Third Semester

VDT2101 **Electronic Devices-I** **[3 1 0 4]**

Course Outcomes:

At the end of the course, students will be able to
CO1. Understand the principles of semiconductor Physics and apply it to electronic devices.
CO2. Understand construction and operation of semiconductor devices.
CO3. Appreciate different devices for different applications.
CO4. Analyze PN junctions, JFETs, MOSFETs, and BJTs
CO5. Apply electronic devices to design and implement circuits and systems.

Syllabus:

Semiconductor Physics fundamentals: intrinsic and extrinsic semiconductors. Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility, and resistivity; sheet resistance. **PN Junctions:** PN junction formation, depletion region, and forward/reverse bias. Generation and recombination of carriers; Poisson and continuity equation P-N junction characteristics, I-V characteristics, and small signal switching models; Diode circuits: rectifiers, clippers, and clampers. Avalanche breakdown, Zener diode, Schottky diode.**Junction Field Effect Transistors (JFETs):** JFET fundamentals: construction and operation. JFET characteristics and applications.**Metal Oxide Semiconductor FETs:** MOSFET fundamentals; n-channel and p-channel MOSFETs; MOSFET characteristics and regions of operation. MOSFET small-signal analysis, Common source, common gate, and common drain amplifier configurations. MOSFET Applications: MOSFET-based digital circuits. MOSFET as a switch and its role in digital systems. **Bipolar Junction Transistors (BJTs):** BJT fundamentals: construction and operation. BJT characteristics and comparison with MOSFETs.

References:

1. R. L. Boylestad, L. Nashelsky, *Electronic Devices and Circuit Theory,* (10e), Pearson, 2009.
2. A. S. Sedra, K. C. Smith, *Microelectronic Circuits, Technology and System Applications*, (7e), Oxford University Press, 2014.
3. B.G. Streetman, and S. K. Banerjee, *Solid State Electronic Devices,* (7e), Pearson, 2014.
4. S. M. Sze and K. N. Kwok, *Physics of Semiconductor Devices*, (3e), John Wiley &Sons, 2006.
5. P. R. Gray, P. J. Hurst, S. H. Lewis, *Analysis and design of analog integrated circuits* (5e), Hoboken, NJ: Wiley, 2015.
6. D. A. Neamen, *Semiconductor physics and devices: Basic principles* (4e)z. Boston, MA: McGraw-Hill, 2012.

VDT2102 **Digital Electronics** **[3 1 0 4]**

Course Outcomes:
At the end of the course, students will be able to
CO1. Analyse and Design Combinational circuits
CO2. Describe and characterize flip flops & its applications.

CO3. Design and analyse Sequential Circuits and analyse timing analysis.
CO4. Design Finite State Machines and Algorithmic State Machines.
CO5. Understand the different Logic families and semiconductor families.

Syllabus:

Introduction of Combinational logic design: Overview of Boolean Algebra and K-Map, Half and Full Adders, Subtractors, Serial and Parallel Adders, BCD Adder. MSI devices: Comparators, Multiplexers, Encoder, Decoder, Driver & Multiplexed Display, Barrel shifter and ALU. **Sequential logic design:** latch, Flip-flop, S-R FF, D FF, JK FF, T FF, and Master-Slave JK FF, Edge triggered FF, Ripple and Synchronous counters, Shift registers, Timing Analysis of sequential circuits.**Designing of State Machines:** Finite state machines, Design of synchronous FSM, State Reduction, Timing issues in synchronous circuits. Algorithmic State Machines, Designing synchronous circuits like Pulse train generator, Pseudorandom Binary Sequence generator, Clock generation. Design of asynchronous circuits.**Logic Families and Semiconductor Memories:** TTL NAND gate, Specifications, Noise margin, Propagation delay, fan-in, fan-out, Tristate TTL, ECL, CMOS families and their interfacing, Memory elements, Concept of Programmable logic devices, Logic implementation using Programmable Devices.

References:

1. A. A. Kumar, *FUNDAMENTALS OF DIGITAL CIRCUITS*. Prentice Hall India Pvt., Limited, (2e), 2016.
2. R. P. Jain, *Modern Digital Electronics*. McGraw-Hill Education (India) Pvt Limited, (4e), 2003.
3. W.H. Gothmann, *Digital Electronics- An introduction to theory and practice*, PHI, (2e), 2006.
4. R.P. Jain, Modern digital Electronics, Tata McGraw Hill, (4e), 2009.
5. S. Brown and Z. Vranesic, Fundamentals of Digital logic with Verilog Design, McGraw Hill, (3e) 2013.

VDT2103 Circuits & network theory [3 0 2 4]

Course Outcomes:

At the end of this course students will demonstrate the ability to

CO1. Apply the knowledge of basic circuital law and simplify the network using reduction techniques
CO2. Evaluate transient response, Steady state response, network functions
CO3. Determine different network functions.
CO4. Evaluate two-port network parameters
CO5. Synthesize an electrical network from a given impedance/admittance function

Syllabus:
Network theorems and elements: Superposition, Thevenin's and Norton's Theorem, maximum power transfer theorem. Networks with dependent sources. **Transients analysis:** Impulse, Step, Ramp and sinusoidal response analysis of first order and second order circuits. Time domain & transform domain (Laplace) analysis. Initial and final values of networks; **Two port networks:** Two Port General Networks: Two port impedance, admittance, hybrid, ABCD

parameters and their inter relations. Equivalence of two ports. **Interconnection of two port networks:** filters, image impedance symmetric T and pi networks; **Network functions:** Terminals and terminal pairs, Driving point Impedance, admittance and transfer functions. Procedure for finding network functions for general two terminal pair networks, Stability & causality, Hurwitz polynomial, positive real function; **Network synthesis:** The four-reactance function forms, specification for reactance function. Foster form of reactance networks. Cauer form of reactance networks Synthesis of R-L and R-C and L-C networks in Foster and Cauer forms.

References:

1. Van Valkenburg, Mac Elwyn, *Network analysis, (3e),* Prentice Hall of India*, 2000.*
2. A. Sudhakar, S. P. Shyammohan, *Circuits and Network,*(5e),Tata McGraw-Hill, New Delhi, 2017.
3. *William H. Hayt,Jr. Jack E. Kemmerly, Stevem M. Durbin, Engineering Circuit Analysis, (8e), McGraw-Hill Education,2012.*
4. Ashfaq Husain, *Networks and Systems, (2e),* Khanna Book Publishing, 2021.
5. Ravish S. Salivahanan, S. Pravin Kumar, *Circuit Theory,* Vikas Publishing.

Lab:

Experiments are carried out on hardware and software to analyze the circuits & networks.

VDT2120 Analog and Digital Signal Processing and Communication [3 0 0 3]

Course Outcomes:

At the end of this course students will demonstrate the ability to

CO1. Understand the fundamental principles of analog and digital signal processing.

CO2. Analyze and design analog filters, including both FIR and IIR filters, for signal conditioning in communication systems.

CO3. Apply the Fast Fourier Transform (FFT) for spectral analysis of signals in both time and frequency domains

CO4. Design and implement digital filters, including FIR and IIR filters, for signal processing in communication applications.

CO5. Evaluate the performance of communication systems and Develop proficiency in the use of relevant software tools for simulation and analysis of signal processing and communication systems.

CO6. Understand and apply basic communication protocols in the design of digital communication systems and Explore emerging trends and technologies in the field of communication systems

Syllabus:

Introduction to Signal Processing and Communication: Overview of signal processing and communication systems, Basics of analog and digital signals. **Analog Signal Processing:** Filters (FIR and IIR), Filter fundamentals and types, Design and analysis of both FIR and IIR filters. **Frequency Domain Analysis:** FFT, Introduction to the Fast Fourier Transform (FFT), FFT applications in signal processing and communication. **Analog Communication Systems:** Amplitude Modulation (AM) and Frequency Modulation (FM), Analog demodulation techniques. **Digital Signal Processing: Filters (FIR and IIR): Design**

and analysis of digital FIR and IIR filters, Applications in signal processing. **Digital Modulation and Demodulation Techniques:**Digital modulation schemes: Phase Shift Keying (PSK), Frequency Shift Keying (FSK), and Quadrature Amplitude Modulation (QAM), Digital demodulation techniques. **Communication Protocols and Emerging Technologies:** Overview of communication protocols, Exploration of emerging trends in communication technologies.

References:

1. Frédéric Cohen Tenoudji, *Analog and digital signal analysis*,**(1e),** Springer International Publishing Switzerland, 2016.
2. Li Tan, Jean Jiang, *Digital signal processing: fundamentals and applications*, (1e), Academic press, 2018.
3. John Kronenburger, John Sebeson, *Analog & Digital Signal Processing*, (1e), Delmar Learning, 2007.
4. Yarlagadda, RK Rao, *Analog and digital signals and systems,* Vol. 1, (1e), New York: Springer, 2010.
5. Ashok Ambardar, *Analog and digital signal processing,* (1e), Boston, MA: PWS, 1995.
6. Sunil Bhooshan, *Fundamentals of Analogue and Digital Communication Systems*, (1e), Springer, 2022.

VDT2121 Linear Integrated circuits [3 0 2 4]

Course Outcomes:

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

CO1. Identify the characteristics of an ideal op amp and model the ideal op amp for circuit analysis.

CO2. Analyse op amp circuits that perform useful functions such as precisely amplifying signals etc., and their linear and non-linear applications.

CO3. Design different type of filters by using Op amp circuit.

CO4. Analyse IC555 timer using Op amp for different applications.

CO5. Analyse data converters and IC565 and IC566 using op-amp.

Syllabus:

Operational amplifiers: Function and characteristics of the ideal Op-amp Differential and common mode signals, Block level representation of Op-amp.**Linear applications of op-amp**: Weighted Amplifier, Converter circuits, design specification of Differentiator and Integrator circuits, instrumentation amplifier and bridge amplifier. **Non-linear applications of operational amplifier**: Active filters: Design and analysis of low pass, high pass, band pass, band elimination and all pass active filters. rectifiers, peak detector, sample and hold circuit, comparators, window detector, Schmitt trigger, square wave, triangular wave generators, oscillators. **Timer IC**: pin details and internal working of 555 IC. Applications: multivibrator, Schmitt trigger. **Data converters**: Principles and specifications of digital to analog converter (DAC) and analog to digital converters (ADC), binary weighted and R-2R DAC, successive approximation type, counter type and servo tracking type and dual slope ADC. Phase-locked loop IC 565 and voltage-controlled oscillator IC 566: Analysis and applications. IC based voltage regulators and power amplifiers.

References:

1. R.A. Gayakwad, *Op-Amps and Linear Integrated Circuits,* (4e), Prentice Hall of India, 2002.
2. W. D. Stanley, *Operational Amplifiers with Linear Integrated Circuits*, (4e), Pearson Education, 2007.
3. F. Sergio, *Design with Op amps & Analog Integrated Circuits*, (4e), McGraw Hill, 2014.
4. D. Roy Chowdhury, *Linear Integrated Circuits*, (2e), New Age International (p) Ltd, 2003.
5. William D.Stanley, *Operational amplifiers with linear integrated cuircuits,(*4e), Pearson Education India,2009.

Lab:
Experiments are performed on hardware as well as software to study linear and non-linear applications of op-amp. Also, circuits based on PLL, VCO and timer IC are designed and performed on hardware as well as software.

VDT2130 Electronic devices Lab-1 [0 0 2 1]

Course Outcomes:
At the end of the course, students will be able to
CO1. Understand semiconductor device characteristics
CO2. Analyze device characteristics to determine important device and circuit parameters
CO3. Implement circuits with diodes
CO4. Implement circuits with BJT and FET
CO5. Understand the effect of input frequency on amplifier circuits

Syllabus:

Experiments are carried out on hardware and software to analyze the characteristics of semiconductor devices and use these devices for various circuit implementations.

VDT2131 Digital Electronics Lab [0 0 2 1]

Course Outcomes:
At the end of the course, students will be able to
CO1. Analyze the various digital ICs and understand their operation.
CO2. Design and analyze combinational circuits.
CO3. Design and analyze synchronous sequential logic circuits.
CO4. Classify all digital circuits using software.

Syllabus:
Experiments of this lab are implemented at Hardware as well as software level. List of experiments include: Study of implementation of combinational and arithmetic circuits using

logic gates and MSI chips. Designing of sequential circuits and implementation of FSMs for their applications.

VDT2170 Project Based Learning 1 [0 0 2 1]

Syllabus:

Based on identification of a research problem/ latest innovation and literature review. Evaluation will be based on report and presentation.

FOURTH SEMESTER

VDT2201 Electronic Devices-II [4 0 0 4]

Course Outcomes:

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

CO1. Understand the principles of semiconductor physics as applied to advanced electronic devices

CO2. Analyze and describe the operation of traditional electronic devices such as PN junctions, JFETs, and MOSFETs.

CO3. Explore the principles and advantages of FinFET technology.

CO4. Design and analyze FinFET-based circuits for specific applications.

