# M.TECH. IN
## DIGITAL ELECTRONICS & COMMUNICATION ENGINEERING (Course Code: 37)
### &
## DIGITAL ELECTRONICS & COMMUNICATION SYSTEMS (Course Code: 38)

## COURSE STRUCTURE AND SYLLABUS

### I – Semester

| S. No. | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | M253701 | Structural Digital System Design | 3 | 1 | 0 | 4 |
| 2 | M253702 | Detection & Estimation Theory | 3 | 1 | 0 | 4 |
| 3 | M253703 | Advanced Communications and Networks | 3 | 1 | 0 | 4 |
| 4 | M253704 | Design of Fault Tolerant System | 3 | 1 | 0 | 4 |
|  | M253705 | System on Chip Architecture |  |  |  |  |
|  | M253706 | Microwave & Millimeter Wave Devices |  |  |  |  |
|  | M253707 | Advanced Digital Signal Processing |  |  |  |  |
| 5 | M253708 | Coding Theory and Techniques | 3 | 1 | 0 | 4 |
|  | M253709 | Optical Communications and Networks |  |  |  |  |
|  | M253710 | Wireless MIMO Communications |  |  |  |  |
|  | M253711 | IOT Architecture and Computing |  |  |  |  |
| 6 | M253712 | Digital System Design Lab | 0 | 1 | 2 | 2 |
| 7 | M253713 | Advanced Communications and Networks Lab | 0 | 1 | 2 | 2 |
| 8 | M253714 | Seminar-I | 0 | 0 | 2 | 1 |
|  |  | **TOTAL** | **15** | **7** | **6** | **25** |

### II – Semester

| S. No. | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | N253701 | Network Security and Cryptography | 3 | 1 | 0 | 4 |
| 2 | N253702 | Wireless Communications and Networks | 3 | 1 | 0 | 4 |
| 3 | N253703 | FPGA Based System Design | 3 | 1 | 0 | 4 |
| 4 | N253704 | IOT Architecture and Computing | 3 | 1 | 0 | 4 |
|  | N253705 | Speech & Image Processing |  |  |  |  |
|  | N253706 | Software Defined Radio for Advanced Communication Chip Design |  |  |  |  |
|  | N253707 | Remote Sensing and Navigational Systems |  |  |  |  |
| 5 | N253708 | Quantum Communication & Information Systems | 3 | 1 | 0 | 4 |
|  | N253709 | Pattern Recognition and Machine Learning |  |  |  |  |
|  | N253710 | Ad-hoc & Wireless Sensor Networks |  |  |  |  |
|  | N253711 | Embedded RTOS |  |  |  |  |
| 6 | N253712 | Network Security and Cryptography Lab | 0 | 1 | 2 | 2 |
| 7 | N253713 | Wireless Communications and Networks Lab | 0 | 1 | 2 | 2 |
| 8 | N253714 | Seminar-II | 0 | 0 | 2 | 1 |
|  |  | **TOTAL** | **15** | **7** | **6** | **25** |

## III Semester

| S. No. | Course Code | Course Title | L | T | P | C |
|--------|-------------|--------------|---|---|---|---|
| 1 | P253701 | Research Methodology and IPR / Swayam 12-week MOOC course – RM&IPR | 4 | 0 | 0 | 3 |
| 2 | P253701 | Summer Internship/ Industrial Training (8-10 weeks) | - | - | - | 3 |
| 3 | P253701 | Dissertation Part – A | - | - | 16 | 8 |
| | | **TOTAL** | **4** | **-** | **16** | **14** |

## IV Semester

| S. No. | Course Code | Course Title | L | T | P | C |
|--------|-------------|--------------|---|---|---|---|
| 1 | O253701 | Dissertation Part – B | - | - | 32 | 16 |
| | | **TOTAL** | **-** | **-** | **32** | **16** |

# Structural Digital System Design

**Course Overview:**

This course provides an in-depth understanding of focuses on modern hardware description languages, FPGA/ASIC implementation, modular architecture, and verification techniques applied in VLSI, IoT, AI accelerators, and embedded industry solutions.

**Course Objective:**

- To study about structural functionality of different digital blocks.
- To provide an exposure to ASM charts, their notations, and their realizations.
- To provide an exposure to VHDL and different styles of modelling using VHDL.
- microprogramming to introduce concept of microprogramming and study issues related to

**Course Outcomes:**

- After completion of the course students able to
- Understand structural functionality of different digital blocks
- Represent and realize their designs in ASM charts
- Represent their designs in different modeling styles by using VHDL
- Understand concept of Micro program and issues related to microprogramming

**UNIT- I**

**Building Blocks for Digital Design**: Multiplexer, Demultiplexer, Decoder, Encoder, Comparator, Adder, ALU, Carry-look-ahead adder.

**Building Blocks with Memory**: Clocked building blocks, register building blocks, RAM, ROM, PLA, PAL, Timing devices.

**Unit-II:**

**Design Methods:** Elements of design style, top-down design, separation of controller and architecture, refining architecture, and control algorithm, Algorithmic State Machines, ASM chart notations.

**Unit-III:**

**Realizing ASMS** - Traditional synthesis from ASM chart, multiplexer controller method, one-shot method, ROM based method.

**Asynchronous Inputs and RACES** - Asynchronous ASMs, Design for testability, test vectors, fault analysis tools.

**Unit-V:**

**Modelling with VHDL**: CAD tools, simulators, schematic entry, synthesis from VHDL.

**Design Case Studies**: Single pulse, system clock, serial to parallel data conversion, traffic light controller.

**Textbooks:**

Franklin P. Prosser and David E. Winkel, "The Art of Digital Design", Prentice Hall.

Roth, "Digital System Design using VHDL", Mc. Graw Hill, 2000

**Reference Books:**

William Fletcher, An Engineering Approach to Digital Design, 1st Edition, Prentice-Hall India, 1997.

William J Dally and John W Poulton, Digital Systems Engineering, Cambridge University Press, 2008.

Jayaram Bhasker, A VHDL Primer, 3rd edition, Prentice-Hall India, 2009.

VHDL for Programmable Logic -Kevin Skahill, Cypress Semiconductors

**Resources:**

NOC: Digital System Design  https://onlinecourses.nptel.ac.in/noc21_ee39/preview

NOC: Computer Organization

http://www.digimat.in/nptel/courses/video/106106092/L09.html

## DETECTION & ESTIMATION THEORY

Course Overview:

The course aims to build a foundation in vector spaces and stochastic processes, introduce detection theory for signal analysis, and develop skills in estimation and filtering techniques such as Kalman and Wiener filters for system identification and parameter estimation.

Course Objective:

- To learn fundamentals of vector spaces and matrix theory for signal processing.
- To understand stochastic processes and their role in random signal analysis.
- To study detection theory methods for signals in noise using Bayesian approaches.
- To apply estimation and filtering techniques like Kalman and Wiener filters.

Course Outcomes:

- After completion of the course students able to
- Explain matrix operations and orthogonal transformation techniques.
- Apply the mathematical foundations of stochastic processes.
- Apply Bayesian methods to signal detection problems.
- Make use filtering techniques for parameter estimation.

**UNIT-I Review of Vector Spaces Vectors and matrices:** notation and properties, orthogonality and linear independence, bases, distance properties, matrix operations, Eigen values and eigenvectors.

**UNIT -II: Properties of Symmetric Matrices** Diagonalization of symmetric matrices, symmetric positive definite and semi definite matrices, principal component analysis (PCA), singular value decomposition.

**UNIT -III: Stochastic Processes** Time average and moments, ergodicity, power spectral density, covariance matrices, response of LTI system to random process, cyclisation process, and spectral factorization.

**UNIT -IV: Detection Theory** Detection in white Gaussian noise, correlator and matched filter interpretation, Bayes'criterion of signal detection, MAP, LMS, entropy detectors, detection in colored Gaussian noise, Karhunen-Loeve expansions and whitening filters.

**UNIT -V:** Estimation Theory Minimum variance estimators, Cramer-Rao lower bound, examples of linear models, system identification, Markov classification, clustering algorithms. Topics in Kalman and Weiner Filtering: Discrete time Wiener-Hopf equation, error variance computation, causal discrete time Wiener filter, discrete Kalman filter, extended Kalman filter, examples.

**Text Books:**

1. H.V.Poor, Introduction to Signal Detection and Estimation, Springer, 2013.

2. Theory, Practice and Matlab" by Thomas Schonhoff (2006)

**Reference Books:**

1. B.C.Levy, Priciples of Signal Detection and Parameter Estimation, Springer, 2015

**2.** J.C.Hancock& P.A. Wintz, Signal Detection Theory, Mc-Graw Hill, 1966.

**e-Resources:**

1. NOC: Statistical Signal Processing, IIT Guwahati https://nptel.ac.in/courses/108103158

2. NOC: Advanced Mathematical Techniques in Chemical Engineering, IIT Kharagpur

**3.** https://nptel.ac.in/courses/103105106

# Advanced Communications and Networks

**Course Overview:**

This course provides an in-depth understanding of focuses on spread spectrum, OFDM, MIMO, WLAN, WPAN, and WMAN technologies, emphasizing modern wireless communication systems, architectures, synchronization, coding, standards, and applications in current industry.

