit elements; 3-D CMOS, SOI, TFET, FINFET.[8L]

**Analysis of CMOS logic Circuits:**

MOSFET as Switch; Recapitulation of MOS; CMOS Inverter, CMOS logic circuits; NAND gate and NOR Gate; Complex logic circuits; Pass transistor logic; CMOS Transmission gate; CMOS full adder.[10L]

**Advanced Techniques in CMOS logic circuit:**Pseudo nMOS; Tri-state; Clocked CMOS; Dynamic CMOS logic- Domino, NORA, Zipper, etc.; Dual rail logic networks. [6L]

**Memories:** Static RAM; SRAM arrays; Dynamic RAMs; ROM arrays; Logic arrays. [6L]

**Timing issues in VLSI system design:** Timing classification- synchronous timing basics, skew and jitter, latch based clocking, self timed circuit design; self timed logic; completion signal generation; self timedsignaling–synchronizers and arbiters. [6L]

**Text/Reference Books:**

1. Neil H. E. Weste and Kamran Eshraghian, “Principles of CMOS VLSI Design”, 2nd edition, Pearson Education Asia.
2. Jan M. Rabaey, AnanthaChandrakasan, BorivojeNikolic, “Digital Integrated Circuits: A Design Perspective,” Prentics Hall
3. Jan M. Rabaey, AnanthaChandrakasan, BorivojeNikolic, “Digital Integrated Circuits: A Design Perspective,” Prentics Hall
4. R. Jacob Baker, “CMOS Mixed-Signal Circuit Design,” Wiley India Pvt. Ltd.
5. Ivan Sutherland, R. Sproull and D. Harris, “Logical Effort: Designing Fast CMOS Circuits”, Morgan Kaufmann
6. Jan M. Rabaey, AnanthaChandrakasan, BorivojeNikolic, “Digital Integrated Circuits: A Design Perspective,” Prentics Hall