CO5. Evaluate the impact of FinFET technology on the development of advanced semiconductor devices.

Syllabus:

Review of Semiconductor Physics and Traditional Electronic Devices: Recap of semiconductor fundamentals. In-depth review of PN junctions, JFETs, and MOSFETs. **FinFET Technology:** Evolution of MOSFETs to FinFETs, Advantages and challenges of FinFET technology. **FinFET Device:** FinFET structure and fabrication, Operational principles of FinFETs. Analyzing FinFET characteristics, Modeling FinFET behavior for circuit simulation. **FinFET Circuit Design:** Design considerations for FinFET-based circuits, Applications of FinFETs in analog and digital circuits. **Future Trends:** Scaling trends in FinFET technology, FinFETs in integrated circuits and system-on-chip (SoC) designs. Case studies of FinFET applications in real-world scenarios.

References:

1. Samar K. Saha, *FinFET Devices for VLSI Circuits and Systems,(1e),* CRC Press, 2021.
2. Jean-Pierre Colinge (Ed.), *FinFETs and Other Multi-Gate Transistors,(1e),* Springer, 2008.
3. Corrado Di Natale, *Introduction to Electronic Devices,(1e),* Springer, 2023.
4. S. Salivahanan, N. Suresh Kumar, *Electronic Devices and Circuits*,(5e), McGrawHill, 2022.
5. Segio M. Rezende, *Introduction to Electronic Materials and Devices,(1e),* Springer, 2022.

VDT2202 **Computer and Processor Architecture** **[3 1 0 4]**

Course Outcomes:

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

CO1. Classify the organization and structure of modern computer systems.
CO2. Demonstrate an understanding of addressing techniques and control unit design.
CO3. Examine microarchitecture and its role in computer system design.
CO4. Apply knowledge of cache memory and its impact on system performance.
CO5. Analyze pipelining and parallel processing in computer architecture.

Syllabus:

Introduction to Computer Architecture: Overview of computer architecture and design, Basic Structure of Computers, Functional units, Instruction set architecture basics, Processor design principles. **Data Path and Control Unit Design. Memory Systems and Input/Output Systems:** Understanding memory hierarchies, Input/output system organization, **Cache Memory and Pipelining:** Principles and types of cache memory, Overview and analysis of pipelining. **Parallel Processing and Performance Evaluation:** Concepts of parallel processing in computer architecture, Performance evaluation for architectures. **Advanced Topics and Emerging Trends: Computer arithmetic** and its role in system design, System-on-chip design and emerging trends in computer architecture, Discussion on parallel computing, energy-efficient designs, and emerging memory technologies.

References:

1. V.C. Hamacher, Z. Vranesic & S. Zaky, “Computer Organization”, McGraw Hill International Edition, Computer Science series, (5e), 2002.
2. M. Morris Mano, “Computer System Architecture, Pearson”, (3e), 2008.
3. John P. Hayes, “Computer Architecture and Organization”, TMH, (3e), 1998
4. M. Dalrymple, “Inside an Open-Source Processor”, elector, (1e) 2021.
5. S. Brown and Z. Vranesic, “Fundamentals of Digital logic with Verilog Design”, McGraw Hill, (3e), 2014.
6. J. Ledin, “Modern Computer Architecture and Organization”, Packt Publishing Ltd, (1e), 2022.

Lab:

An Introduction to Computer Architecture, Microprocessor, Assembly language programming, and Verilog. Experiments to be performed using 80x86 / Arm / OpenSPARC.

VDT2220 **System Design using HDL** **[3 0 2 4]**

Course Outcomes:

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

CO1. Describe the basic attributes, operators & syntax of Verilog HDL for implementation of digital circuits using Verilog for enhanced employability.
CO2. Discuss the structural, register-transfer level (RTL), and algorithmic levels of abstraction for modelling digital hardware systems.

CO3. Explain modelling of combinational and sequential digital systems (Finite State Machines) for acquiring skills in the domain of Digital Systems.
CO4. Apply the concept of test-benches to create testing behavioural environments for simulation-based verification
CO5. Illustrate problems of finite state machine for various system implementation.
CO6. Analyse circuits efficiently in digital system design to achieve optimization for high device utilization and performance for digital applications.

Syllabus:

Introduction to Verilog HDL, Hardware Simulation & Synthesis, **Verilog Attributes:** Switch level, Gate level. Pin to Pin Delay, Dataflow, Top-Down design with Verilog, Subprograms, Operators, Syntax and constraints. **Characterization of HDL:** Timing, concurrency, data types, nets, Verilog primitives. Modelling of Test Bench. Combinational and Sequential Design. Usage of subprograms, parametrization and specifications, path delay specification. Utilities for high level Description. Dataflow description, Behavioural Description of Hardware, Modelling for Hardware Design. Interface design & Modelling.

References:

1. K. S. Kundert and O. Zinke, The Designer's Guide to Verilog-AMS. Springer, (1e) 2004.
2. S. Palnitkar, Verilog HDL, (2e), Pearson education, 2003.
3. J. Bhasker, A Verilog HDL Primer, Star Galaxy Pub., (3e), 2005.
4. S. Brown and Z. Vranesic, Fundamentals of Digital logic with Verilog Design, McGraw Hill, (3e) 2013.
5. M. Morris Mano, Michael D. Ciletti, Digital Design: With an introduction to Verilog HDL, Pearson, (6e), 2017.

VDT2221	**HF & RF Circuits**	**[4 0 0 4]**

Course Outcomes:

At the end of the course, students will be able to
CO1. Understand the fundamentals of HF and RF Electronics.
CO2. Explain the concepts of transmission line and apply the concepts to calculate various parameters of transmission Line using smith chart.
CO3. Understand the matching and biasing networks.
CO4. Explain the function of RF Passive and Active Components in HF and RF circuit Design.
CO5. Design RF transistor amplifier with minimum noise and stability considerations.
CO6. Design RF oscillator with high frequency oscillation configuration.

Syllabus:

Introduction to HF and RF Electronics: The Electromagnetic Spectrum, units and Physical Constants, Microwave bands – RF behaviour of Passive components: Tuned resonant circuits, Vectors, Inductors and Capacitors **Introduction to Transmission Line:** Examples of transmission lines- Transmission line equations Single and Multiport Networks: The Smith Chart Network properties and Applications, Scattering Parameters. **Matching and Biasing Networks:** Impedance matching using discrete components – Micro strip line matching networks, Amplifier classes of Operation and Biasing networks. **RF Passive & Active Components:** Filter Basics – Lumped filter design – Distributed Filter Design – Diplexer Filters- Crystal and Saw filters- Active Filters - Tunable filters – Directional Couplers – Hybrid

Couplers – Isolators. RF Diodes **Transistor Amplifier and Oscillator Design:** Characteristics of Amplifiers - Amplifier Circuit Configurations, Amplifier Matching Basics, Low phase noise oscillator design, High frequency Oscillator configuration and types.

References:

1. Reinhold Ludwing, Pavel Bretchko, *RF Circuit design: Theory and applications,* Pearson Education Asia Publication, New Delhi 2001.
2. Devendra K. Misra, *Radio Frequency and Microwave Communication Circuits – Analysis and Design*, Wiley Student Edition, John Wiley & Sons.
3. Mathew M. Radmangh, *Radio frequency and Microwave Electronics*, PE Asia Publ., 2001.
4. Christopher Bowick, Cheryl Aljuni and John Biyler, *RF Circuit Design*, Elsevier Science, 2008.
5. Joseph Carr., *Secrets of RF Design*, (3e), Tab Electronics.
6. Less Besser and Rowan Gilmore, *Practical RF Circuit Design for Modem Wireless Systems,* Vol.2.

VDT2240 Data Structures & Algorithms [3 0 0 3]

Course Outcomes:

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

CO1. Describe the basic concepts of object-oriented programming using C++.
CO2. Explain the basic operations on arrays, lists, stacks and queue data structures.
CO3. Elaborate the notions of trees, binary search trees, Red Black tree, Heap.
CO4. Learn appropriate sorting algorithms such as merge sort, heap sort and quick sort etc. based on the problem given.
CO5. Develop C++ programs for simple applications.

Syllabus:
Introduction to C++: An overview of C++ programming language basic terms and operations. **Linked List:** Representing the linked list in memory with traversing and searching a linked list. **Stack, Queues and Recursion:** Array/ Linked representation of stack and Queues with its applications. **Trees:** Tree Definitions, Type of Trees, Traversal Algorithms, **Heaps and Priority Queues:** Heaps, the Natural Mapping, Insertion into a Heap, Removal from a Heap, Path length: Huffman's algorithm. **Sorting and Searching:** Various sorting algorithms like Bubble Sort etc., Searching and data modification, Hashing. **Graphs:** Types of Graphs, The Adjacency Matrix for a Graph, The Incidence Matrix for a Graph, The Adjacency List for a Graph, Dijkstra's Algorithm, Graph Traversal Algorithms. **Analysis of algorithm**: Synergy between data structures and algorithm, Factors to be considered in the choice of data structures and algorithms.

References:

1. J. R. Hubbard, *Data Structures and Algorithms*, Schaum's Outlines. McGraw-Hill, New York, USA, 2000.
2. Michael T. Goodrich, Roberto Tamassia, David M. Mount, *Data Structures and Algorithms in C++*, 2, illustrated Edition, John Wiley & Sons, 2010.
3. R. Lewis, L. Deneberg, Data Structures and their Algorithms, Addison-Wesley UK, 1991.

4. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, University Paperback, Perason, 2014.
5. Clifford A. Shaffer, *Data Structures & Algorithm Analysis in C++,* (3e), Dover Publication US, 2011.

VDT2241 Optical Components and Sensors [3 0 0 3]

Course Outcomes:

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

CO1. Understand fundamental properties of light and operating principles of optical and photonic devices.
CO2. Understand and analyze the principle behind semiconductor optoelectronic sources and detectors and their characteristics.
CO3. Demonstrate an in-depth understanding of the basic mechanism of Opto-electronic components like modulators, couplers, multiplexers, demultiplexers, and polarizers
CO4. Understand the operating principles, and characteristics, of different types of optical sensor
CO5. To demonstrate the design architectures of various optical sensors and their applications.

Syllabus:

Review of Semiconductor device Physics, Semiconductor Opto electronics- Solid State Materials, Emitters, Detectors and Amplifiers, **Semiconductor Emitters**- LEDs, Diodes, SLDs, CCDs, **Semiconductor lasers-** basic Structure, theory and device characteristics, DFB, DBR, Quantum well lasers, Laser diode arrays, VCSEL etc. Photoconductors, photo diodes, PIN , APD ,Photo transistors, solar cells, CCDs, IR and UV detectors.Optical filters, Directional couplers, Dividers, Multiplexers, Phase and Amplitude Modulators, Polarization and polarization controllers, etc. Photonics Signal processing, Nonlinear optics- Frequency Converters, Phase conjugation, optical Correlation. Optical sensing principles (temperature, strain, stress, pressure, refractive index, etc.).Fibre types and materials for optical fibre sensing (silica based, polymer based, etc.). Point sensors (Fibre Bragg gratings, long period gratings, and microfibres/nanowires). Distributed sensors (Brillouin scattering based, Raman scattering based, Rayleigh scattering. Fibre gyroscopes. Fibre-based gas and chemical sensors. Optical fibre sensors for extreme and harsh environments (high temperature and strain, shock, high radiation).Principles and application of optical fibre sensors in medicine and life sciences.

References:

1. J Wilson and J F B J iS Hawkers, *Opto electronics - An introduction*, (2e), Prentice-Hall India, 1993.
2. S. O. Kasap, *Optoelectronics and Photonics: Principles and practices*, Pearson 2012
3. J. C. Palais, *Introduction to optical electronics*, (5e), Prentice Hall, 2004.
4. Jörg Haus, *Optical Sensors -Basics and Applications*, (1e), Weinheim : Wiley-VCH Verlag GmbH & Co, 2010.
5. Jasprit Singh, *Semiconductor opto electronics*, (1e), McGraw-Hill, Inc, 1995.
6. P Bhattacharya, *Semiconductor optoelectronic devices*, (2e), Pearson, 1996.

VDT2242 FPGA based system design [3 0 0 3]

Course Outcomes:

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

CO1. Understanding the basic concept and design of programmable logic devices
CO2. Identify logic and technology-specific parameters to control the functionality, timing, power, and parasitic effects.
CO3. Understand the design flow involved in designing for FPGAs using modern tools
CO4. Distinguish different FPGA programming technologies
CO5. Understand general design issues to implement circuits using ACT architecture

Syllabus:

Introduction to programmable logic devices: Read Only Memories, Programmable Logic Arrays, Programmable Array Logic, Generic Array Logic, Complex Programmable Logic Devices, Field Programmable Gate Array (FPGA). **The Structure of FPGA:** FPGA architecture, Programmable Logic Block Architectures, Programmable Interconnects, Programmable I/O blocks in FPGAs. **FPGA Programming Technologies:** SRAM Programmable FPGAs. Anti-Fuse Programmed FPGAs. **FPGA Design Flow:** Architecture design. Project design using Verilog. RTL simulation, synthesizing, implementation, gate level simulation of design. Reusing of internal hard modules during design and implementation. **Design Applications:** FPGA manufacturers (Xilinx, Altera, Actel, Lattice Semiconductor, Atmel). General Design Issues, Counter Examples, Designing Adders and Accumulators with the ACT Architecture.