**Course Objective:**

- To understand spread spectrum principles and multi-user detection techniques.
- To analyze OFDM systems, modulation, synchronization, and spectral efficiency
- To evaluate MIMO architectures, channel models, and space-time processing.
- To study WLAN, WPAN, and WMAN standards, protocols, and applications.

**Course Outcomes:**

After completion of the course students able to

- Analyze spreading sequences, CDMA receivers, and power control strategies in spread spectrum systems
- Evaluate OFDM system performance with synchronization, channel estimation, and
- spectral efficiency trade-offs
- Assess MIMO channel capacity, diversity techniques, and applications in 3G/5G wireless systems.
- Compare WLAN, WPAN, and WMAN standards for security, architecture, and system operations.

**UNIT - I  Spread Spectrum Communications:**

Spreading sequences- Properties of Spreading Sequences, Pseudo- noise sequence, Gold sequences, Kasami sequences, Walsh Sequences, Orthogonal Variable Spreading Factor Sequences, Barker Sequence, Complementary Codes Direct sequence spread spectrum: DS-CDMA Model, Conventional receiver, Rake Receiver, Synchronization in CDMA, Power Control, Soft handoff, Multiuser detection – Optimum multiuser detector, Liner multiuser detection.

**UNIT - II  Orthogonal Frequency Division Multiplexing**:

Basic Principles of Orthogonality, Single vs Multicarrier Systems, OFDM Block Diagram and Its Explanation, OFDM Signal Mathematical Representation, Selection parameter for Modulation, Pulse shaping in OFDM Signal and Spectral Efficiency, Window in OFDM Signal and Spectrum, Synchronization in OFDM, Pilot Insert in OFDM Transmission and Channel Estimation, Amplitude Limitations in OFDM, FFT Point Selection Constraints in OFDM, CDMA vs OFDM,

Hybrid OFDM.

**UNIT - III   MIMO Systems:**

Introduction, Space Diversity and System Based on Space Diversity, Smart Antenna system and MIMO, MIMO Based System Architecture, MIMO Exploits Multipath, Space – Time Processing, Antenna Consideration for MIMO, MIMO Channel Modelling, MIMO Channel Measurement, MIMO Channel Capacity, Cyclic Delay Diversity (CDD), Space Time Coding, Advantages and Applications of MIMO in Present Context, MIMO Applications in 3G Wireless System and Beyond, MIMO-OFDM

**UNIT - IV  Wireless LANs/IEEE 802.11x:**

Introduction to IEEE802.11x Technologies, Evolution of wireless LANs, IEEE 802.11 Design Issues, IEEE 802.11 Services, IEEE 802.11 MAC Layer operations, IEEE 802.11 Layer1, IEEE 802.11 a/b/g Higher Rate Standards, Wireless LAN Security, Computing Wireless Technologies, Typical WLAN Hardware

**UNIT - V   Wireless PANs/IEEE 802.15x:**

Introduction to IEEE 802.15x Technologies: Wireless PAN Applications and Architecture, IEEE 802.15.1 Physical Layer Details, Bluetooth Link Controllers Basics, Bluetooth Link Controllers Operational States, IEEE 802.15.1 Protocols and Host Control Interface. Evaluation of IEEE 802.15 Standards Broad Band Wireless MANs/IEEE 802.16x: Introduction to WMAN/IEEE 802.16x Technology, IEEE 802.16Wireless MANs, IEEE 802.16 MAC Layer Details, IEEE 802.16 Physical Layer Details, IEEE 802.16 Physical Layer Details for 2-11 GHz, IEEE 802.16 Common System Operations.

**TEXT BOOKS:**

1. Gary J. Mullett, "Introduction to Wireless Telecommunications Systems and Networks", CENGAGE

2. Upena Dalal, "Wireless Communication", Oxford University Press, 2009.

**REFERENCES:**

1. Ke-Lin Du & M N S Swamy, "Wireless Communication System", Cambridge University Press, 2010

2. Gottapu Sasibhusan Rao, "Mobile Cellular Communication", PEARSON

# DESIGN OF FAULT TOLERANT SYSTEMS

**Course Overview:**

This course focuses on the fundamentals of fault-tolerant design and the requirements for building self-checking circuits to ensure system reliability. It explores techniques for test pattern generation using Linear Feedback Shift Registers (LFSR) and emphasizes the rules and methods of design for testability (DFT), particularly for combinational circuits, including the use of scan architectures. Additionally, it provides an understanding of Built-In-Self-Test (BIST) design, highlighting its role in improving the testability and dependability of digital systems.

**Course Objective:**

- To provide broad understanding of fault diagnosis and tolerant design approach.
- To illustrate the framework of test pattern generation using semi and fully automatic approach.

**Course Outcomes:**

After completion of the course students able to

- Apply fundamental concepts of fault- tolerant design and the design requirements of self-checking circuits.
- Learn methods of generating test patterns using Linear Feedback Shift Registers (LFSR).
- Study DFT rules and techniques, particularly for combinational circuits, along with scan-based architectures.
- Acquire knowledge of BIST design and its applications in improving circuit testability.

**UNIT- I Fault Tolerant Design:** Basic concepts: Reliability concepts, Failures & faults, Reliability and Failure rate, Relation between reliability and mean time between failures.

**Fault Tolerant Design:** Basic concepts-static, dynamic, hybrid, triple modular redundant system (TMR), 5MR reconfiguration techniques, Data redundancy

**UNIT -II:**

**Self-Checking circuits & Fail-safe Design:** Self Checking Circuits: Basic concepts of sel f-checking circuits, Design of Totally self-checking checker, Checkers using m out of n codes, Berger code, Low-cost residue code.

**Fail Safe Design:** Strongly fault secure circuits, fail safe design of sequential circuits using partition theory and Berger code, totally self-checking PLA design

**UNIT -III:**

**Design for Testability:** Design for testability for combinational circuits: Basic concepts of Testability, Controllability and observability, The Reed Muller's expansion technique, use of control and syndrome testable designs.

**Design for testability by means of scan:** Making circuits Testable, Testability Insertion, Full scan DFT technique- Full scan insertion, flip-flop Structures, Full scan design and Test, Scan Architectures- full scan design, Shadow register DFT, Partial scan methods, multiple scan design, other scan designs.

**UNIT -IV:**

**Logic Built-in-self-test:** BIST Basics-Memory-based BIST effectiveness, BIST types, Designing a BIST, Test Pattern Generation-Engaging TPGs, exhaustive counters, ring counters, twisted ring counter, Linear feedback shift register. incorporating configurations in BIST, Design of STUMPS, RTS and STUMPS results.

**UNIT -V:**

**Standard IEEE Test Access Methods:** Boundary Scan Basics, Boundary scan architecture- Test access port, Boundary scan registers, TAP controller, the decoder unit, select and other units, Boundary scan Test Instructions-Mandatory instructions, Board level scan chain structure-One serial scan chain, multiple-scan chain with one control test port virtual boundary scan tester, Boundary Scan Description language.

**Text Books:**

1. Parag K. Lala, "Fault Tolerant & Fault Testable Hardware Design", 1984, PHI
2. Parag.K. Lala, "Fault Tolerant and fault testable hardware design", BS publications, 2002.

**Reference Books:**

1. Miron Abramovici, Melvin A. Breuer and Arthur D. Friedman, "Digital Systems Testing and Testable Design", Jaico Publishing House, 2002.
2. Alfred L. Crouch, "Design for Test for Digital IC's and Embedded Core Systems", 2008, Pearson Education.

**Resources:**

1. https://www.youtube.com/watch?v=Efac1G9Rd-I
2. https://www.youtube.com/watch?v=MgCFUO2BrkQ

# SYSTEM ON CHIP ARCHITECTURE

**Course Overview:**

This course introduces the fundamentals of system architecture and System-on-Chip (SoC) design. It covers processor architectures, micro-architectures, and instruction handling with advanced processing techniques. Memory design, cache organization, and processor–memory interaction are explored in detail. The course also focuses on interconnects, customization, and practical applications through case studies like AES and JPEG compression.

**Course Objective:**

- To introduce the fundamentals of system architecture, components, and SoC design principles.
- To study processor architectures, micro-architectures, and advanced processing techniques.
- To understand memory organization, cache design, and processor–memory interactions in SoC.
- To explore interconnects, customization, and practical SoC applications through case studies.

**Course Outcomes:**

**After completion of the course students able to**

- Apply system architecture, processor design, memory organization, and interconnections for SoC.
- Apply concepts of processor architectures, instruction handling, and advanced processing techniques.
- Analyze SoC memory systems including cache design, policies, and processor memory interaction.
- Evaluate SoC customization and apply design approaches to case studies like AES and JPEG compression.

**UNIT-I**

**Introduction to the System Approach:** System Architecture, Components of the system, Hardware & Software, Processor Architectures, Memory and Addressing. System level interconnection, An approach for SOC Design, System Architecture and Complexity.

**UNIT -II: Processors**: Introduction, Processor Selection for SOC, Basic concepts in Processor Architecture, Basic concepts in Processor Micro Architecture, Basic elements in Instruction handling. Buffers: minimizing Pipeline Delays, Branches, More Robust Processors, Vector Processors and Vector Instructions extensions, VLIW Processors, Superscalar Processors.

**UNIT -III: Memory Design for SOC:** Overview of SOC external memory, Internal Memory, Size, Scratchpads and Cache memory, Cache Organization, Cache data, Write Policies, Strategies for line replacement at miss time, Types of Cache, Split – I, and D – Caches, Multilevel Caches, Virtual to real translation, SOC Memory System, Models of Simple Processor – memory interaction.

**UNIT-IV: Interconnect Customization and Configuration:** Inter Connect Architectures, Bus: Basic Architectures, SOC Standard Buses, Analytic Bus Models, Using the Bus model, Effects of Bus transactions and contention time. SOC Customization: An overview, Customizing Instruction Processor, Reconfiguration Technologies, Mapping design onto Reconfigurable devices, Instance-Specific design, Customizable Soft Processor, Reconfiguration overhead analysis and trade-off analysis on reconfigurable Parallelism.

**UNIT -V: Application Studies / Case Studies:** SOC Design approach, AES algorithms, Design and evaluation, Image compression – JPEG compression.

**Text Books:**

Computer System Design System-on-Chip by Michael J. Flynn and Wayne Luk, Wiely India Pvt. Ltd,2011

ARM System on Chip Architecture – Steve Furber –2nd Eed., 2000, Addison Wesley Professional.

**Reference Books:**

Design of System on a Chip: Devices and Components – Ricardo Reis, 1st Ed., Springer,2004.

System on Chip Verification – Methodologies and Techniques –PrakashRashinkar, Peter Paterson and Leena Singh L, Kluwer Academic Publishers, 2001.

Resources:

NOC: Microprocessors and Microcontrollers, IIT Kharagpur

ttps://nptel.ac.in/courses/108105102

NOC: Computer Organization and Architecture, IIT Madras https://nptel.ac.in/courses/106106166

## MICROWAVE & MILLIMETER WAVE DEVICES

**Course Overview:**

This course covers the fundamentals of RF and microwave tubes, including vacuum tube device physics, limitations, and unique features. It introduces non-relativistic and relativistic electron tubes such as klystrons, TWTs, magnetrons, gyrotrons, and free electron lasers. The study extends to microwave semiconductor devices including Schottky, varactor, PIN, tunnel, IMPATT, TRAPATT, BARRITT, and Gunn-effect devices with their operating principles.

**Course Objective:**

To understand the basics of microwave device physics.

To familiarize with operation and characteristics of various microwave devices and circuits such as klystron, TWT, magnetrons.

To Study the application of RF and Microwave devices.

To study three terminal Microwave devices.

**Course Outcomes:**

After completion of the course students able to

Explain the principles and limitations of RF and microwave tubes.

Analyze electron tubes like klystrons, TWTs, magnetrons, and gyrotrons.

Illustrate microwave diodes such as Schottky, PIN, IMPATT, and Gunn devices.

Evaluate the physics, characteristics, and models of three-terminal devices.


**UNIT- I**

**RF and Microwave tubes:** Vacuum tube microwave device physics: Beam field interaction; power frequency limitation, device size limitations; special features of microwave tubes.


**UNIT-II:**

Non-relativistic electron tubes, Parallel field type – Klystron, Reflex Klystron, Helix TWT, coupled cavity TWT, Twystrons; Crossed field type – magnetrons, FWCFA, carcinotron. Relativistic electron tubes: gyrotrons; free electron LASER.


**UNIT-III:**

**RF and Microwave Devices:** Diodes; high-frequency equivalent circuit; Schottky barrier diode; varactor diode; PIN diode; Applications, Tunnel diodes, Quantum tunneling mechanism, Impact ionization; IMPATT and other related diodes

**UNIT-IV:**

Small-signal analysis and model of IMPATT diode; TRAPATT; BARRITT, Transferred electron devices; differential negative resistance and two-valley model of Gunn Effect devices; modes of operation; waveguide cavity Gunn oscillator.

**UNIT-V:**

Three terminal devices: BJT, MESFET, MOSFET, HFET, HEMT – device physics, characteristics, model, Three terminal devices; BJT, MESFET, MOSFET, HFET, HEMT – device physics, model.

**Text Books:**
1. S. GILMOUR, "MICROWAVE TUBES", ARTECH HOUSE, 1986
2. S. Y. LIAO, MICROWAVE DEVICES AND CIRCUITS, PEARSON EDUCATION,2003

**Reference Books:**
1. R. E. Collin, Foundations for Microwave Engineering, Wiley, 2001
2. S. Das, Microwave Engineering, Oxford University Pres,2014

**Resources:**
3. NOC: Microwave Theory and Techniques, IIT Bombay https://nptel.ac.in/courses/108101112
4. NOC: High Speed Semiconductor Devices, IIT Kanpur https://nptel.ac.in/courses/117104071

# ADVANCED DIGITAL SIGNAL PROCESSING

**Course Overview:**

This course provides in-depth study of signal theory, including multirate systems, wavelets, adaptive filtering, design of digital IIR and FIR filters and spectral analysis.

**Course Objective:**

- To provide an overview of Discrete time systems in time and frequency domain.
- To analyse discrete-time signals and systems using DFT and FFT.
- To understand the necessity of FIR and IIR filters.
- To Understand and develop multirate digital signal processing systems.

**Course Outcomes:**

After completion of the course students able to

- Analyze discrete-time systems in both times & transform domain and also through pole-zero placement.
- Analyze discrete-time signals and systems using DFT and FFT.
- Design and implement digital finite impulse response (FIR) and digital infinite impulse response (IIR) filters
- Understand and develop multirate digital signal processing systems.

**UNIT- I Review of DFT, FFT, IIR Filters and FIR Filters:**

Multi-Rate Signal Processing: Introduction, Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a rational factor I/D, Multistage Implementation of Sampling Rate Conversion, Filter design & Implementation for sampling rate conversion.

**UNIT-II: Applications of Multi-Rate Signal Processing:**

The design of Phase Shifters, Interfacing of Digital Systems with Different Sampling Rates, Implementation of Narrow Band Low Pass Filters, Implementation of Digital Filter Banks, Sub-band Coding of Speech Signals, Quadrature Mirror Filters, Trans-multiplexers, Over Sampling A/D and D/A Conversion.

**UNIT-III: Non-Parametric Methods of Power Spectral Estimation:**

Estimation of spectra from finite duration observation of signals, Non-parametric Methods: Bartlett, Welch & Blackman-Tukey methods, Comparison of all Non-Parametric Methods

**UNIT-IV: Implementation of Digital Filters:**

Introduction to filter structures (IIR & FIR), Frequency sampling structures of FIR, Lattice structures, Forward prediction error, Backward prediction error, Reflection coefficients lattice realization, Implementation of lattice structures for IIR filters, Advantages of lattice structures.

**UNIT-V: Parametric Methods of Power Spectrum Estimation:**

Autocorrelation & Its Properties, Relation between auto correlation & model parameters, AR Models - Yule-Walker& Burg Methods, MA & ARMA models for power spectrum estimation, Finite word length effects in IIR Digital Filters – Finite word length effects in FFT algorithms.

**Text Books:**

1. Digital Signal Processing: Principles, Algorithms &Applications - J.G.Proakis&D.G.Manolakis,4th Ed., PHI.
2. Discrete Time Signal Processing-Alan Oppenheim& R.WSchaffer, ,PHI.
3. DSP–A Practical Approach–Emmanuel C.Ifeacher, Barrie. W.Jervis, 2Ed.,Pearson Education

**Reference Books:**

1. Modern Spectral Estimation: Theory & Application –S.M.Kay, 1988,PHI.
2. Digital Signal Processing–S. Salivahanan, A. Vallavaraj,C.Gnanapriya,2000,TMH

**e- Resources:**

1. NOC: Multirate DSP, IIT Madras https://nptel.ac.in/courses/108106136
2. NOC: Digital Signal Processing and its Applications, https://onlinecourses.nptel.ac.in/noc23_ee31/preview

**CODING THEORY AND TECHNIQUES**

**Course Overview:**

This course introduces the fundamental principles and practical methods of error control coding which is essential for reliable communication and data storage systems. It emphasizes both the theoretical aspects of coding theory and the techniques used to design, analyze, and implement error detection and correction schemes.

**Course Objectives:**

- To understand the fundamental concepts of information and coding theory for reliable communication.
- To understanding of error detection and error correction techniques using linear block, cyclic, and convolution codes.
- To Understanding algebraic structures and encoding/decoding algorithms to analyze coding schemes.