References:

1. Charles H. Roth Jr, Lizy Kurian John, *Digital Systems Design*, (2e), Cengage Learning, 2012.
2. Stephen M. Trimberger, *Field Programmable Gate Array Technology*, (1e), Springer International Edition, 1994.
3. J. Oldfield, R. Dorf, O. M. C. Safari, *Field-Programmable Gate Arrays: Reconfigurable Logic for Rapid Prototyping and Implementation of Digital Systems*, (1e), Wiley-Interscience, 1995.
4. V. Oldfield, Richard C. Dorf, Field Programmable Gate Arrays, (1e), Wiley India, 2008.
5. Ian Grout, *Digital Systems Design with FPGAs and CPLDs*, (1e), Elsevier, Newnes, 2008.

VDT2230 — SPICE Lab — [0 0 2 1]

Course Outcomes:

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

CO1. Simulate semiconductor devices
CO2. Design and analysis of semiconductor devices and their fabrication processes
CO3. Analyze device characteristics to determine important device parameters
CO4. Implement circuits with MOSFET
CO5. Implement circuits with FinFET

Syllabus:

Experiments are carried out on software to analyze the characteristics of semiconductor devices and use these devices for various circuit implementations.

VDT2231 Computer and Processor Architecture Lab [0 0 2 1]

Course Outcomes:

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

CO1. Describe the function, types, and hierarchies of memory in computer architecture design.
CO2. Implement a simple bus structure.
CO3. Implement a simple pipeline.
CO4. Implement assembly language programming.

Syllabus:
An Introduction to Computer Architecture, Microprocessor, Assembly language programming, and Verilog. Experiments to be performed using 80x86 / Arm / OpenSPARC.

VDT2270 Project based learning lab 2 [0 0 2 1]

Syllabus:
Based on planning and designing of the solution. Evaluation will be based on report and presentation.

OPEN ELECTIVES

ECE0001 Introduction To Communication Systems [3 0 0 3]

Optical Fiber Communications: Types of Optical Fibers, Numerical Aperture, Time Delay and Group Delay, Concept of V number, Attenuation and Dispersion (dispersion shifted and dispersion flattened fibers), Macro and Micro Bending, Pulse Broadening, Optical Sources and Detectors, Optical Communication System. Satellite Communications: Satellite orbits, Keplers laws, speed, period, angle of elevation, orbital effects in communication satellites, launching of a satellite, Earth Station technology, Space Segment, Modern Trends in Satellite Communications.

References:

1. J. M. Senior, *Optical Fiber Communications- Principles and Practise*, (3e), Pearson Education India, 2010.
2. R.P. Khare, *Fiber Optics and Optoelectronics*, (1e), Oxford University Press, 2004.
3. R. N. Mutagi, *Satellite Communications Principles and Applications*, (1e), Oxford University Press, 2016.
4. Wilbur L. Pritchard et al, *Satellite Communication Systems Engineering*, (2e), Prentice Hall, 1993.

ECE0002 Introduction to Game Theory [3 0 0 3]

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

CO1. Comprehend the foundational principles of strategic decision-making through game theory.
CO2. Analyze complex interactions among rational decision-makers, in evolutionary biology contexts.
CO3. Execute strategic planning and management skills to formulate effective strategies in competitive environments.
CO4. Make decision in Uncertain Environments through understanding concepts like Bayesian Games and Perfect Bayesian Equilibrium.
CO5. Solve problems by analyzing complex strategic interactions, identifying optimal strategies, and evaluating outcomes in scenarios like Cournot Duopoly and Non-Cooperative Bargaining.
CO6. Apply game theory concepts to various fields such as economics, biology, and political science, demonstrating proficiency in modelling strategic interactions and deriving insights applicable to real-world decision-making contexts.

Syllabus:

Introduction Examples: Markets/ Politics/ Auctions; **Prisoners' Dilemma**, Best Response and Nash Equilibrium, Dominant Strategies, Stag Hunt – Coordination and Bank Runs. **Multiple Nash Equilibria**, Tragedy of Commons, Cournot Duopoly, Mixed Strategies, Battle of Sexes, Best Response Dynamic, Paying Taxes; **Portfolio Management Game,** Rationality, Choice and Common Knowledge, Iterated Elimination of Domination Strategies, Auction: As a Normal Form Game, Traffic at Equilibrium and Braess's Paradox; **Extensive Form Games,** Strategies in Extensive from Games, Sub Game Perfect Equilibrium, The Art of War, Ultimatum Game, Stackelberg Model, **Bayesian Games,** Bayesian Nash Equilibrium, Yield vs Fight, Bayesian Cournot Game, Bayesian Games with mixed strategies, Auctions, Sealed Bid First Price Auction, Expected Revenue, Bayesian Second Price Auction, Second Price Auction, All Pay Auction; **Evolutionary Biology,** Evolutionary stable Strategy (ESS), Repeated Games, Multiple Equilibriums, Chain-Store Paradox, Non – Cooperative Bargaining; Extensive Form Game with Incomplete Information, Introduction to perfect Bayesian Equilibrium, Obtaining PBE, Gift Game.

References:

1. Martin Osborne, *An Introduction to Game Theory*, (1e), Oxford University Press, 2003.
2. Ken Binmore, *Game Theory*: A *Very Short Introduction*, (1e), Oxford University Press, 2007.
3. Steven Tadelis, *Game Theory: An Introduction*, (2e) Princeton University Press, 2013.
4. Philip D. Straffin, *Game Theory and Strategy*, (1e) Mathematical Association of America, 1993.
5. Joel Watson, *Strategy: An Introduction to Game Theory*, (3e) W.W. Norton & Company, 2013.
6. Roger B. Myerson, *Game Theory: Analysis of Conflict*, (1e) Harvard University Press, 1997.

ECE0003 ***Stress Free living** **[3 0 0 3]**
*(in collaboration with Abhigya Club & faculty from Hare Krishna Movement Jaipur)

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

CO1. Identify some of the commonly felt problems that individuals, organizations and the society faces
CO2. Discuss the usefulness of Gita in addressing some of these problems
CO3. Describe how alternative world views and paradigms of management could be developed with Gita
CO4. Illustrate Ancient Indian wisdom using Gita as a vehicle

Syllabus:
Spirituality in Business and Workplace: Current Challenges in Business Management & Society, Relevance of Ancient Indian Wisdom for contemporary society, Spirituality in Business, The notion of Spirituality, An introduction to Bhagavad Gita & its relevance. **Perspectives on Leadership & Work:** Failed Leadership: Causes & Concerns, Leadership Perspectives in the Gita, Axioms of Work & Performance, The Notion of Meaningful Work. **Perspectives on Individuals:** Mind as a key player in an individual, Meditation as tools for self-management, Yoga as tools for self-management, Role of Yoga in addressing stress & burnout of managers, Self-Management by understanding the world within, Values & their role in Self-management, Shaping the personality through Trigunas. **Perspectives on Life and Society:** Perspectives on Sustainability, Death as a creative destruction process, The Law of Conservation of Divinity, Conclusions.

References:

1. Prabhupada, His Divine Grace A.C. Bhaktivedanta. Bhagavad Gita As It Is. Mumbai: Bhaktivedanta Book Trust, 2009.
2. Prabhupada, His Divine Grace A.C. Bhaktivedanta. The Science of Self-Realization. Mumbai: Bhaktivedanta Book Trust, 2002.

ECE0051 Excel Fundamentals for Data Analysis [3 0 0 3]

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

CO 1. Apply a range of text functions to manipulate and restructure data.
CO 2. Apply logical functions to correct or transform data.
CO 3. Convert a range to a table and work effectively with that table.
CO 4. Demonstrate a range of methods for creating Named Ranges.
CO 5. Employ a range of logical functions to automate performing different operations under different circumstances.

Syllabus:
Data analysis: Overview, data analysis with Excel. Conditional formatting, sorting nd filtering data, Cleaning and manipulating text data. Working with numbers and dates. Calculation with named ranges. Automating data validation. Working with Tables. Logical and lookup function. Data visualization and validation.

References:

1. L. Winston Wayne, Microsoft Excel 2019: Data Analysis & Business Model, PHI.
2. Data Analysis with Excel, tutorialspoint,https://www.tutorialspoint.com/excel_data_analysis
3. Manisha Nigam, Data Analysis with Excel, BPB Publications.

ECE0052 Introduction to Word Processing [3 0 0 3]

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

CO1. Apply a range of text functions to manipulate and restructure data.
CO2. Apply logical functions to correct or transform data.
CO3. Convert a range to a table and work effectively with that table.
CO4. Demonstrate a range of methods for creating Named Ranges.
CO5. Employ a range of logical functions to automate performing different operations under different circumstances.

Syllabus:

MS Word Basics: Getting Started, Explore Window, Backstage View, Entering Text, Move Around**,** Save Document, Opening a Document, Closing a Document, Context Help, **Editing Documents:** Text Insert/Select/Delete/Move/Copy & Paste/Find & Replace/ Spell Check/ Zoom In-Out/ Special Symbols/ Undo Changes operations. **Formatting Text:** Setting Text Fonts, Text Decoration, Change Text Case, Change Text Color, Text Alignments, Indent Paragraphs, Create Bullets, Set Line Spacing, Borders and Shades, Set Tabs, Apply Formatting. **Formatting Pages:** Adjust Page Margins, Header and Footer, Add Page Numbers, Insert Page Breaks, Insert Blank Page, Cover Pages, Page Orientation. **Working With Tables:** Create a Table, Rows & Columns, Move a Table, Resize a Table, Merging Cells, Split a Table, Split Cells, Add Formula, Borders & Shades. **Advanced Operations:** Quick Styles, Use Templates, Use Graphics, Auto Correction, Auto Formatting, Table of Contents, Preview Documents, Printing Documents, Email Documents, Translate Document, Compare Documents, Document Security, Set Watermark.

References:

1. Al Sweigart, *Word For Dummies*,(1e), Wiley India Pvt Ltd., 2021, ISBN-13: 1119829178.
2. Peter John, *Microsoft Word & Excel 2021 For Beginners & Advanced Learners,* (1e), Wiley India Pvt Ltd, 2016. ISBN-13: 979-8483206361.
3. James Holler, *Microsoft Word 2023: The Most Updated Crash Course from Beginner to Advanced*, Independently published, 2022. ISBN-13: 979-8364609687.

FIFTH SEMESTER

VDT3101: Digital VLSI Design [3 1 0 4]

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand CMOS device & its characteristics
2. Apply the working principles and characteristics of MOS devices in circuit analysis.
3. Analyze the static and dynamic behaviour of CMOS inverters.
4. Design Combinational & Sequential Circuits using various logic families
5. Design and implement semiconductor memory systems and arithmetic building blocks.

Syllabus:

Overview of VLSI Design: Historical perspective, overview of VLSI design methodologies, VLSI design flow, design hierarchy, VLSI design styles, design quality, Fabrication process flow- basic steps, the CMOS n-Well process. MOS Transistor Theory: Working of MOS devices and their I-V characteristics, Operating regions and currents, DC transfer characteristics, MOS Capacitances, CMOS Latchup, MOS Scaling.MOS Inverter: Resistive-load inverter, Static CMOS Inverter: Static Behaviour: Switching threshold, Noise margins, Dynamic Behaviour: Delay-time definitions, calculation of delay times, logical efforts, Power, Energy & Energy-Delay. Combinational CMOS Logic Circuits: MOS logic circuits with depletion nMOS loads, CMOS logic circuits, complex logic circuits, CMOS transmission gates (pass gates), ratioed, dynamic and pass transistor logic circuits.Sequential MOS logic circuits: Timing Metrics for Sequential Circuits , Static Latches and Registers : Bistable Principle SR latch circuits, clocked latch and flip-flop circuits, CMOS D-latch and edge-triggered flip-flop, Multiplexer based latches, C^2MOS,TSPC,Pipeling using NORA. Semiconductor Memories: Semiconductor Memories, Memory Core, Memory Design, Memory Peripheral Circuitry. Arithmetic Building Blocks: Datapaths in Digital Processor Architectures, Adders, Multipliers, Shifters.

References:

1. S. M. Kang & Y. Leblebici, CMOS digital Integrated circuits design and analysis, Tata McGraw Hill, 3rd edition, 1996.
2. Weste, N. H. E., & Harris, D. M. (2010). CMOS VLSI Design: A Circuits and Systems Perspective (4th ed.). Pearson.
3. Rabaey, J. M., Chandrakasan, A., & Nikolić, B. (2003). Digital Integrated Circuits: A Design

VDT3102: Semiconductor Device Fabrication [3 1 0 4]

Course Outcomes:

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

1. Explain the fundamental properties of semiconductor materials and their role in device fabrication.
2. Apply photolithography, etching, doping, and deposition techniques in the fabrication process.
3. Analyze the physical principles and processes involved in the fabrication of semiconductor devices.
4. Evaluate the performance of fabricated devices and identify sources of defects.