**Course Outcomes:**

After completion of the course students able to

- Learning the measurement of information and errors
- Obtain knowledge in designing Linear Block Codes and Cyclic codes.
- Construct tree and trellies diagrams for convolution codes
- Design the Turbo codes and Space time codes and also their applications

**UNIT – I**

**Coding for Reliable Digital Transmission and storage:** Mathematical model of Information, A Logarithmic Measure of Information, Average and Mutual Information and Entropy, Types of Errors, Error Control Strategies. Linear Block Codes Introduction to Linear Block Codes, Syndrome and Error Detection, Minimum Distance of a Block code, Error-Detecting and Error- correcting Capabilities of a Block code, Standard array and Syndrome Decoding, Probability of an undetected error for Linear Codes over a BSC, Hamming Codes. Applications of Block codes for Error control in data storage system.

**UNIT -II**

**Cyclic Codes:**Cyclic Codes Description, Generator and Parity-check Matrices, Encoding, Syndrome Computation and Error Detection, Decoding, Cyclic Hamming Codes, Shortened cyclic codes, Error-trapping decoding for cyclic codes, Majority logic decoding for cyclic codes.

**UNIT – III**

**Convolutional Codes:** Encoding of Convolutional Codes, Structural and Distance Properties, maximum likelihood decoding, Sequential decoding, Majority- logic decoding of Convolution codes. Application of Viterbi Decoding and Sequential Decoding, Applications of Convolutional codes in ARQ system.

**UNIT – IV**

**Turbo Codes: LDPC Codes-** Codes based on sparse graphs, decoding for binary erasure channel, Log-likelihood algebra, Brief propagation, Product codes, Iterative decoding of product codes, Concatenated convolutional codes- Parallel concatenation, The UMTS Turbo code, Serial concatenation, Parallel concatenation, Turbo decoding.

**UNIT - V**

**Space-Time Codes Introduction:** Digital modulation schemes, Diversity, Orthogonal space-Time Block codes, Alamouti's schemes, Extension to more than Two Transmit Antennas, Simulation Results, Spatial Multiplexing: General Concept, Iterative APP Preprocessing and Per-layer Decoding, Linear Multilayer Detection, Original BLAST Detection, QL Decomposition and Interface Cancellation, Performance of Multi – Layer Detection Schemes, Unified Description by Linear Dispersion Codes.

**TEXT BOOKS**

1. Error Control Coding- Fundamentals and Applications –Shu Lin, Daniel J. Costello, Jr, Prentice Hall, Inc.
2. Error Correcting Coding Theory-Man Young Rhee, McGraw-Hill, 1989.

**Reference Books**:

1. Introduction to Coding Theory  by Jürgen Bierbrauer ,2nd Edition, 2017.
2. Introduction to Coding Theory by J. H. van Lint ,3rd Edition.

**e- Resources**:

1. NOC: Introduction to Information Theory

   https://youtu.be/U4dzerJHIFw?si=XoaX6laXgFy5uTV3&t=1

2. NOC: Introduction to Information Theory and Coding

   https://youtu.be/f8RvFlr5wRk?si=msCR5dIbEaQK7Gtj

# Optical Communications and Networks

**Course Overview:**

This course provides an in-depth understanding of focuses fundamentals, sources, detectors, digital/analog links, optical networks, WDM technologies, and performance monitoring, emphasizing modern communication systems, high-speed networking, and photonic applications in industry.

**Course Objective:**

- To understand the structure, properties, and signal propagation in optical fibers and sources.
- To analyze optical detectors, receiver performance, and WDM components for communication systems.
- To evaluate digital and analog optical link performance with advanced modulation techniques.
- To evaluate optical system performance using measurement network topologies, and high-speed link architectures and monitoring tools.

**Course Outcomes:**

After completion of the course students able to

- Analyze optical fiber structures, dispersion, and attenuation for communication applications
- Evaluate WDM components (couplers, isolators, circulators) for optical system integration.
- Analyze error control, power penalties, and modulation schemes in digital optical links.
- Evaluate end-to-end optical system performance using monitoring and characterization techniques

**UNIT- I Optical Fibers:** Structures, waveguiding and Fabrication: Nature of Light, Basic optical laws and definitions,

Single mode fibers, Graded index fiber structure, Attenuation, Signal Dispersion in fibers. Optical Sources- LEDs, Laser Diodes, Line Coding.

**UNIT-II: Photo detectors**: Photo detector Noise, Detector Response Time, Avalanche Multiplication Noise.

**Optical Receiver Operation:** Fundamental receiver operation, Digital receiver performance,

Eye diagrams. WDM Concepts and Components: Passive optical Couplers, Isolators and Circulators.

**UNIT-III: Digital Links:** Point to point links, power penalties, error control, Coherent detection, Differential Quadrature Phase Shift Keying.

Analog Links: Carrier to noise ratio, Multichannel Transmission Techniques, RF over Fiber, Radio over fiber links, Microwave Photonics.

**UNIT-IV: Optical Networks:** Network Concepts, Network Topologies, SONET/SDH, High speed Lightwave links, Optical add/ Drop Multiplexing, Optical Switching, WDM Network, Passive Optical Networks, IP Over DWDM, Optical Ethernet, Mitigation of Transmission Impairments

**UNIT-V: Performance Measurement and Monitoring:** Measurement standards, Basic Test Equipment, Optical power measurement, Optical fiber characterization, Eye diagram tests, optical time domain reflectometer, optical performance monitoring, optical fiber system performance measurements.

**Textbooks:**

Gerd Keiser, "Optical Fiber Communications", 5th Edition, Mc Graw Hill.

Rajeev Ramaswamy and Kumar N Sivarajan, "Optical Networks: A Practical Perspective", 2nd Ed., 2004, Elsevier Morgan Kaufmann Publishers (An imprint of Elsevier).

**Reference Books:**

John. M. Senior, "Optical Fiber Communications: Principles and Practice", 2nd Ed, 2000, PE.

Harold Kolimbris, "Fiber Optic Communication", 2nd Ed, 2004, PEI

Uyless Black, "Optical Networks: Third Generation Transport Systems", 2nd Ed, 2009, PEI

Govind Agarwal, "Optical Fiber Communications", 2nd Ed, 2004, TMH.

S. C. Gupta, "Optical Fiber Communications and its Applications", 2004, PHI

**e- Resources:**

NOC: Optical Communications  https://onlinecourses.nptel.ac.in/noc21_ee42/preview

Virtual Lab: VL: Optical Communication  https://oc-iitr.vlabs.ac.in/

# DIGITAL SYSTEM DESIGN LAB

Part –I

Programming can be done using any complier. Down load the programs on FPGA/CPLD boards and performance testing may be done using pattern generator (32 channels) and logic analyzer apart from verification by simulation with any of the front-end tools.

1. HDL code to realize all the logic gates
2. Design and Simulation of adder, Serial Binary Adder, Multi Precession Adder,
3. Carry Look Ahead Adder.
4. Design of 2-to-4 decoder
5. Design of 8-to-3 encoder (without and with parity)
6. Design of 8-to-1 multiplexer
7. Design of 4 bit binary to gray converter
8. Design of Multiplexer/ Demultiplexer, comparator
9. Design of Full adder using 3 modeling styles
10. Design of flip flops: SR, D, JK, T
11. Design of 4-bit binary, BCD counters (synchronous/ asynchronous reset) or any sequence counter
12. Design of a N- bit Register of Serial- in Serial –out, Serial in parallel out, Parallel in Serial out and Parallel in Parallel Out.
13. Design of Sequence Detector (Finite State Machine- Mealy and Moore Machines).
14. Design of 4- Bit Multiplier, Divider.
15. Design of ALU to Perform – ADD, SUB, AND-OR, 1's and 2's Compliment,
16. Multiplication, and Division.
17. Design of Finite State Machine.
18. Implementing the above designs on Xilinx/Altera/Cypress/equivalent based FPGA/CPLD kits.

Part –II

1. Static and Dynamic Characteristics of CMOS Inverter
2. Implementation of EX-OR gate using complementary CMOS, Psedo-NMOS, Dynamic and domino logic style
3. Implementation of Full Adder using Transmission Gates.

# ADVANCED COMMUNICATIONS AND NETWORKS LAB (LAB – IV)

Note: Below experiments are to be performed using MATLAB List of Experiments:

1. Implementation of Matched Filters.
2. Optimum receiver for the AWGN channel.
3. Design FIR (LP/HP/BP) filter using Window method.
4. Measurement of effect of Inter Symbol Interference.
5. Generation of constant envelope PSK signal wave form for different values of M.
6. Simulation of PSK system with M=4
7. Simulation of DPSK system with M=4
8. Design of FSK system
9. Simulation of correlation type demodulation for FSK signal
10. BPSK Modulation and Demodulation techniques
11. QPSK Modulation and Demodulation techniques
12. DQPSK Modulation and Demodulation techniques
13. 8-QAM Modulation and Demodulation techniques
14. DQAM Modulation and Demodulation techniques
15. Verification of Decimation and Interpolation of a given signal
16. Power spectrum estimation using AR models.

# NETWORK SECURITY AND CRYPTOGRAPHY

**Course Objectives:**

- Explain the importance and application of each of confidentiality, integrity, authentication and availability
- Understand various cryptographic algorithms.
- Understand the basic categories of threats to computers and networks
- Describe public-key cryptosystem.
- Describe the enhancements made to IPv4 by IPSec
- Understand Intrusions and intrusion detection

**Course Outcomes:**

- Student will be able to understand basic cryptographic algorithms, message and web authentication and security issues.
- Ability to identify information system requirements for both of them such as client and server.
- Ability to understand the current legal issues towards information security.

**UNIT - I**

**Security Concepts:** Introduction, The need for security, Security approaches, Principles of security, Types of Security attacks, Security services, Security Mechanisms, A model for Network Security Cryptography Concepts and Techniques: Introduction, plain text and cipher text, substitution techniques, transposition techniques, encryption and decryption, symmetric and asymmetric key cryptography, steganography, key range and key size, possible types of attacks.

**UNIT - II**

**Symmetric key Ciphers:** Block Cipher principles, DES, AES, Blowfish, RC5, IDEA, Block cipher operation, Stream ciphers, RC4. Asymmetric key Ciphers: Principles of public key cryptosystems, RSA algorithm, Elgamal Cryptography, Diffie-Hellman Key Exchange, Knapsack Algorithm.

**UNIT - III**

**Cryptographic Hash Functions:** Message Authentication, Secure Hash Algorithm (SHA-512), Message authentication codes: Authentication requirements, HMAC, CMAC, Digital signatures, Elgamal Digital Signature Scheme. Key Management and Distribution: Symmetric Key Distribution Using Symmetric & Asymmetric Encryption, Distribution of Public Keys**, Kerberos,**

X.509 Authentication Service, Public – Key Infrastructure

**UNIT - IV**

**Transport-level Security:** Web security considerations, Secure Socket Layer and Transport Layer Security, HTTPS, Secure Shell (SSH) Wireless Network Security: Wireless Security, Mobile Device Security, IEEE 802.11 Wireless LAN, IEEE 802.11i Wireless LAN Security

**UNIT - V**

**E-Mail Security:** Pretty Good Privacy, S/MIME IP Security: IP Security overview, IP Security architecture, Authentication Header, Encapsulating security payload, Combining security associations, Internet Key Exchange Case Studies on Cryptography and security: Secure Multiparty Calculation, Virtual Elections, Single sign On, Secure Inter-branch Payment Transactions, Cross site Scripting Vulnerability.

**TEXT BOOKS:**

1. Cryptography and Network Security - Principles and Practice: William Stallings, Pearson Education, 6th Edition
2. Cryptography and Network Security: Atul Kahate, Mc Graw Hill, 3rd Edition

**REFERENCE BOOKS:**

**1**. Cryptography and Network Security: C K Shyamala, N Harini, Dr T R Padmanabhan, Wiley India, 1st Edition.
2. Cryptography and Network Security: Forouzan Mukhopadhyay, Mc Graw Hill, 3rd Edition
3. Information Security, Principles, and Practice: Mark Stamp, Wiley India.
4. Principles of Computer Security: WM. Arthur Conklin, Greg White, TMH
5. Introduction to Network Security: Neal Krawetz, CENGAGE Learning
6. Network Security and Cryptography: Bernard Menezes, CENGAGE Learning

WIRELESS COMMUNICATIONS AND NETWORKS

Course Objectives:

The objectives of this course are to make the student

- To study the Channel planning for Wireless Systems
- To study the Mobile Radio Propagation
- To study the Equalization and Diversity
- To study the Wireless Networks

Course Outcomes:

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

- Understand Cellular communication concepts
- Study the mobile radio propagation
- Study the wireless network different type of MAC protocols

## UNIT -I

**The Cellular Concept-System Design Fundamentals:** Introduction, Frequency Reuse, Channel Assignment Strategies, Handoff Strategies- Prioritizing Handoffs, Practical Handoff Considerations, Interference and system capacity – Co channel Interference and system capacity, Channel planning for Wireless Systems, Adjacent Channel interference, Power Control for Reducing interference, Trunking and Grade of Service, Improving Coverage & Capacity in Cellular Systems- Cell Splitting, Sectoring.

## UNIT –II

**Mobile Radio Propagation:** Large-Scale Path Loss: Introduction to Radio Wave Propagation, Free Space Propagation Model, Relating Power to Electric Field, The Three Basic Propagation Mechanisms, Reflection-Reflection from Dielectrics, Brewster Angle, Reflection from prefect conductors, Ground Reflection (Two-Ray) Model, Diffraction-Fresnel Zone Geometry, Knife-edge Diffraction Model, Multiple knife-edge Diffraction, Scattering, Outdoor Propagation Models- Longley-Ryce Model, Okumura Model, Hata Model, PCS Extension to Hata Model, Walfisch and Bertoni Model, Wideband PCS Microcell Model, Indoor Propagation Models- Partition losses (Same Floor), Partition losses between Floors, Logdistance path loss model, Ericsson Multiple Breakpoint Model, Attenuation Factor Model, Signal penetration into buildings, Ray Tracing and Site Specific Modeling.

## UNIT –III

**Mobile Radio Propagation:** Small –Scale Fading and Multipath: Small Scale Multipath propagation Factors influencing small scale fading, Doppler shift, Impulse Response Model of a multipath channel- Relationship between Bandwidth and Received power, Small-Scale Multipath Measurements-Direct RF Pulse System, Spread Spectrum Sliding Correlator Channel Sounding, Frequency Domain Channels Sounding, Parameters of Mobile Multipath Channels-Time Dispersion Parameters, Coherence Bandwidth, Doppler Spread and Coherence Time, Types of Small-Scale Fading-Fading effects Due to Multipath Time Delay Spread, Flat fading, Frequency selective fading, Fading effects Due to Doppler Spread-Fast fading, slow fading, Statistical Models for multipath Fading Channels-Clarke's model for flat fading, spectral shape due to Doppler spread in Clarke's model, Simulation of Clarke and Gans Fading Model, Level crossing and fading statistics, Two-ray Rayleigh Fading Model.

## UNIT -IV

**Equalization and Diversity:** Introduction, Fundamentals of Equalization, Training A Generic Adaptive Equalizer, Equalizers in a communication Receiver, Linear Equalizers, Non-linear Equalization Decision Feedback Equalization (DFE), Maximum Likelihood Sequence Estimation (MLSE) Equalizer, Algorithms for adaptive equalization-Zero Forcing Algorithm, Least Mean Square Algorithm, Recursive least squares algorithm. Diversity Techniques-Derivation of selection Diversity improvement, Derivation of Maximal Ratio Combining improvement, Practical Space Diversity Consideration-Selection Diversity, Feedback or Scanning Diversity, Maximal Ratio Combining, Equal Gain Combining, Polarization Diversity, Frequency Diversity, Time Diversity, RAKE Receiver.

## UNIT -V

**Wireless Networks:** Introduction to wireless Networks, Advantages and disadvantages of Wireless Local Area Networks, WLAN Topologies, WLAN Standard IEEE 802.11, IEEE 802.11 Medium Access Control, Comparison of IEEE 802.11 a,b,g and n standards, IEEE 802.16 and its enhancements, Wireless PANs, Hiper Lan, WLL.

## TEXT BOOKS:

1. Wireless Communications, Principles, Practice – Theodore, S. Rappaport, 2nd Ed., 2002, PHI.
2. Wireless Communications-Andrea Goldsmith, 2005 Cambridge University Press.
3. Principles of Wireless Networks – Kaveh PahLaven and P. Krishna Murthy, 2002, PE

4. Mobile Cellular Communication – Gottapu Sasibhushana Rao, Pearson Education, 2012.

**REFERENCE BOOKS:**

1. Wireless Digital Communications – Kamilo Feher, 1999, PHI.
2. Wireless Communication and Networking – William Stallings, 2003, PHI.

# FPGA-BASED SYSTEM DESIGN

## Course Objectives

- Introduce the fundamentals of FPGA architectures and reconfigurable computing.
- Enable students to design combinational and sequential circuits on FPGA platforms.
- Explore design trade-offs involving area, timing, and power.
- Familiarize with HDL-based design, IP cores, and system-level design tools.
- Provide insight into large-scale, embedded, and DSP system implementations using FPGAs.

## Course Outcomes

- After completing this course, students will be able to:
- Understand FPGA architectures and reconfigurable computing principles.
- Design and implement digital systems using HDL and IP-based methodologies.
- Perform timing, power, and resource analysis for FPGA-based systems.
- Integrate processors, memory, and communication buses into FPGA platforms.
- Develop FPGA-based DSP and embedded applications for real-world problems.

**UNIT-I**

**Introduction to FPGA Systems:** Reconfigurable computing basics, FPGA architectures: basic and advanced fabrics, Combinational and sequential logic implementation, FPGA design issues: area, timing, and power

**UNIT- II**

**Design Methodologies:** Behavioral and high-level design approaches, Hardware Description Languages (HDL), Use of IP cores and System Generator, Processor and memory cores in FPGA

**UNIT- III**

**Timing and Clocking:** Static timing analysis, Clock distribution and management techniques, Power optimization strategies, Design verification and simulation practices

**UNIT - IV**

**Large-Scale System Design**: Platform FPGA concepts, multi-FPGA system integration, Bus architectures and I/O communication systems, High-performance interconnect strategies

**UNIT- V**

**Applications and Embedded Systems:** DSP system design and implementation on FPGA, FPGA-based embedded system platforms, Case studies: FPGA in real-world applications, Future trends in reconfigurable systems

**Text/Reference Books:**

1.  Wayne Wolf, *FPGA-Based System Design*, Prentice Hall, 2004.
2.  Ron Sass and Andrew G. Schmidt, *Embedded System Design with Platform FPGAs*, Elsevier, 2010.
3.  Steve Kilts, *Advanced FPGA Design – Architecture, Implementation and Optimization*, Wiley, 2007.