Syllabus:

Introduction to semiconductor: Overview of semiconductors: intrinsic and extrinsic materials, Crystal structures and properties of silicon and compound semiconductors, defects in crystal, cleanroom substrates processing technology. Thermal oxidation, RTP and furnaces, laser and spike processing. Doping and implantation. Lithography : Fundamentals of lithography: masks, resist materials, and exposure techniques, contrast, process, photoresist, direct write, EBL, proximity, etc. Oxidation and diffusion, ion implantation. Basics of thin film deposition, PVD (sputtering, evaporation), Epitaxial growth, LPCVD, PECVD, crystallization/recrystallization. Wet etching, Dry etching, Metallization and wire bonding. Device isolation and packaging, Device technology (CMOS, GaAs FET, silicon photonics) Integrated circuit manufacturing (yield, DOE, SPC, etc). Electrical characterization of devices: I-V and C-V measurements, Techniques for analyzing device performance and defects, Reliability testing.

References:

1. S. M. Sze and Kwok K. Ng, *Physics of Semiconductor Devices*, Wiley.
2. Stephen Campbell, *The Science and Engineering of Microelectronic Fabrication*, Oxford University Press.
3. Sorab K. Ghandhi, *VLSI Fabrication Principles: Silicon and Gallium Arsenide*, Wiley.
4. Gary S. May and Simon M. Sze, *Fundamentals of Semiconductor Fabrication*, Wiley.

VDT3130: IC Design Lab [0 0 2 1]

Lab Outcomes:

By the end of the lab, students should be able to:

1. Demonstrate current-voltage characteristics for MOS for understanding device working
2. Observe DC and transient response of CMOS logic gates
3. Design and simulate CMOS circuits at both schematic and layout levels.
4. Perform timing and power analysis of circuits.
5. Design layout of CMOS circuits.

Syllabus:

IC Design Lab syllabus focuses on providing hands-on experience in designing, simulating, and analyzing CMOS-based circuits using industry-standard VLSI tools. The lab begins with an introduction to EDA tools enabling students to familiarize themselves with schematic, spice code and layout environments. Fundamental CMOS concepts, including the design and analysis of inverters and basic logic gates, are covered. Students learn to implement combinational and sequential circuits. The lab emphasizes power analysis, timing analysis, and optimization techniques for low-power designs. By the end of the course, students acquire proficiency in CMOS circuit design and simulation, with a strong understanding of performance, power, and layout considerations.

VDT3131: Device Fabrication Lab [0 0 2 1]

Lab Outcomes

By the end of the lab, students should be able to:

1. Demonstrate the overview of semiconductor device fabrication and utilize the process for skill development.
2. Applying the various steps involved in the fabrication of semiconductor device: Cleaning and Drying, Oxidation, Photolithography.
3. Applying the fabrication processes: Diffusion, Metallization, Etching.
4. Analyse the V-I characteristic curve of diode

Syllabus:

This course gives an overview on different fabrication process of semiconductor devices. In this course different steps are followed for fabrication and testing of Diode which inlucdes Cleaning Process,Oxidation, Photolithography, Etching, Diffusion, Metallization and Characterization.

VDT3170: Project-Based Learning 3 [0 0 2 1]

Syllabus:

Based on project implementation and execution. Evaluation will be based on report/draft and presentation.

FLEXI CORE

VDT3120: CAD for VLSI [4 0 0 4]

Course Outcomes:

By the end of this course learners will be able to

1. Understand the constraints and problem formulation for circuit synthesis with respect to requirements of CAD Tools to achieve the best design
2. Apply graphs and Boolean algebra for VLSI Design Automation
3. Apply optimization strategies to enhance circuit performance which underpin architectural level synthesis with optimal scheduling
4. Assess resource sharing and binding algorithms which underpin architectural level synthesis
5. Apply logic optimization for two-level and multiple level combinational and sequential circuits for user-defined constraints
6. Choose circuit implementation from library cells based for area/delay optimization

Syllabus:

Introduction to CAD tools: Evolution of Design Automation, Types of CAD tools. **Algorithmic Graph Theory:** Graphs, graph optimization, basic algorithms. **Architectural Synthesis:** Constraints and problem formulation, Datapath and control unit synthesis, Scheduling, resource sharing and binding, Area/latency/Cycletime optimization. **Combinational Logic Synthesis:** Binary Decision Diagrams, positional cube notation, Two Level Logic Synthesis, Unate Recursive Paradigm, logic minimization algorithms, Multiple-Level Combinational Logic Optimization. **Sequential logic optimization:** State minimization and encoding, retiming. **Logical Effort and delay optimization:** Logical Effort, Multistage Logic Networks, Logical Effort Optimizing performance. **Cell-library Binding:** problem formulation, covering algorithms.

References:

1. G. D. Micheli, Synthesis and optimization of digital systems, (1e), Mc Graw Hill, 2003.
2. S. Imam, M. Pedram, Logic Synthesis for Low Power VLSI Designs, (1e), Kluwer, 1997.
3. M. J. S. Smith, Application Specific ICs, (1e), Pearson, 1997.
4. Rabaey, J. M., Chandrakasan, A. P., & Nikolic, B., Digital integrated circuits (2e), Englewood Cliffs, Prentice hall, 2002.

VDT3121: Microcontrollers & its applications [4 0 0 4]

Course Outcomes:

By the end of this course learners will be able to

1. Describe architecture and operation of Microcontroller 8051.
2. Foster ability to understand the design concept of Microcontroller.
3. Design various applications using its peripherals.
4. Analyze the data transfer information through serial and parallel ports.
5. Applying the concepts of an in-depth knowledge on real time applications.
6. Develop application programs using assembly and C Languages.

Syllabus:

Microcontroller Basics: Difference between microprocessor and microcontroller, architectural considerations, CPU, memory sub system, I/O sub system, control logic. Architecture of MCS-51 microcontroller. Memory structure, different registers (SFR's), addressing modes. Timing Diagram, timing diagram for execution cycle. Programming: Concept of assembler directives, editor, linker, loader, debugger, simulator, emulator. Instruction set, basic programming using 8051 instructions. Introduction to embedded-C, Integrated Development Environment (IDE), cross compiler, ISP, software delay generation. I/O Programming: I/O programming, interfacing with simple switch, LED. Seven segment interfacing techniques. Programming with alphanumeric LCD and matrix keypad.On-Chip Peripheral Interfaces: Programming with on-chip Timers, Counters, UART, RS485 transceiver. I2C and SPI protocols. Interrupts, interrupt execution sequence, programming with software and hardware interrupts. External Interfaces: Analog to digital convertor, interfacing with external serial and parallel ADC's, Digital to analog convertor (DAC), interfacing with DAC, Interfacing with stepper motor and DC motor. RISC Microcontrollers: Introduction to AVR series microcontrollers. Introduction to ARM7 microcontroller (LPC2148).

References:

1. 8051 Microcontroller Architecture, Programming and Application Kenneth J.Ayala PHI Learning New Delhi, July 2004, ISBN: 978-1401861582
2. Microcontroller Theory and Application Ajay V.Deshmukh McGraw Hill, New Delhi, 2011, ISBN-9780070585959
3. The 8051 Microcontroller and Embedded system Using Assembly and C Muhammad Ali Mazidi. Janice GillispieMazidi.Roli n D.Mckinlay Pearson /Prentice Hall,, 2nd edition, Delhi,2008, ISBN 978-8177589030
4. Microprocessors and Microcontrollers Sunil Mathur, JeebanandaPanda PHI Learning,NewDelhi, 2016,ISBN :978-81-203-5231-5
5. Microprocessors and Microcontrollers: Architecture programming and System Design Krishna Kant PHI Learning New Delhi, 2016,ISBN:978-81-203-4853-0

SIXTH SEMESTER

VDT3201: System Verilog for Verification [3 1 0 4]

Course Outcomes:

1. Understand the fundamental concepts of System Verilog, including its declaration spaces, literal values, and built-in data types.
2. Explain the use of assignments, variables, operators, and user-defined data types, including enumerated types, queues, and dynamic arrays.
3. Apply procedural statements, tasks, functions, and procedural blocks in System Verilog to design and model hardware systems.
4. Analyze class-based structures, polymorphism, virtuality, use of interfaces and cover.
5. Describe the role of Assertion-Based Verification (ABV) and System Verilog Assertions (SVA) in enhancing functional verification of hardware designs.

Syllabus:

Introduction to System Verilog, System Verilog declaration Spaces, System Verilog Literal Values and Built in Data types: assignments, variables, models. Procedures Statements and Procedural Blocks, Operators. User-defined data types and enumerated types. Queues Dynamic and Associative Arrays. Tasks and Functions. System Verilog Procedural Statements. Classes, Polymorphism and Virtuality, Class-Based Random Stimulus Interfaces in Verification, Cover group Coverage. Introduction to Assertion-Based Verification (ABV). Introduction to System Verilog Assertions (SVA).

References:

1. Christian B. Spear, System Verilog for Verification: A Guide to Learning the Testbench Language Features, Springer 2012
2. Mark Glasser, Harry Foster, Tom Fitzpatrick, Adam Rose, Dave Rich, Open Verification Methodology Handbook: Creating Testbenches in System Verilog and System-C, Morgan Kaufmann, 2009
3. Faisal Haque, Jonathan Michelson, Khizar Khan, The Art of Verification with System Verilog Assertions, Verification Central, 2006.

VDT3210: Professional Practice [0 0 0 1]

Professional Practice: The evaluation will be done after successful completion of training on professional development, soft-skill development, aptitude development, technical skill development etc.

VDT3230: System Verilog Lab [0 0 2 1]

Lab Outcomes:

1 Understand System Verilog constructs for digital system modeling and simulation.
2 Apply System Verilog to design combinational l digital circuits.
3 Apply System Verilog to design sequential l digital circuits.
4 Analyze and develop test benches to verify the functionality of digital systems

Syllabus:

The System Verilog course will cover essential concepts of hardware description and verification. Participants will learn RTL design, synthesis, and simulation, along with advanced features like interfaces. The course will also delve into building testbenches using object-oriented programming and constrained random verification. Hands-on lab sessions will provide practical experience with industry-standard EDA tools. By the end, students will have a strong foundation to excel in chip design and verification.

VDT3231: Advanced System Design Lab [0 0 2 1]

Lab Outcomes:

1 Generating optimized gate-level netlist and Standard Design Constraints.
2 Familiarization with chip Floorplan and standard cell placement techniques.
3 Familiarization with clock tree synthesis, and detail routing.
4 Familiarization with physical verification and power analysis

Syllabus:

The student will implement one complete circuit from RTL to GDSII. This flow is a vital process in digital chip design, converting a high-level hardware description (RTL) into a manufacturable layout (GDSII). It encompasses key stages such as RTL synthesis, design optimization, floor planning, placement, clock tree synthesis, routing, and physical verification. Each step ensures the design meets functional, timing, power, and area requirements. Labs focusing on this process provide hands-on experience with industry-standard tools.

VDT3270: Project Based Learning 4 [0 0 2 1]

Based on application of the project. Evaluation will be based on the outcomes of the project in the form of research articles or draft, IPR, app/product development. A+ grade may be awarded for SCOPUS indexed publication or published patent or functional product/prototype/app development etc. A departmental PBL evaluation committee will evaluate the outcomes of the PBL courses and to award grades based on the merit of the project.

PROGRAM ELECTIVES

PROGRAM ELECTIVE-II

VDT 3140: AI for circuits [3 0 0 3]

Course Outcomes:

By the end of the course, students will be able to
1. Explain the significance and evolution of AI circuit design in modern technology.
2. Describe AI algorithms, hardware acceleration, and neural network architectures in circuit design.
3. Apply design methodologies to optimize efficiency and performance in AI circuits.
4. Analyse neuromorphic computing and hardware accelerators for AI and machine learning tasks.
5. Explain parallel processing architectures for AI applications, addressing challenges.

Syllabus:
Introduction to AI Circuit Design: Overview of the significance of AI circuit design in modern technology. Historical context and evolution of AI hardware. Introduction to key concepts: AI algorithms, hardware acceleration, and neural network architectures. **Design Methodologies for AI Applications:** Principles of design methodologies for AI applications. Techniques for optimizing efficiency and performance in AI circuits. **Neuromorphic Computing and Hardware Accelerators:** In-depth study of neuromorphic computing principles. Exploration of hardware accelerators designed for machine learning and AI tasks. **Parallel Processing Architectures for AI:** Principles of parallel processing architectures and their applications in AI circuits. Design considerations and challenges in achieving parallelism for AI applications. **Optimization of AI Circuits:** Techniques for optimizing AI circuits for efficiency, speed, and power consumption. **Practical Implementation of AI Circuits:** Application of AI circuit design principles in practical circuits.