# IoT Architecture & Computing

**Course Outcomes:**

- Understand the various concepts of the IoT and their technologies.
- Develop the IoT application using different hardware platforms
- Understanding and implement the various IoT Protocols
- Understand the basic principles of cloud computing.
- Develop and deploy the IoT application into cloud environment.

## Unit I –

**Fundamentals of IoT**: Introduction to IoT, Definition, Characteristics, Applications, Complete IoT Architectural Stack, IoT enabling technologies and challenges, Sensors and Hardware for IoT – Hardware Platforms: Arduino, Raspberry Pi, Nede MCU,

## Unit II

**IoT Protocols and Communication:** Infrastructure protocols: IPv4, IPv6, RPL, Identification protocols: URIs, Transport protocols: Wi-Fi, Li-Fi, BLE, Discovery and Data protocols, Device management protocols, Case study: Implementation of MQTT/CoAP for IoT applications, IoT privacy, security, and vulnerability solutions

## Unit III –

**Cloud Computing Fundamentals**: Basics of Cloud Computing, Cloud Architecture, Standards and Interoperability, Cloud Deployment Models: Public, Private, Community, Hybrid Clouds, Cloud Service Models: IaaS, PaaS, SaaS, Benefits and challenges of cloud computing
Development environments: Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform

## Unit IV –

**IoT and Cloud Integration:** Role of Cloud Computing in IoT, AWS Components for IoT applications, Connecting web applications to AWS,IoT communication using MQTT with AWS IoT Core, AWS IoT Examples and Use Cases, Security Concerns, Risk Issues, and Legal Aspects in Cloud Computing, Cloud Data Security

**Unit V –**

**IoT Applications:** Applications with architectural analysis: Smart City, Smart Water Management, Smart Agriculture, Smart Energy Systems, Smart Healthcare, Smart Transportation, Smart Waste Management

**Course Outcomes (COs)**

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

- Explain the fundamentals, characteristics, and architecture of IoT systems.
- Demonstrate the use of IoT hardware platforms and acquire data from sensors.
- Analyze and apply various IoT communication protocols for device connectivity.
- Understand cloud computing models, architectures, and platforms for IoT integration.
- Develop IoT solutions integrated with cloud platforms (AWS, Azure, Google Cloud) ensuring security and privacy.
- Evaluate real-time IoT applications in domains like smart city, healthcare, agriculture, and transportation.

**Text books/Reference Books:**

1. Pethuru Raj and Anupama C. Raman by The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press,2007,1stEdition.
2. Adrian McEwen, Designing the Internet of Things, Wiley, 2013,1stEdition.
3. Singh, Rajesh. Gupta, LoviRaj. Gehlot, Anita. Singh, Bhupendra. Swain, Mahendra, "Internet of Things with Raspberry Pi and Arduino" United Kingdom: Taylor & Francis Limited, 2021.

**Speech and Image Processing**

Course Outcomes (COs):

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

- Analyse speech processing feature extraction and speaker recognition methods using Fourier Transform.
- Analyse and process Images using multi-resolution transform, segmentation, edge detection and colour image processing algorithms.
- Apply speech and image processing algorithms for voice and object recognition problems.

**UNIT I:**

**Speech Processing:** Introduction, Anatomy and physiology of speech production, Vocal Tract categorization of speech sounds, Prosody- The melody of speech, Speech Perception

**UNIT II:**

Analysis of Speech Signals Analysis and synthesis of Pole Zero speech models, STFT analysis and synthesis, wiener Filter based speech enhancement techniques, Selected methods of speech enhancement, Speech Analysis and Synthesis.

**UNIT III:**

Digital Image Processing Introduction to Digital Image Processing, Structure of the Human Eye, Image Formation in the Eye, Brightness Adaptation and Discrimination, Light and the Electromagnetic Spectrum, Image enhancement and filtering in spatial and frequency domain. Image restoration algorithms

**UNIT IV:**

Transform based Image Processing DFT, DCT, Singular Value Decomposition, Discrete Wavelet Transform.

Image Segmentation Detection of Discontinuities, Point Detection, Line Detection, Edge Detection, Edge Linking and Boundary Detection, Thresholding, Region-Based Segmentation.

**UNIT V:**

Color and Morphological Image Processing Color Fundamentals Color Models Pseudo color Image Processing, Morphological Image Processing , Some Basic Concepts from Set Theory Logic Operations Involving Binary Images Dilation and Erosion Dilation Erosion, Opening and

Closing, Some Basic Morphological Algorithms.

Object Recognition Patterns and pattern class, decision-theoretic methods, structural methods

**Text /Reference Books:**

1. R. C. Gonzalez, R. E. Woods, Digital Image Processing, Addison-Wesley.
2. Thomos F. Quatieri, Discrete time speech signal Processing principles and practice, Pearson Education
3. Maria Petrou, Costas Petrou, Image Processing-The fundamentals, Wiley
4. Bishop, C., Pattern Recognition and Machine Learning, Springer
5. Rabinar L R, Schafer R W , Digital Processing of Speech Signals, Prentice Hall

**SOFTWARE DEFINED RADIO FOR ADVANCED COMMUNICATION CHIP DESIGN**

**Course Objectives:**

- Provide fundamental knowledge of Software Defined Radios, their design principles, and benefits.
- Introduce RF front-end architectures and analyze their role in SDR performance.
- Develop understanding of digital signal processing techniques for SDR implementations.
- Explore the role of smart antennas and their integration into SDR systems.
- Familiarize students with SDR hardware and software platforms through real-world case studies.

**UNIT- I**

Introduction to Software Radio: The Need for Software Radios, Characteristics and, Benefits of a Software Radio, Design Principles of a Software Radio

**UNIT -II**

RF Implementation, Purpose of RF Front-End, Dynamic Range Considerations Receiver Front-End Topologies, Enhanced Flexibility of the RF Chain with Software Radios, Importance of RF Components to Overall Performance, Transmitter Architectures and their Issues, Noise and Distortion in the RF Chain, Hybrid DDS–PLL Systems, Applications of Direct Digital Synthesis

**UNIT -III**

Digital Signal Processing in SDR, Principles of Digital Conversion and Channelization, Digital Down Conversion and Up Conversion, Filtering, Modulation, and Demodulation in SDR,Adaptive Filtering and Error Correction Coding, Reconfigurable DSP Architectures for SDR,Trade-offs in Digital Implementation

**UNIT- IV**

Smart Antennas, Benefits of Smart Antennas in SDR, Structures for Beamforming Systems Smart Antenna Algorithms, Hardware Implementation of Smart Antennas, Digital Hardware Choices – Key Hardware Elements

**UNIT- V**

Hardware & Software for SDR and Case Studies: Hardware Platforms: DSP Processors, FPGA, ASICs – Trade-offs, Software Design: Object-Oriented Programming, Object Brokers, GNU Radio and USRP-based Implementations, Case Studies: Speak-easy, JTRS, SDR-3000

**Course Outcomes (COs)**

- After completing this course, students will be able to:
- Explain the need, benefits, and design principles of Software Defined Radio.
- Analyze RF front-end topologies, transmitter/receiver issues, and their effect on SDR performance.
- Apply digital signal processing techniques for filtering, modulation, demodulation, and error correction in SDR.
- Evaluate smart antenna structures, algorithms, and hardware implementations in SDR systems.
- Assess SDR hardware/software trade-offs and demonstrate knowledge of platforms like GNU Radio and USRP using real-world case studies.

**Text Books:**

1. **Walter H.W. Tuttlebee**, *Software Defined Radio: Enabling Technologies*, John Wiley & Sons, 2002.
2. **Markus Dillinger, Kambiz Madani, Nancy Alonistioti**, *Software Defined Radio: Architectures, Systems and Functions*, Wiley, 2003.
3. **Joseph Mitola III**, *Software Radio Architecture: Object-Oriented Approaches to Wireless Systems Engineering*, Wiley-Interscience, 2000.

**Reference Books:**

1. **Ettus Research**, *USRP and GNU Radio Application Notes & Manuals* (online resources).
2. **Alexander M. Wyglinski, Di Pu, Theodore S. Rappaport**, *Cognitive Radio Communications and Networks: Principles and Practice*, Academic Press, 2010.

## Remote Sensing and Navigational Systems

### Course Objectives

The course aims to:

- Provide knowledge of the principles and fundamentals of remote sensing and navigation.

- Familiarize students with different sensors, platforms, and data acquisition techniques.

- Introduce global navigation satellite systems and their integration with modern applications.