References:

1. Sze, Vivienne. Efficient Processing of Deep Neural Networks. Morgan & Claypool Publishers, 2020.
2. Mohammad, Baker. In-Memory Computing Hardware Accelerators for Data-Intensive Applications. Springer Nature, 2023.
3. Takano, Shigeyuki. Thinking Machines. Academic Press, 2021.
4. Mishra, Ashutosh. Artificial Intelligence and Hardware Accelerators. Springer Nature, 2023.
5. Munir, Arslan. Accelerators for Convolutional Neural Networks. John Wiley & Sons, 2023.
6. Zheng, Nan. Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design. John Wiley & Sons, 2019.

VDT 3141: Introduction to Electronic System Packaging [3 0 0 3]

Course Outcomes:

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

1. To understand the significance, historical context, and evolution of IC packaging technologies.
2. To explain the various types of IC packaging, including through-hole, surface-mount, and ball grid array
3. Apply knowledge of materials and interconnection techniques, such as wire bonding, flip-chip, and solder bump technologies, in IC packaging.
4. Analyse thermal management principles and techniques for effective heat dissipation in IC packaging.
5. Analyse signal and power integrity challenges in IC packaging and propose solutions.

Syllabus:

Introduction to IC Packaging Technologies: Overview of IC packaging and its significance. Historical context and evolution of packaging technologies. Introduction to packaging types: through-hole, surface-mount, ball grid array. **Packaging Materials and Interconnection Techniques:** Study of materials used in semiconductor packaging. Interconnection techniques: wire bonding, flip-chip, and solder bump technologies. **Thermal Management in IC Packaging** Principles of thermal management in IC packaging. Techniques for heat dissipation and cooling. **Signal and Power Integrity Considerations:** Signal integrity challenges in IC packaging. Power integrity considerations and solutions. **Packaging Types and Trade-offs:** In-depth study of through-hole, surface-mount, and ball grid array packaging. Trade-offs involved in selecting packaging types. **Reliability in IC Packaging** Factors affecting reliability in IC packaging. Testing and validation techniques for packaged ICs. **Advanced Topics in IC Packaging** Emerging trends in IC packaging technologies. Advanced materials and techniques.

References:

1. John H. Lau. Semiconductor Advanced Packaging. Springer, 2021.
2. King-Ning Tu, Chih Chen, Hung-Ming Chen. Electronic Packaging Science and Technology. John Wiley and Sons Inc., 2022

VDT 3142: Semiconductor Device modelling [3 0 0 3]

Course Outcomes:

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

1. Understand the reverse-bias breakdown mechanisms, high-frequency behavior, and temperature-dependent characteristics of diodes in advanced applications.
2. Explain carrier statistics, quantum effects, and their influence on the behavior and modeling of semiconductor devices.
3. Describe non-ideal effects, frequency-dependent behavior, and the impact of temperature and process variations on Bipolar Junction Transistor (BJT) performance.
4. Analyze MOSFET models, including quantum effects and variability analysis, to understand their application in nanoscale technologies.
5. Study trade-offs, and advantages of advanced transistors such as FinFETs, nanowire transistors, and Tunnel FETs for emerging semiconductor technologies.

Syllabus:

Diode Modeling: Reverse-bias breakdown and avalanche effects, High-frequency diode behavior, Modeling temperature-dependent characteristics, Advanced Semiconductor Physics Carrier statistics in semiconductors. Quantum effects and their impact on device behavior. **Bipolar Junction Transistor (BJT) Modeling:** Non-ideal effects in BJT operation, High-frequency and low-frequency BJT models, Impact of temperature and process variations on BJT characteristics. **Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) Modeling:** Advanced MOSFET models for nanoscale technologies, Quantum effects in MOSFETs, Compact modeling for variability analysis. **Advanced Transistor Structures:** FinFET and nanowire transistor modelling, Tunnel FETs and other emerging transistor technologies, Trade-offs and advantages of advanced transistor structures. **Simulation Challenges and Solutions:** Simulation challenges in advanced semiconductor devices. Monte Carlo simulations for statistical variability.

References:

1. Wu, Yung-Chun. 3D TCAD Simulation for CMOS Nanoeletronic Devices. Springer, 2017.

2. Chauhan, Yogesh. FinFET Modeling for IC Simulation and Design. Academic Press, 2015.

3. Snowden, Christopher. Semiconductor Device Modelling. Springer Science & Business Media, 2012.

4. Massabrio, Giuseppe. Semiconductor Device Modeling with Spice. McGraw Hill Professional, 1998.

PROGRAM ELECTIVE-III

VDT 3143: Design for Testability [3 0 0 3]

Course Outcomes:

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

1. Understand the concepts of VLSI testing and design for testability for Built-in Self-Test.
2. Apply the concepts of fault modelling and collapsing for optimal fault coverage in digital circuits and memories.
3. Apply various fault simulation and detection methods for digital circuits and memories.
4. Apply various test pattern generation methods for fault testing in digital circuits and memories.
5. Examine controllability and observability of digital circuits.
6. Evaluate different methods for test response compaction.

Syllabus:

Introduction: Verification vs Testing, Need for testing, Level of testing, Cost of testing, Roles of testing. **Fault modelling:** Stuck at Faults, Bridging Faults; Fault collapsing; Transistor (switch) faults. **Fault Simulation:** Deductive, Parallel and Concurrent Fault Simulation, Critical Path Tracing. **SCOAP Controllability and Observability:** significance and calculation of SCOAP measures. **ATPG for Combinational Circuits**: D-Algorithm, PODEM, Random pattern generation, Boolean difference symbolic method, Path sensitization method. **Scan chain:** Concept of scan chains for serial testing. **ATPG for Sequential Circuits:** Time frame expansion, Nine-valued logic, Drivability, Complexity of ATPG, Test generation system. **Compaction Techniques:** General Aspects of Compaction Techniques; Ones-Count, Transition Count and Parity Check Compression; Syndrome Testing; Signature Analysis. **Memory Testing:** Fault models, March tests. **Built-In Self-Test (BIST) concept**: BIST pattern generation, BIST response compaction, Aliasing definition. BIST Architecture**.**

References:
1. M. Bushnell and V. Agrawal, Essentials of Electronic Testing for Digital, Memory, and Mixed-Signal VLSI Circuits, Kluwer Academic Publishers, 2000.
2. M. Abramovichi, M. Breuer and A. Friedman, Digital Systems Testing and Testable Design, IEEE Press, 1999.
3. L. T. Wang, C. W. Wu and X. Wen, VLSI Test Principles and Architectures, Elsevier, 2006

VDT 3144: Principles of Nanomaterials and Quantum Dots [3 0 0 3]

Course Outcomes:

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

1. Able to understand nanomaterial's types and properties.
2. Able to understand the synthesis process of nanomaterials
3. Able to understand the optical sensing and quantum effects related to nanomaterials
4. Able to understand the testing and characterization of the nanomaterials
5. Able to apply nanomaterials and nanostructures for global solutions and applications.

Syllabus:

Introduction to nanomaterials: Scaling Laws , Properties of materials & nanomaterials, Three-, two-, one- and zero-dimensional nanomaterials, role of size in nanomaterials, nanoparticles, semiconducting nanoparticles, nanowires, nanoclusters, quantum wells, conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state. **Synthesis of metal nanoparticles:** Top down and bottom up approaches for nanomaterial synthesis. Synthesis of nanoparticles by physical, chemical and biological methods. , Anisotropic nanoparticles. Metal nanoclusters, Bimetallic nanoparticles, Metallic nanoparticles: Surface plasmon resonance.**Quantum Dots:** Quantum confinement, Band gap tuning and properties of quantum dots. Surface defects and Doping in Quantum dots. Carbon nanomaterials: Preparation and properties of graphene oxide, graphene, fullerenes, carbon nanotubes and carbon dots. Composites of carbon nanomaterials. **Characterization of nanomaterials** by various analytical methods, optical characterization, spectroscopy, structural characterization and imaging techniques. **Applications of nanomaterials:** health and disease diagnostics, biomedical, delivery vehicles, sensors and biosensors, cosmetics, agriculture, environment , food, energy and defence.

References:

1 Nanoscience & Nanotechnology: Fundamentals of Frontiers; M. S. Ramachandra Rao, S. Singh.John Wiley & Sons, 2017.
2 Schmid, Günter, ed. *Nanoparticles: from theory to application*. John Wiley & Sons, 2011.
3 Kumar, Challa SSR, ed. *Nanomaterials for medical diagnosis and therapy*. John Wiley & Sons, 2007.
4 Nanostructures and Nanomaterials: Synthesis, Properties, and Application; G. Cao, Y. Wang.
A. L. Rogach, Semiconductor nanocrystal quantum dots synthesis, assembly, spectroscopy and applications (Springer, Wien; London, 2008).
5 E. Gazit, Plenty of room for biology at the bottom: an introduction to bionanotechnology (Imperial College Press ; Distributed by World Scientific Pub. in the USA, London : Hackensack, NJ, 2007).

VDT 3145: Semiconductor Instruments [3 0 0 3]

Course Outcomes:

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

1. Discuss the significance and evolution of semiconductor manufacturing instruments,
2. Understand the design principles of semiconductor manufacturing instruments
3. To analyse methods for characterizing semiconductor materials and devices.
4. Discuss the principles and applications of metrology and inspection tools in quality control processes
5. Analyse challenges in semiconductor manufacturing instrumentation

Syllabus:

Introduction to Semiconductor Manufacturing Instruments: Overview of semiconductor manufacturing instruments and their significance. Historical context and evolution of instruments in semiconductor manufacturing. Introduction to metrology tools, inspection systems, and testing equipment. **Design Principles of Semiconductor Instruments:** Principles governing the design of semiconductor manufacturing instruments. **Characterization Methods for Semiconductor Materials**: Methods for characterizing semiconductor materials in the manufacturing process. Analyzing the impact of material properties on device performance. Metrology Tools in Semiconductor Manufacturing. Principles of inspection systems in semiconductor manufacturing. Application of inspection tools in quality control processes.

Overview of wafer testing equipment and its role in process development. Identification and analysis of challenges in semiconductor manufacturing instrumentation.

References:

1. Dieter K Schroder. Semiconductor Material and Device Characterization. John Wiley and Sons Inc., 3rd edition, 2015.
2. Su, Bo. Introduction to Metrology Applications in IC Manufacturing. 2015.
3. Bowen, D. X-Ray Metrology in Semiconductor Manufacturing. CRC Press, 2018.
4. Diebold, Alain. Handbook of Silicon Semiconductor Metrology. CRC Press, 2001.

PROGRAM ELECTIVE-IV

VDT 3240: VLSI Physical Design [3 0 0 3]

Course Outcomes:

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

1. Identify the goal, objective, constraints and graphs for various phases of Physical Design Process
2. Apply VLSI Physical design algorithms for circuit partitioning
3. Recommend floorplan and placement for digital circuits with estimation of wirelength
4. Assess circuit and clock routing based on routing algorithms
5. Apply VLSI Physical design algorithms for layout generation and compaction
6. Understand design verification, tape-out and DFT-DFM principles

Syllabus:

VLSI Physical Design Introduction: VLSI Design Process, difficulties in Physical design, Graph theory; **Circuit Partitioning:** Problem definition, cost functions and constraints, Partitioning algorithms; **Floorplanning:** Problem definition, cost functions and constraints, Floorplanning algorithms; **Placement:** Problem definition, cost functions and constraints, Placement algorithms; **Routing:** Problem definition, cost functions and constraints, Global routing algorithms, Channel routing algorithms, switchbox routing, Clock Tree Synthesis and Routing; **Layout generation and Compaction:** Layout generation, layout compaction. **Physical design verification and tape-out:** Methods for physical design verification, Overview of tape-out process, Introduction to Design for Testability (DFT) and Design for Manufacturability (DFM) principles.

References:

1. Naveed Sherwani, “Algorithms for VLSI Physical Design Automation” (3e) Kluwer Academic Publishers. 2002
2. S.H. Gerez, “Algorithms for VLSI Design Automation”, John Wiley & Sons, 2008
3. C. J. Alpert, D. P. Mehta, S. S. Sapatnekar, “Hand Book of Algorithms of Physical design Automation”, CRC press, 2009
4. S. M .Sait, H. Youssef, “VLSI Physical design automation theory and Practice”, World Scientific Publishing, 1999

VDT 3241: Introduction to MEMS [3 0 0 3]

Course Outcomes:

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

1. Analyze the evolution and significance of MEMS technology across various industries.
2. Discuss MEMS design principles and fabrication techniques like bulk and surface micromachining.
3. Understand sensing and actuation mechanisms in MEMS devices such as accelerometers and energy harvesters.

4. To understand the properties of MEMS materials and the impact of fabrication processes like lithography and etching.
5. Analyze challenges in integrating MEMS devices into larger systems and propose practical solutions.

Syllabus:

Overview of MEMS and its significance in various industries. Historical context and evolution of MEMS technology. Introduction to key concepts: sensing, actuation, and microfabrication. MEMS Technology Principles. MEMS Design and Fabrication Techniques. Principles of MEMS design and design considerations. Fabrication techniques: bulk micromachining, surface micromachining. Sensing and Actuation Mechanisms in MEMS. Principles of sensing mechanisms in MEMS devices. MEMS Accelerometers. MEMS Energy Harvesters. MEMS Modeling & Simulation. Materials used in MEMS fabrication and their properties. Processes such as lithography, deposition, and etching in MEMS fabrication. Integration of MEMS devices into larger systems. System-level considerations and challenges in MEMS applications.

References:

1. Gad-el-Hak, Mohamed. *MEMS: introduction and fundamentals*. CRC press, 2005.
2. Tai-Ran Hsu. MEMS and Microsystems: Design, Manufacture and Nanoscale Engineering. John Wiley and Sons Inc., 2020.
3. Zhuoqing Yang. Advanced MEMS/NEMS Fabrication and Sensors. Springer, 2022.
4. C. Liu, *Foundations of MEMS*. Upper Saddle River, 2012.

VDT 3242: VLSI DSP Architectures [3 0 0 3]

Course Outcomes:

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

1. Understand VLSI methodologies and DSP systems and architectures
2. Apply pipelining and parallel processing for digital signal processing
3. Appraise systolic architecture for digital signal processing
4. Apply fast convolution algorithms for IIR filters.
5. Design arithmetic architectures for FIR filters

Syllabus:

Introduction: Introduction to DSP systems, Typical DSP algorithms, Data flow and Dependence graphs, critical path, Loop bound, iteration bound, Accuracy in DSP Implementations. Longest path matrix algorithm, Pipelining and Parallel processing of FIR filters, Pipelining and Parallel processing for low power. **Retiming:** Solving System of Inequalities, Retiming Techniques. **Unfolding:** Algorithms for Unfolding, Properties of Unfolding, Critical Path, Unfolding and Retiming. **Folding:** Introduction to Folding Transformation, Register Minimization Techniques, Register Minimization in Folded Architectures, Folding in Multirate Systems. **Systolic Architecture Design:** Introduction, Systolic Array Design Methodology, FIR Systolic Arrays, Selection of Scheduling Vector, Matrix Multiplication and 2D Systolic Array Design, Systolic Design for Space Representations Containing Delays. **Fast Convolution:** Introduction, Cook, Toom Algorithm, Winogard Algorithm, Iterated Convolution, Cyclic Convolution, Design of Fast Convolution Algorithm by Inspection. **Bit-level arithmetic architectures**: Parallel multipliers with sign extension, parallel carry-ripple and carry-save multipliers, Design of Lyon's bit-serial multipliers using Horner's rule, bit-serial FIR filter. CSD representation, CSD multiplication using Horner's rule for precision improvement, Distributed Arithmetic fundamentals and FIR filters. **Programmable Digital Signal Processors:** Basic Architectural features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation UNIT, Programmability and Program Execution, Speed Issues, Features for External interfacing. Commercial Digital Signal-Processing Devices, Case study: TMS320C54XX Processors-Data Addressing

Modes, Memory Space, Program Control, Instructions and Programming, On-Chip Peripherals, Interrupts, Pipeline Operation.

References:

1. Keshab K. Parhi. VLSI Digital Signal Processing Systems, Wiley-Inter Sciences, 2007.
2. Mohammed Ismail, Terri, Fiez, Analog VLSI Signal and Information Processing, McGraw Hill, 1994.
3. Kung. S.Y., H.J. While house T.Kailath, VLSI and Modern singal processing, Prentice Hall, 1985.
4. Jose E. France, YannisTsividls, Design of Analog Digital VLSI Circuits for Telecommunications and Signal Processing' Prentice Hall, 1994.
6. Texas Instrument "Digital Signal Processing Applications with the TMS320 Family", Prentice-Hall, 1988.

PROGRAM ELECTIVE-V

VDT 3243: Low Power VLSI Design [3 0 0 3]

Course Outcomes:

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

1. Understand the need for low-power VLSI chips and identify sources of power dissipation in digital integrated circuits.
2. Analyze the impact of device physics, technology scaling, and innovations on power dissipation in CMOS and FinFET devices.
3. Apply circuit-level power reduction techniques, including design of Flip-Flops, latches, dynamic logic families, and adiabatic logic.
4. Implement logic-level power reduction techniques, such as state machine encoding, logic encoding, and bus power reduction strategies.
5. Design low-power architectures and systems by leveraging switching activity reduction, voltage scaling.

Syllabus:

Introduction: Need for Low Power VLSI chips, Sources of power dissipation in Digital Integrated circuits. Overview of the importance of low-power circuit design in CMOS and FinFET technologies. Device & Technology Impact on Low Power: Physics of power dissipation in CMOS devices & FinFET Devices; Dynamic and static power dissipation, Transistor sizing & gate oxide thickness; Impact of technology Scaling and Device innovation. Power estimation, Simulation and Power analysis: SPICE circuit simulators, gate level logic simulation, capacitive power estimation, static state power, gate level capacitance estimation, architecture level analysis. Circuit level Power reduction techniques: Power consumption in circuits; Design of Flip Flops and Latches; Low Power Dynamic logic families & adiabatic logic families. Logic level Power reduction techniques: logic encoding, state machine encoding, reduction of power in address and data buses. Low power Architecture and Systems: Power and performance management, switching activity reduction, parallel architecture with voltage reduction, flow graph transformation, low power arithmetic components, low power memory design. Emerging trends in low-power circuit design with CMOS and FinFET, Optimization techniques for minimizing power consumption in advanced semiconductor designs

References:

1. G. K. Yeap, "*Practical Low Power Digital VLSI Design*", KAP, 2002.
2. Rabaey, Pedram, "*Low power design methodologies*" Kluwer Academic, 1997.
3. K. Roy, Sharat Prasad, "*Low Power CMOS VLSI Circuit Design*" Wiley, 2000.
4. Samar K. Saha. FinFET Devices for VLSI Circuits and Systems. Taylor and Francis Group, 2020.

VDT 3244: Thin Film Transistors [3 0 0 3]

Course Outcomes:

By the end of the course, students will be able to
1. Understand the historical evolution, significance, and basic principles of operation of Thin Film Transistors (TFTs).
2. Classify different types of TFTs based on their material and performance characteristics.
3. Explain various thin film deposition techniques and assess their suitability for TFT fabrication.
4. Explain TFT fabrication processes.
5. Describe electrical and optical characterization methods to evaluate TFT performance metrics.

Syllabus:

Introduction to Thin Film Transistors: Overview of Thin Film Transistors and their significance in electronics. Historical perspective and evolution of TFT technology. **Principles of Operation**: Understanding the working principles of Thin Film Transistors. Types of TFTs: amorphous, polysilicon, and organic TFTs. **Thin Film Deposition Techniques:** Overview of thin film deposition methods: PVD, CVD, and atomic layer deposition (ALD)**.** Material selection and considerations in thin film deposition for TFTs**.** **TFT Fabrication Processes:** Semiconductor layer deposition and patterning. Gate dielectric and electrode fabrication. Source and drain electrode deposition and contact formation. **Electrical Characterization of TFTs:** Measurement techniques for electrical parameters: mobility, threshold voltage, and on/off ratio Role of thin film properties in electrical performance**. Optical Properties and Applications** Optical transparency and its significance in TFT applications**.** Applications of TFTs in flat-panel displays and sensors**.** Emerging trends in flexible electronics using TFT technology**.**

References:

1. Kagan, Cherie. Thin-Film Transistors. CRC Press, 2003.
2. Brotherton, S. D. Introduction to Thin Film Transistors. Springer Science & Business Media, 2013.
3. Zhou, Ye. Semiconducting Metal Oxide Thin-Film Transistors. IOP Publishing Limited, 2020.
4. Facchetti, Antonio. Transparent Electronics. John Wiley & Sons, 2010.

VDT 3245: Compound Semiconductors [3 0 0 3]

Course Outcomes:

By the end of the course, students will be able to
1. Understand the significance, historical evolution, and key materials of compound semiconductors in modern electronics.
2. Describe the crystal structures and properties of compound semiconductors and compare them with elemental semiconductors.
3. Explain the device physics principles underlying compound semiconductors.
4. Analyze the working principles and applications of optoelectronic devices based on compound semiconductors.
5. Describe fabrication techniques such as epitaxial growth, lithography, and etching processes specific to compound semiconductors.

Syllabus:

Introduction to Compound Semiconductors: Overview of compound semiconductors and their significance. Historical context and evolution of compound semiconductor technologies Introduction to key compound semiconductor materials. **Crystal Structures and Properties of Compound Semiconductors**: Crystal structures and properties of compound semiconductors. Comparison with elemental semiconductors. **Device Physics of Compound Semiconductors:** Device physics principles specific to compound semiconductors. Electronic devices: High-speed transistors and integrated circuits. **Optoelectronic Devices and Applications**: Principles and applications of optoelectronic devices using compound semiconductors. Lasers, photodetectors, and light-emitting diodes (LEDs). **Fabrication Techniques for Compound Semiconductors:** Epitaxial growth techniques for compound semiconductors. Lithography and etching processes specific to compound semiconductors. Applications of compound semiconductors in high-frequency devices. Latest developments and trends in compound semiconductor technology.

References:

1. Keh Yung Cheng. III-V Compound Semiconductors and Devices. Springer,2020.
2. Udo W. Pohl. Epitaxy of Semiconductors Physics and Fabrication of Heterostructures. Springer, 2020.
3. Gupta, S. OPTOELECTRONIC DEVICES AND SYSTEMS. PHI Learning Pvt. Ltd., 2014.
4. Birtalan, Dave. Optoelectronics. CRC Press, 2018.

PROGRAM ELECTIVE-VI

VDT 3246: Embedded Systems [3 0 0 3]

Course Outcomes:

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

1. Review the basic concepts of Embedded Systems, Communication Protocols and Real time Operating System.
2. Describe the architectures, structural and software requirements of Embedded Systems and their roles in real life applications.
3. Design Embedded System's firmware using ARM programming and apply these programming skills for solving various microcontroller-based problems and interfacing different peripheral devices.
4. Identify and apply the knowledge of real-time operating systems for real life embedded systems and hence develop the employability skills.
5. Investigate the effects and various issues related to real time operating systems like scheduling, deadlock avoidance, inter process communications, etc. in embedded system design.

Syllabus:

ARM Architecture and Instruction Set: ARM Design Philosophy, Registers, PSR, Pipeline, Interrupts and Vector Table, Architecture Revision, ARM Processor Families. Instruction Set: Data Processing Instructions, Branch, Load, Store Instructions, PSR Instructions, Conditional Instructions. ARM Programming Model: Thumb Instruction Set: Register Usage, Other Branch Instructions, Data Processing Instructions, Single-Register and Multi Register Load-Store Instructions, Stack, Interrupts, Software Interrupt Instructions, Exception handling. ARM Programming using High Level Language: Simple C Programs using Function Calls, Pointers, Structures, Integer and Floating-Point Arithmetic, Assembly Code using Instruction Scheduling, Register Allocation, Conditional Execution and Loops. Memory Management: Cache Architecture, Polices, Flushing and Caches, MMU, Page Tables, Translation, Access Permissions, Content Switch. Integer and Floating-Point Arithmetic on ARM: Double precision Integer Multiplication, Division, Square roots, Endian Reversal and Bit Operations, Random Number Generation, DSP on ARM – FIR filters, IIR filters.

References:

1. S. Furber, ARM System-on- Chip Architecture, Second Edition, Pearson Education, 2000.
2. Yifeng Zhu, Embedded Systems with Arm Cortex-M Microcontrollers in Assembly Language and C, E-Man Press LLC; 2nd ed. edition (15 October 2015).
3. J. R. Gibson, ARM Assembly Language-an Introduction, Dept. of Electrical Engineering and Electronics, The University of Liverpool, 2007.
4. Frank Vahid, Tony Givargis, "Embedded System Design: A unified Hardware/Software approach", John Wiley and Sons, 1999

5. Abraham Silberschaltz, Peter Baer Galvin, Greg Gagne ,“Operating System Concepts” , 9th edition, 2013.
6. Muhammad Ali Mazidi, ARM Assembly Language Programming Architecture: Volume (ARM books), MicroDigitalEd.com, 2016.