- Develop skills in remote sensing data processing, classification, and interpretation.

- Explore advanced applications of remote sensing and navigation in real-world scenarios.

### UNIT I

Fundamentals of Remote Sensing: Introduction to Remote Sensing – Definition, Principles, and Historical Background, Electromagnetic Spectrum and Radiation Principles, Energy Sources and Radiation Laws, Interaction of EM Radiation with Atmosphere and Earth Surface (scattering, absorption, reflection, refraction),Remote Sensing Platforms: Ground-based, Airborne, Spaceborne Systems

### UNIT II

Sensors and Data Acquisition: Imaging and Non-Imaging Sensors, Sensor Parameters: Spatial, Spectral, Radiometric, and Temporal Resolutions, Optical Remote Sensing: Panchromatic, Multispectral, Hyperspectra, Sensors, Microwave Remote Sensing: Active and Passive Systems, RADAR and SAR Principles, LiDAR Remote Sensing and Applications, Data Acquisition and Pre-processing Techniques

### UNIT III

Navigational Systems: Introduction to Satellite Navigation Systems, Fundamentals of GPS, GLONASS, Galileo, BeiDou, and NAVIC (IRNSS),GPS Segments: Space, Control, and User Segments, Positioning Principles: Trilateration, Pseudorange Measurements, and Error Sources, Differential GPS (DGPS) and Real-Time Kinematic (RTK) Techniques, Integration of GPS with INS (Inertial Navigation Systems)

### UNIT IV

Data Processing and Applications: Image Enhancement and Restoration Techniques, Image

Classification: Supervised and Unsupervised Methods, Feature Extraction and Pattern Recognition, Change Detection in Remote Sensing Data, Integration of Remote Sensing and GIS,Applications: Land Use/Land Cover, Forestry, Water Resources, Urban Planning, Disaster Management

**UNIT V**

Advanced Topics and Case Studies: GNSS Augmentation Systems (WAAS, EGNOS, GAGAN),Remote Sensing for Climate Studies and Environmental Monitoring, Navigation Applications in Aviation, Marine, and Land Transportation, Remote Sensing in Agriculture, Mineral Exploration, and Smart City Planning, Case Studies: GPS in Precision Agriculture, Remote Sensing in Disaster Response, GNSS in Air Traffic Management

**Course Outcomes (COs)**

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

- Explain the principles of electromagnetic radiation and its interaction with the Earth for remote sensing.
- Analyze the characteristics and performance of various sensors and platforms used in remote sensing.
- Demonstrate understanding of global navigation satellite systems and positioning techniques.
- Apply image processing and GIS techniques for remote sensing data interpretation.
- Evaluate case studies and applications of remote sensing and navigation in environmental, agricultural, and transportation sectors.

**Text Books**

1. **Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman**, *Remote Sensing and Image Interpretation*, Wiley, 7th Edition, 2015.
2. **Bhatta, B.**, *Global Navigation Satellite Systems: Insights into GPS, GLONASS, Galileo, Compass, and Others*, BS Publications, 2008.
3. **Basudeb Bhatta**, *Remote Sensing and GIS*, Oxford University Press, 2nd Edition, 2011.
4. **George Joseph**, *Fundamentals of Remote Sensing*, Universities Press, 2015.

**Reference Books**

1. **Herbert J. Kramer**, *Observation of the Earth and Its Environment: Survey of Missions and Sensors*, Springer, 5th Edition, 2002.

2. **A.M. Balint and L. Csillik**, *Introduction to Remote Sensing*, Springer, 2017.

3. **B. Hofmann-Wellenhof, H. Lichtenegger, J. Collins**, *GPS: Theory and Practice*, Springer, 5th Edition, 2001.

4. **E.D. Kaplan and C.J. Hegarty**, *Understanding GPS/GNSS: Principles and Applications*, Artech House, 3rd Edition, 2017.

## Quantum Communication & Information Systems

**Course Objectives**

- To infix mathematical background for communication signal analysis, information theory and coding.
- To equip students with knowledge of performance evaluation parameters in presence of channel noise.

**Course Outcome**

- The students will be able to perform the time and frequency domain analysis of the signals in digital communication.
- They will be capable of analyzing and evaluating the performance of baseband/bandpass systems in terms of error rate and spectral efficiency.

**Unit-I:**

**Signals and Spectra:** Fourier transform and properties, Digital communication signal processing, spectral density, autocorrelation, random variable, probability density function, Gaussian & Rayleigh probability density, noise, bandwidth of digital data.

**Unit**-II

Quantum Fourier transform and its applications, the quantum Fourier transform, Performance and requirements, Applications: order-nding and factoring, General applications of the quantum Fourier **transform.**

**Unit-III:**

**Base Band and Band Pass Systems**: sampling theorem, quantization, pulse code modulation, detection of binary signal in Gaussian noise, matched filter, intersymbol interference, Digital modulation techniques, detection of signal in the presence of noise, coherent and non-coherent detection.

**Unit-IV:**

**Channel Coding**: Linear block codes: generator matrix, systematic linear block codes, parity check matrix, cyclic codes, Hamming codes, Convolutional Codes: Encoder representation, maximum likehood decoding.

**Unit -V:**

**Quantum Information Theory**: Communication channels; mutual information, channel capacity and entropy; Shannon's theorems; Quantum communication, dense coding and teleportation; von Neumann entropy.

**Text Books**

1. B. Sklar, Digital Communications, Pearson Education.2/e, 2005.

2. J.G. Proakis, Digital Communications, McGraw-Hill Higher Education, 4/e, 2001.

**Reference Books**

1. Michael A. Nielsen & Isaac L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press

2. B. P. Lathi, Modern Digital & Analog Communications Systems, Oxford University press, 3/e, 1998.

# PATTERN RECOGNITION AND MACHINE LEARNING

**Course Overview:**

This course provides various linear models and basic classifiers and also distinguish different models. The pre requisite is Statistics and Linear Algebra.

**Course Objective:**

- The student will be able to understand the mathematical formulation of patterns.
- To study the various linear models.
- Understand the basic classifiers.
- Can able to distinguish different models.

**Course Outcomes:**

After completion of the course students able to

Learn the basics of pattern classes and functionality.

Construct the various linear models.

Understand the importance kernel methods.

Learn the Markov and Mixed models.

**UNIT- I**

**Introduction to Pattern recognition:** Mathematical Formulation and Basic Functional Equation, Reduction of Dimensionality, Experiments in Pattern Classification, Backward Procedure for Both Feature Ordering- and Pattern Classification, Suboptimal Sequential Pattern Recognition, Nonparametric Design of Sequential Pattern Classifiers, Analysis of Optimal Performance and a Multiclass Generalization.

**Unit-II:**

**Linear Models:** Linear Basis Function Models -Maximum likelihood and least squares, Geometry of least squares , Sequential learning, Regularized least squares, Multiple outputs , The Bias-Variance Decomposition, Bayesian Linear Regression -Parameter distribution, Predictive, Equivalent, Bayesian Model Comparison, Probabilistic Generative Models-Continuous inputs , Maximum likelihood solution, Discrete features, Exponential family, Probabilistic Discriminative Models -Fixed basis functions, Logistic regression, Iterative reweighted least squares, Multiclass logistic regression, Probit regression, Canonical link functions.

**Unit-III:**

**Kernel Methods:** Constructing Kernels, Radial Basis Function Networks - Nadaraya-Watson model, Gaussian Processes -Linear regression revisited, Gaussian processes for regression, Learning the hyper parameters, Automatic relevance determination, Gaussian processes for classification, Laplace approximation, Connection to neural networks, Sparse Kernel Machines-Maximum Margin Classifiers, Overlapping class distributions, Relation to logistic regression, Multiclass SVMs, SVMs for regression, Computational learning theory, Relevance Vector Machines- RVM for regression, Analysis of sparsity, RVM for classification.

**Unit-IV:**

**Graphical Models:** Bayesian Networks, Example: Polynomial regression, Generative models, Discrete variables, Linear-Gaussian models, Conditional Independence- Three example graphs, D-separation, Markov Random Fields -Conditional independence properties, Factorization properties, Illustration: Image de-noising, Relation to directed graphs, Inference in Graphical Models- Inference on a chain, Trees, Factor graphs, The sum-product algorithm, The max-sum algorithm, Exact inference in general graphs, Loopy belief propagation, Learning the graph structure.

**Unit-V:**

**Mixture Models and EM algorithm:** K-means Clustering-Image segmentation and compression, Mixtures of Gaussians-Maximum likelihood, EM for Gaussian mixtures, An Alternative View of EM- Gaussian mixtures revisited, Relation to K-means, Mixtures of Bernoulli distributions, EM for Bayesian linear regression, The EM Algorithm in General, Combining Models- Tree-based Models, Conditional Mixture Models- Mixtures of linear regression models, Mixtures of logistic models, Mixtures of experts

**Text Books:**

1. Sequential methods in Pattern Recognition and Machine Learning-K.S.Fu, Academic Press, volume no.52.
2. Machine Learning – Tomm. Mitchell, Mc Graw Hill Education.

**Reference Books:**

1. Machine Learning- Anuradha Srinivasa raghavan, Vincy Joseph, Wiley,2019
2. The elements of Statistical Learning- Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, Springer, 2nd Ed., 2017.

**e-Resources:**

1. NOC:Pattern Recognition and application- https://nptel.ac.in/courses/117105101

## Ad-hoc & Wireless Sensor Networks

**Course Objectives:**

- To acquire the knowledge about various architectures and applications of Sensor Networks
- To understand issues, challenges and emerging technologies for wireless sensor networks
- To learn about various routing protocols and MAC Protocols
- To understand various data gathering and data dissemination methods
- To Study about design principals, node architectures, hardware and software required for implementation of wireless sensor networks.

**Course Outcomes:**

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

- Analyze and compare various architectures of Wireless Sensor Networks
- Understand Design issues and challenges in wireless sensor networks
- Analyze and compare various data gathering and data dissemination methods.
- Design, Simulate and Compare the performance of various routing and MAC protocol

**UNIT - I:**

Introduction to Sensor Networks, unique constraints and challenges, Advantage of Sensor Networks, Applications of Sensor Networks, Types of wireless sensor networks

**UNIT - II:**

Mobile Ad-hoc Networks (MANETs) and Wireless Sensor Networks, Enabling technologies for Wireless Sensor Networks. Issues and challenges in wireless sensor networks

**UNIT - III:**

Routing protocols, MAC protocols: Classification of MAC Protocols, S-MAC Protocol, B-MAC protocol, IEEE 802.15.4 standard and ZigBee

**UNIT - IV:**

Dissemination protocol for large sensor network. Data dissemination, data gathering, and data fusion; Quality of a sensor network; Real-time traffic support and security protocols.

**UNIT - V:**

Design Principles for WSNs, Gateway Concepts Need for gateway, WSN to Internet Communication, and Internet to WSN Communication. Single-node architecture, Hardware components & design constraints, Operating systems and execution environments, introduction to TinyOS and nesC.

**TEXT BOOKS:**

1. Ad-Hoc Wireless Sensor Networks- C. Siva Ram Murthy, B. S. Manoj, Pearson

2. Principles of Wireless Networks – Kaveh Pah Laven and P. Krishna Murthy, 2002, PE

**REFERENCE BOOKS:**

1. Wireless Digital Communications – Kamilo Feher, 1999, PHI.

2. Wireless Communications-Andrea Goldsmith, 2005 Cambridge University Press.

3. Mobile Cellular Communication – Gottapu Sasibhushana Rao, Pearson Education, 2012.

4. Wireless Communication and Networking – William Stallings, 2003, PHI.

<div align="center">**Embedded Real Time Operating System**</div>

**Course Overview:** This course provides a comprehensive introduction to Real-Time Operating Systems (RTOS) and their applications in embedded systems. Students will explore the fundamental concepts of real-time embedded systems, understand task management, synchronization mechanisms like semaphores and message queues, and delve into exception handling and timer services. The course also covers memory management strategies and practical techniques for modularizing applications to meet real-time constraints. Additionally, it addresses common design challenges such as deadlocks and priority inversion, preparing students to design, analyse, and implement robust real-time embedded applications.

**Course Outcomes (COs):**

By the end of this course, students will be able to:

- Analyse key concepts and roles of real-time operating systems in embedded system design.
- Evaluate task scheduling and synchronization methods in real-time systems.
- Design interrupt and timer handling mechanisms for embedded real-time environments.
- Apply real-time memory management techniques in embedded applications.
- Create modular real-time applications to resolve deadlocks and priority inversion.

**UNIT-I:**

**Introduction to RTOS**: Real life examples of embedded systems, real-time embedded systems, the future of embedded systems, a brief history of operating systems, defining an RTOS, the scheduler, objects, services, key characteristics of an RTOS.

**UNIT-II:**

**Tasks**: Introduction, defining a task, task states and scheduling, typical task operations, typical task structure, synchronization, communication, and concurrency. Semaphores: Introduction, defining semaphores, typical semaphore operations, typical semaphore use. Message Queues: Introduction, defining message queues, message queue states, message queue content, message queue storage, typical message queue operations, and typical message queue use.

**UNIT-III:**

**Exceptions and Interrupts:** Introduction, what are exceptions and interrupts, a closer look at

exceptions and interrupts, processing general exceptions, the nature of spurious interrupts. Timer and Timer Services: Introduction, real-time clocks and system clocks, programmable interval timers, timer interrupt service routines, a model for implementing the soft-timer handling facility, timing wheels, soft timers and timer related operations.

## UNIT-IV:

**Memory Management:** Introduction, dynamic memory allocation in embedded systems, fixed-size memory management in embedded systems, blocking vs. non-blocking memory functions, hardware memory management units.

## UNIT-V:

**Modularizing Applications:** Introduction, an outside-in approach to decomposing applications, guidelines and recommendations for identifying concurrency, schedulability analysis rate monotonic analysis.

Common Design Problems: Introduction, resource classification, deadlocks, priority inversion.

**Text Book**

1. Qing Li, and Caroline Yao. Real-Time Concepts for Embedded Systems. CMP Books, 2003.

**Reference Books:**

1. Prasad, K. V. K. K. Embedded Real-Time Systems: Concepts, Design & Programming. Dream Tech Press, 2005.

2. Simon, David E. An Embedded Software Primer. 1st ed., 5th impression, Addison-Wesley Professional, 2007.

3. Singh, Rajib Mall. Real-Time Systems: Theory and Practice. Pearson Education India, 2006.

## NETWORK SECURITY AND CRYPTOGRAPHY LAB

**List of Experiments:**

1. Write a C program that contains a string (char pointer) with a value 'Hello world'. The program should XOR each character in this string with 0 and display the result.

2. Write a C program that contains a string (char pointer) with a value 'Hello world'. The program should AND or and XOR each character in this string with 127 and display the result.

3. Write a Java program to perform encryption and decryption using the following algorithms a. Ceaser cipher b. Substitution cipher c. Hill Cipher

4. Write a C/JAVA program to implement the DES algorithm logic.

5. Write a C/JAVA program to implement the Blowfish algorithm logic.

6. Write a C/JAVA program to implement the Rijndael algorithm logic.

7. Write the RC4 logic in Java Using Java cryptography; encrypt the text "Hello world" using Blowfish. Create your own key using Java key tool.

8. Write a Java program to implement the RSA algorithm.

9. Implement the Diffie-Hellman Key Exchange mechanism using HTML and JavaScript.

10. Calculate the message digest of a text using the SHA-1 algorithm in JAVA.

11. Calculate the message digest of a text using the MD5 algorithm in JAVA

**TEXT BOOKS:**

1. Cryptography and Network Security - Principles and Practice: William Stallings, Pearson Education, 6th Edition

2. Cryptography and Network Security: Atul Kahate, McGraw Hill, 3rd Edition

**REFERENCE BOOKS:**

1. Cryptography and Network Security: C K Shyamala, N Harini, Dr T R Padmanabhan, Wiley India, 1st Edition.

2. Cryptography and Network Security: Forouzan Mukhopadhyay, McGraw Hill, 3rd Edition

3. Information Security, Principles, and Practice: Mark Stamp, Wiley India.

4. Principles of Computer Security: WM. Arthur Conklin, Greg White, TMH

5. Introduction to Network Security: Neal Krawetz, CENGAGE Learning

6. Network Security and Cryptography: Bernard Menezes, CENGAGE Learning

## WIRELESS COMMUNICATIONS AND NETWORKS LAB

**Course Outcomes:**

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

- Implement the advanced digital modulation techniques.

- Design Convolutional encoder and decoder for error control coding techniques.

- Calculate path loss for Free space, Okumura and Hata models for outdoor propagation.

- Comprehend Cellular concepts of GSM and CDMA networks.

- Simulate RAKE receiver for CDMA with MATLAB.

**List of Experiments:**

1. FSK Modulation and Demodulation technique.

2. QPSK Modulation and Demodulation technique.

3. DQPSK Modulation and Demodulation technique

4. 8-QAM Modulation and Demodulation technique.

5. Implementation of Convolutional Encoder and Decoder.

6. Simulation of the following Outdoor Path loss propagation models using MATLAB.

a. Free Space Propagation model

b. Hata model

b. Okumura model

7. Simulation of Adaptive Linear Equalizer using MAT LAB software.

8. Measurement of call blocking probability for GSM &CDMA networks using Netsim software.

9. Study of GSM handset for various signalling and fault insertion techniques (Major GSM handset sections: clock, SIM card, charging, LCD module, Keyboard, User interface).

10. Study of transmitter and receiver section in mobile handset and measure frequency

11. band signal and GMSK modulating signal.

12. Simulation of RAKE Receiver for CDMA communication using MAT LAB software.

13. Simulate and test various types of PN codes, chip rate, spreading factor and processing gain on performance of DSSS in CDMA.

14. Simulate and test the 3G Network system features using GSM AT Commands. (Features of 3G Communication system: Transmission of voice, video calls, SMS, MMS, TCP/IP, HTTP, GPS)

15. Modelling of communication system using Simulink.