VDT 3247: Analog VLSI [3 0 0 3]

Course Outcomes:

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

1 Apply small signal model for MOS transistor for calculating small signal parameters of analog amplifiers
2 Analytically quantify the behavior of current mirrors, single-stage and differential amplifiers
3 Analyze the effect of noise and feedback on amplifiers and its frequency response
4 Analyze CMOS operational amplifier circuits
5 Design analog amplifiers for given requirements
6 Understand the evolution of mixed signal design with latest devices

Syllabus:

Introduction to MOSFETS: MOSFET circuits, Threshold voltage model, Capacitance model, Mobility model, MOSFET basics. **Current mirrors:** Basic current mirrors, Cascode current mirrors, Active current mirrors with large and small signal analysis, MOSFET in integrated circuits. **Differential Amplifiers:** Common mode, differential mode response analysis and gain calculation. **CMOS amplifier Frequency response:** Miller effect, common source (CS), common gate (CG), common drain (CD) stages, and cascode stage. **Noise**: noise statistics, significance of flicker and thermal noise, noise in single-stage amplifiers and differential pairs. **Negative feedback**: Stability of negative feedback systems, Stability and frequency compensation. **CMOS operational amplifiers:** One-stage and two-stage opamps, Gain boosting techniques, folded cascode, telescopic amplifier, common mode feedback (CMFB) amplifier. **Short channel effect:** from CMOS to FinFets. **Mixed signal circuits:** evolution of mixed signal design, Introduction to key components: ADC, DAC.

References:

1. Behzad, Razavi, Design of Analog CMOS Integrated Circuits, (2e), McGraw Hill, 2001.
2. Allen Holberg, CMOS Analog Integrated Circuit Design, (3e), Oxford University Press, 2012.
3. P. R.Gray, Hurst, Lewis and R. G. Meyer, Analysis and Design of Analog Integrated Circuits, (4e), John Wiley, 2001.

VDT 3248: Display Technologies [3 0 0 3]

Course Outcomes:

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

1 Understand the historical evolution, basic principles, and significance of OLED and LCD technologies in modern display systems.
2 Classify different types of OLEDs and LCDs based on their structures, working principles, and applications.
3 Explain thin film deposition, patterning methods, and fabrication processes involved in OLED and LCD display systems.
4 Analyze the electrical and optical parameters of OLEDs and LCDs.
5 Compare the performance characteristics of OLED and LCD technologies to identify their suitability for various applications.

Syllabus:

Introduction to Display Technologies: Overview of display technologies, with a focus on OLEDs and LCDs. Historical development and evolution of OLED and LCD technologies. **Principles of OLEDs**: Working principles of OLEDs, Types of OLEDs: small molecule vs. polymer-based, Emissive layer materials and device structure. **OLED Fabrication and Design**: Thin film deposition techniques for OLEDs, Patterning methods and post-processing steps, Design considerations for OLED-based display systems. **Principles of LCDs:** Working principles of Liquid Crystal Displays. Types of LCDs: Twisted Nematic (TN), In-Plane Switching (IPS), and Vertical Alignment (VA) Liquid crystal alignment and color filters. **LCD Fabrication and Design**: Fabrication processes for LCDs. Backlighting techniques and advancements. Design considerations for LCD-based display systems. **Electrical and Optical Characterization:** Measurement techniques for OLED and LCD parameters, Evaluating luminance, color accuracy, contrast ratio, and response times. Comparative analysis of OLED and LCD performance. **Applications and Emerging Trends**: Diverse applications of OLEDs and LCDs in electronic devices**,** Exploration of emerging trends in display technologies.

References:

1. Lee, Jiun-Haw. Introduction to Flat Panel Displays. John Wiley & Sons, 2020.

2. Linliu, Kung. Micro-Led Display. 2018.

3. Tsujimura, Takatoshi. OLED Display Fundamentals and Applications. John Wiley & Sons, 2017.

4. Linliu, Kung. A Perfect Display! Micro-LED, OLED, LCD and CRT. 2018

OPEN ELECTIVES

ECE0001 Introduction to Communication Systems [3 0 0 3]

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

1. Develop the basic modulation techniques for communication and their calculations involved in finding efficiency, spectrum and various important segments using mathematical tool such as Fourier transform etc. for establishment of fruitful communication.
2. Basic concept of fibre optic communications and analysis of complete optical fiber communication and power budget analysis as well.
3. The basic concepts and applications part of Radars on practical systems.
4. Basic understanding of satellite communication and cellular networks, wireless communication & technologies and their analysis in different environmental conditions.

Syllabus:

Introduction to communication system: A general model of communication systems-transmitter, communication channel, receiver, attenuation, noise; Telecommunication systems: Basic Telephone system, signaling tones, DTMF, Cordless Telephones, Private branch Exchange (PBX); Optical fiber communication: fundamental laws of optics, principal of ray propagation, basics of optoelectronics sources and detectors; Satellite communication systems: Principles of Orbital mechanics, Kepler's law of planetary motion, Look angle, Angle of elevation, Basics of Satellite subsystem; Radar Systems: Introduction to Radar systems, Pulse Radar, Duplexer. Radar displays; Wireless Communication Systems: Concept of cellular mobile communication-frequency reuse; Wireless technologies: Wireless LAN, PAN and Bluetooth.

References:

1 "An Introduction to Analog and Digital Communication Systems" by S.S. Haykin, John Wiley & Sons; 2nd revised edition edition.

2 "Communication Systems" by B.P. Lathi, BSP PUBLICATION (2001).
3 G. Kennedy and B. Davis, S.R. M. Prasanna, "Electronic Communication System", Tata McGraw-Hill, 2011.
4 Satellite Communications 2nd Edition by Timothy Pratt Wiley; 2 edition.
5 Introduction to Radar Systems (Irwin Electronics & Computer Enginering) 3rd Edition by Merrill I Skolnik, McGraw-Hill Education; 3 edition.

ECE0002 Introduction to Game Theory [3 0 0 3]

Course Outcomes: At the end of the course, students will be able to:
1. Understand best response for an agent in a given competitive game scenario.
2. Demonstrate Nash Equilibria for different game scenario that develops strategy making skills among students.
3. Analyse extensive form of game that will enhance employability of students.
4. Illustrate Evolutionary Stable Strategy (ESS) for evolutionary repeated games.

Syllabus:

Introduction Examples: Markets/ Politics/ Auctions; Prisoners' Dilemma, Best Response and Nash Equilibrium, Dominant Strategies, Stag Hunt – Coordination and Bank Runs. Multiple Nash Equilibria, Tragedy of Commons, Cournot Duopoly, Mixed Strategies, Battle of Sexes, Best Response Dynamic, Paying Taxes; Portfolio Management Game, Rationality, Choice and Common Knowledge, Iterated Elimination of Domination Strategies, Auction: As a Normal Form Game, Traffic at Equilibrium and Braess's Paradox; Extensive Form Games, Strategies in Extensive from Games, Sub Game Perfect Equilibrium, The Art of War, Ultimatum Game, Stackelberg Model, Bayesian Games, Bayesian Nash Equilibrium, Yield vs Fight, Bayesian Cournot Game, Bayesian Games with mixed strategies, Auctions, Sealed Bid First Price Auction, Expected Revenue, Bayesian Second Price Auction, Second Price Auction, All Pay Auction; Evolutionary Biology, Evolutionary stable Strategy (ESS), Repeated Games, Multiple Equilibriums, Chain-Store Paradox, Non – Cooperative Bargaining; Extensive Form Game with Incomplete Information, Introduction to perfect Bayesian Equilibrium, Obtaining PBE, Gift Game.

References:
1. An Introduction to Game Theory, Martin Osborne, Oxford University Press.
2. Game Theory: A Very Short Introduction, Ken Binmore, Oxford University Press.

ECE0003 Stress-free living [3 0 0 3]
(in collaboration with Abhigya Club & faculty from AkshayPatra foundation)

Syllabus:

Introduction, Overview: Objectives and Learning Outcomes, The Science of Relaxation: Benefits of a Calm Mind, **Time Management:** Importance of Time Management, Tools and Techniques, Creating a Balanced Schedule, **Stress Management:** Mindfulness and Meditation, Breathing Techniques, **Enhancing Relationships:** Healthy Communication, Building Strong Relationships, Conflict Resolution, **Lifestyle and Well-Being:** Nutrition and Sleep, Digital Detox, Sustainable Habits

ECE0051 Excel Fundamentals for Data Analysis [3 0 0 3]

Course Outcomes:

1. Apply a range of text functions to manipulate and restructure data.
2. Apply logical functions to correct or transform data.
3. Convert a range to a table and work effectively with that table.
4. Demonstrate a range of methods for creating Named Ranges.

5. Employ a range of logical functions to automate performing different operations under different circumstances.

Syllabus:

Data analysis: Overview, data analysis with Excel. Conditional formatting, sorting nd filtering data, Cleaning and manipulating text data. Working with numbers and dates. Calculation with named ranges. Automating data validation. Working with Tables. Logical and lookup function. Data visualization and validation.

References:

1. L. Winston Wayne, Microsoft Excel 2019: Data Analysis & Business Model, PHI.
2. Data Analysis with Excel, tutorialspoint, https://www.tutorialspoint.com/excel_data_analysis
3. Manisha Nigam, Data Analysis with Excel, BPB Publications.

ECE0052 Introduction to word Processing [3 0 0 3]

Syllabus:

MS WORD BASICS: Getting Started, Explore Window, Backstage View, Entering Text, Move Around, Save Document, Opening a Document, Closing a Document, Context Help, Hands-on session Exercises. EDITING DOCUMENTS: Text Insert/Select/Delete/Move/Copy & Paste/Find & Replace/ Spell Check/ Zoom In-Out/ Special Symbols/ Undo Changes operations. Hands-on session Exercises. FORMATTING TEXT: Setting Text Fonts, Text Decoration, Change Text Case, Change Text Color, Text Alignments, Indent Paragraphs, Create Bullets, Set Line Spacing, Borders and Shades, Set Tabs, Apply Formatting, Hands-on session Exercises. FORMATTING PAGES: Adjust Page Margins, Header and Footer, Add Page Numbers, Insert Page Breaks, Insert Blank Page, Cover Pages, Page Orientation, Hands-on session Exercises. WORKING WITH TABLES: Create a Table, Rows & Columns, Move a Table, Resize a Table, Merging Cells, Split a Table, Split Cells, Add Formula, Borders & Shades, Hands-on session Exercises. ADVANCED OPERATIONS: Quick Styles, Use Templates, Use Graphics, Auto Correction, Auto Formatting, Table of Contents, Preview Documents, Printing Documents, Email Documents, Translate Document, Compare Documents, Document Security, Set Watermark, Hands-on session Exercises.

References:

1. Al Sweigart, “Word For Dummies”,1st Edition, Wiley India Pvt Ltd., 2021, ISBN-13: 1119829178

1. Peter John , “MICROSOFT WORD & EXEL 2021 FOR BEGINNERS & ADVANCED LEARNERS”, 1st Edition, Wiley India Pvt Ltd, 2016. ISBN-13: 979-8483206361.
2. James Holler , “ Microsoft Word 2023: The Most Updated Crash Course from Beginner to Advanced”, Independently published, 2022. ISBN-13 : 979-8364609687.

SEVENTH SEMESTER

VDT4140 **Mixed Signal IC Design** **[3 0 0 3]**

Course Outcomes:

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

CO1. Understand the design principles involved in integrating analog and digital components.
CO2. Analyze CMOS based switched capacitor circuits
CO3. Analyze analog-to-digital & digital-to-analog converters
CO4. Design phase-locked-loops (PLL) and its key building blocks
CO5. Implement comparator, preamplifier and filters for signal conversion

Syllabus:

Linearity, noise in mixed signal systems. **Operational amplifier:** block diagram, characteristics, circuit applications. Comparator design. Preamplifier design. Active analog filters. Switched capacitor circuits. **Analog-to-Digital conversion (ADC) and Digital-to-Analog Conversion (DAC):** Basics of data conversion systems, Sampling theory, Sample and hold circuits. ADC topologies. DAC architecture. Data Converter Signal to Noise Ratio. **Phase Locked Loops:** Simple PLL, Charge - Pump PLL, **VCO :** Ring Oscillator, LC Oscillator, Applications in PLL.

References:

1. R. Jacob Baker, *CMOS Mixed-Signal Circuit Design, (2e)*, Wiley, 2008.

2. Karl D. Stephan, *Analog and Mixed- Signal Electronics*, Wiley, 2015

3. R. Jacob Baker, *CMOS – Circuit Design, Layout and Simulation,* Wiley

4. Behzad Razavi, *Design of Analog CMOS Integrated Circuits,* McGraw Hill , *(2e),* 2017.

VDT4141 **Semiconductor Memory Design** **[3 0 0 3]**

Course Outcomes:

At the end of the course, students will be able to
CO1. Understand various types and basic principles of memory operation
CO2. Explain the working principles of semiconductor memories
CO3. Apply memory cell design concepts to analyze read/write operations and array structures
CO4. Discuss memory architectures and their timing considerations.
CO5. Analyse power optimization techniques and performance trade-offs in memory system design.

Syllabus:

Introduction to Memory Design: Memory types and their applications. Basic principles of memory operation. **Static Random-Access Memory (SRAM):** SRAM cell design and optimization, Memory bit-cell stability and read/write operations, SRAM array architecture and peripheral circuitry. **Dynamic Random-Access Memory (DRAM):** DRAM cell design and refresh mechanisms, Memory array organization and addressing, Timing considerations in DRAM design. **Flash Memory:** NAND and NOR Flash architectures, Programming and erasing mechanisms Timing and Signal Integrity. Power Optimization in Memory Systems.

References:

1. Itoh, Kiyoo. VLSI Memory Chip Design. Springer Science & Business Media, 2013.
2. Tanović, Sabina. Designing Memory. Cambridge University Press, 2019.
3. Campardo, Giovanni. VLSI-Design of Non-Volatile Memories. Springer Science & Business Media, 2005.
4. Yu, Shimeng. Resistive Random Access Memory (RRAM). Springer Nature, 2022.

VDT4142 Static Timing Analysis [3 0 0 3]

Course Outcomes:

At the end of the course, students will be able to
CO1. Understand timing parameters such as setup time, hold time, clock skew, and slack in digital circuits
CO2: Analyze & calculate of timing parameters in digital circuits,
CO3: Analyze timing paths to detect and interpret setup and hold violations
CO4: Apply clocking strategies and timing constraints to estimate maximum operating frequency
CO5: Discuss the effects of On-Chip Variation (OCV) on timing and perform OCV-aware timing analysis

Syllabus:

Introduction to STA: Importance & Classification. **Timing Parameters:** Timings paths, Arrival time, Required Time, Basics of hold time & set up time, Skews & Jitter. **Static Timing analysis of combination circuits: Delay modelling and calculation:** gate, interconnect, cell delays, analysis of critical paths, Timing analysis in multi-path combinational logic. **Static Timing Analysis of Sequential Circuits: Clocking strategies:** single-phase, multi-phase, and derived clocks, Setup and Hold timing violations, Maximum operating frequency estimation, Impact and analysis of clock skew in sequential circuits, Setup and Hold analysis considering clock skew. **Timing Checks:** Setup Timing Checks, Hold Timing Checks, **On-Chip Variation (OCV):** sources, modelling, and impact, OCV-aware timing analysis: derating, pessimism removal

References:

1. S. S. Sapatnekar, *Timing,* Springer, 2004.
2. J. Bhasker, R. Chadha, *Static Timing Analysis for Nanometer Designs: A Practical Approach,* Springer, 2009.
3. K. Golshan, *Timing Verification of Application-Specific Integrated Circuits (ASICs),* Springer, 2003.

VDT4143 **EMC and signal integrity** **[3 0 0 3]**

Course Outcomes:

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

CO1. Understand the fundamental concepts of electromagnetic compatibility (EMC) and the significance of signal integrity (SI) in high-speed digital systems.

CO2. Identify and analyze various sources and coupling mechanisms of electromagnetic interference (EMI) including conducted and radiated types.

CO3. Apply transmission line theory to predict and mitigate issues such as reflection, crosstalk, ringing, and impedance mismatch in high-speed circuits.

CO4. Design PCB layouts that ensure signal integrity and minimize EMI through effective stack-up planning, trace routing, via design, and PDN optimization.

CO5. Evaluate and apply EMI control techniques such as grounding, shielding, filtering, and connector/cable selection in electronic system design.

Syllabus:

Introduction to EMC and SI: Definition and scope of EMC, Importance of signal integrity in high-speed design, EMC standards and regulations (FCC, CISPR, MIL-STD, etc.), **Types of electromagnetic interference (EMI):** Conducted and Radiated. EMI Sources and Coupling Mechanisms: Natural and man-made EMI sources**, EMI coupling:** Conductive, Inductive, Capacitive, Radiative, Differential mode vs. Common mode interference. **Transmission Line Theory:** Transmission line modeling, Reflection, crosstalk, ringing, Impedance matching and discontinuities, Termination techniques. **Signal Integrity in PCB Design:** High-speed signal behavior in PCB traces, Stack-up design and ground planes, Trace geometry and impedance control, Power distribution networks (PDNs), Crosstalk and via transitions. **EMI Control Techniques:** Grounding and shielding principles, Filtering techniques (LC, π filters), Cable shielding and connectors, PCB layout guidelines for EMC. **EMC Measurements and Testing:** EMC test setups (Open area test site, Anechoic chamber), Conducted and radiated emission tests, Susceptibility and immunity testing, Spectrum analyzers and EMI receivers.

References:

1. Henry W. Ott, *Electromagnetic Compatibility Engineering*, (1e), John Wiley & Sons, 2009.
2. Clayton R. Paul, *Introduction to Electromagnetic Compatibility*, (2e), Wiley-Interscience, 2006.
3. Eric Bogatin, *Signal and Power Integrity – Simplified*, (3e), Pearson Education, 2018.
4. Douglas Brooks. *Signal Integrity Issues and Printed Circuit Board Design*, (1e), Prentice Hall, 2003.
5. Mark I. Montrose, *EMC and the Printed Circuit Board: Design, Theory, and Layout Made Simple*, (1e), IEEE Press / Wiley-Interscience, 1998.

VDT4144 **Scripting Language for VLSI** **[3 0 0 3]**

Course Outcomes:

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

CO1. Discuss basic Linux shell commands, scripting concepts, and key syntax feature
CO2. Interpret the structure and flow of simple scripts written in PERL, BASH, and TCL/TK, including data types, control structures, and regular expressions.
CO3. Develop scripts using PERL, BASH, and TCL to automate file handling, tool invocation in Linux environments.
CO4. Use scripting languages to integrate and automate common tasks in EDA tools for synthesis and simulation processes.
CO5. Examine and debug scripting code to identify errors and improve script efficiency

Syllabus:

Introduction to Scripting Languages: Overview of scripting in the context of system administration and EDA, Introduction to Linux shell environment, Common Linux Commands and Kernel Usage. **PERL Programming:** PERL DATA TYPES, syntax and control structures, Regular expressions and pattern matching, Regular expressions in Perl, Debugging Perl Scripts. **Shell Scripting (BASH):** Shell basics: variables, loops, conditionals, functions, File handling, process control, and automation, Writing scripts for tool invocation and batch processing, Text processing tools: grep, sed, awk. **TCL/TK Scripting:** TCL basics: variables, loops, conditionals, procedures. File I/O and error handling, TK for GUI development (basics only), Application in EDA tools like Synopsys, Cadence, etc., TCL scripting in simulation and synthesis automation

References:

1. Randal L. Schwartz, brian d foy, Tom Phoenix *Learning Perl*, (7e), O'Reilly Media, 2016

2. Brent B. Welch, Ken Jones, Jeffrey Hobbs, *A Practical Guide to Linux Commands*, Editors, and Shell Programming, (4e), Pearson, 2017.

3. Mark G. Sobell, *Practical Programming in Tcl and Tk*, (4e), Prentice Hall, 2003.

VDT4145 VLSI Interconnects [3 0 0 3]

Course Outcomes:

At the end of the course, students will be able to
CO1. Explain the classification, structure, and physical phenomena affecting interconnects in VLSI circuits (Understanding)

CO2. Model and compute key electrical parameters (resistance, capacitance, inductance) of interconnects using analytical and physical methods.(Applying)

CO3. Analyze the timing behavior of interconnect networks using RC/RLC models, Elmore delay, and node analysis techniques. (Analyzing)

CO4. Evaluate the effects of crosstalk and interconnection noise on VLSI logic performance and propose mitigation techniques. (Evaluating)

CO5. Design routing strategies and explore advanced interconnect technologies for performance and scalability in VLSI systems. (Creating)

Syllabus:

Introduction to VLSI interconnects: classification, Cu Interconnect, Typical interconnect structure, Electromigration phenomenon, Signal transmission on interconnects, On-chip Interconnects, Package level interconnections. **Extraction of interconnect parameters:** Physics of interconnects in VLSI, Interconnect resistance, capacitance, inductance modelling, Extended Miller effect, Alternatives for extraction. Modelling interconnect drivers. **Modelling interconnect wires:** General interconnect network, An RC tree, Elmore delay, Step response of lumped vs. distributed RC line. Sample RLC network. Modified node analysis equations. Active and Passive interconnections, Multilevel and multilayer interconnections, Propagation delays. **Crosstalk effects in digital circuits:** spurious signals, crosstalk induced delay, crosstalk effects in logic VLSI circuits. Techniques for avoiding interconnection noise, noise detection problem, brief introduction to the testing of logic circuits, Crosstalk configuration, DC noise margins, Crosstalk-induced spurious signal detection, Reasons for high delay uncertainty, switch factor modelling of delay uncertainty, **Buffer insertion for noise;** Routing topology generation for speed optimization, Width optimization based on separability/monotonicity properties. **Current trends in interconnects:** CNT, Graphene, optical interconnects.

References:

1. Grabinski, Hartmut, *Interconnects in VLSI Design, (1e)*, Springer, 2000.

2. C-K. Cheng, J. Lillis, S. Lin, N. H. Chang. *Interconnect Analysis and Synthesis*, J. Wiley, 2000.

3. M. Celik, L. Pillegi, A. Odabasioglu. *IC Interconnect Analysis,* Kluwer, 2002.

4. A. B. Kahng, G. Robins. *On Optimal Interconnections for VLSI*. Kluwer, 1995.

5. Moll, Francesc, Roca, Miquel, *Interconnection Noise in VLSI Circuits*, *(1e)*, Springer, 2004.

VDT4146 High speed circuits [3 0 0 3]

Course Outcomes:

At the end of the course, students will be able to
CO1. Analyze delay and power dissipation in high-speed circuits.
CO2. Apply circuit techniques to mitigate timing errors and noise.
CO3. Design and simulate high-speed digital and mixed-signal blocks.
CO4. Evaluate clocking schemes, I/O techniques, and signal integrity.
CO5. Integrate high-speed modules into VLSI systems considering layout and packaging effects.

Syllabus:

Introduction to High-Speed Design: Sources of delay in CMOS circuits, High-speed design challenges in deep sub-micron technologies, Importance of interconnect modeling, Technology scaling and performance limits. **Timing and Delay Optimization:** Logical effort, Elmore delay, Advanced transistor sizing techniques, Pipelining and retiming, Design trade-offs in high-speed paths. **Interconnects and Signal Integrity:** Interconnect modeling (RC, RLC models), Crosstalk and coupling capacitance, Ground bounce and IR drop, Shielding and repeater insertion techniques. **Clocking Strategies and Skew Reduction:** Clock distribution techniques (H-tree, spine, mesh), Skew, jitter, duty cycle distortion, On-chip PLLs and DLLs, Clock gating and power-aware clocking. **High-Speed I/O Circuit Design:** I/O driver circuits, Transmission line effects, termination, ESD protection in high-speed design, Standards: LVDS, SSTL, HSTL. **Mixed-Signal Interfaces and Layout Considerations:** Design of comparators, sense amplifiers, High-speed ADC/DAC interface, Substrate noise and isolation techniques, Parasitic extraction and post-layout simulation.

References:

1. Howard Johnson, Martin Graham, *High-Speed Digital Design: A Handbook of Black Magic*, Prentice Hall.
2. Jan Rabaey et al., *Digital Integrated Circuits: A Design Perspective*, Pearson.
3. Baker, Li, Boyce, *CMOS: Circuit Design, Layout, and Simulation*, Wiley.
4. David A. Johns, Ken Martin, *Analog Integrated Circuit Design*
5. Razavi, *Design of Analog CMOS Integrated Circuits*
6. *EDA Tool Manuals and Application Notes* (Cadence, Synopsys, Keysight)

VDT4147 Hardware System Engineering [3 0 0 3]

Course Outcomes:

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

CO1. Apply systems thinking to analyze and solve complex hardware engineering problems.
CO2. Conduct thorough requirements analysis for hardware system design.
CO3. Architect and model hardware systems using appropriate methodologies and tools.
CO4. Evaluate and enhance system reliability through appropriate design and testing methods.
CO5. Optimize hardware systems through trade-off studies and performance analysis.
CO6. Apply verification and validation techniques to ensure the functionality and correctness of chip designs.

Syllabus:

Introduction to Hardware System Engineering: Overview, System thinking and its application. **Introduction to the system lifecycles:** Requirements Analysis and System Architecture, Methods for requirements analysis in chip design. Principles of system architecture. **System modelling and simulation techniques:** Risk Management and Decision Analysis, Identifying and managing risks in hardware system engineering. **Decision analysis techniques for hardware design choices:** Reliability, Optimization, and Trade-off Studies, Enhancing system reliability through design and testing. **Optimization strategies and trade-off studies in chip design**: Verification, Validation, and Project Management, Techniques for verification and validation in chip design, Project management principles for hardware system development.

References:

1. Kossiakoff, Alexander. *Systems Engineering Principles and Practice.* John Wiley & Sons, 2020.
2. Bonnema, G. *Systems Design and Engineering.* CRC Press, 2016.
3. Badiru, Adedeji. *Systems Engineering Models.* CRC Press, 2019.
4. Liu, Dahai. *Systems Engineering.* CRC Press, 2018.
5. Kung, H. T. *VLSI Systems and Computations.* Springer Science & Business Media, 2012.