SEMESTER WISE PLAN

SEMESTER 1

S. No.	Course Code	Course Title	L	T	P	Credit
	3 WEEKS COMPULSORY INDUCTION PROGRAM (UHV-I)					
1	BS-01	Physics I	3	0	0	3
2	BS-02	Mathematics-I	3	0	0	3
3	ES-01	Basic Electrical Engineering	3	0	0	3
4	ES-02	Engineering Graphics & Design	1	0	2	2
5	HSM-01	English for Technical Writing	2	0	2	3
6	ES-093	CAD Tool-I	0	0	4	2
7	BS-091	Physics lab	0	0	2	1
8	ES-091	Basic Electrical Engineering Lab	0	0	2	1
9	AU-01	IDEA Lab Workshop/ Maker Space 1	0	0	3	0
	TOTAL		13	3	16	18

SEMESTER 2

S. No.	ourse Code	Course Title	L	T	P	Credit
1	BS-03	Physics II	3	0	2	4
2	BS-04	Mathematics-II	3	1	0	4
3	ES-04	C Programming for Problem Solving	3	0	2	4
4	BS-05	Basic Electronics	3	0	2	3
5	ES-05	CAD Tool-II	0	0	4	2
6	SCC-10	Linux and Scripting	1	0	2	2
7	HSM-02	Universal Human Values	2	0	0	2
8	AU-02	Sports and Yoga or NSS/NCC	2	0	0	0
		TOTAL	18	2	12	20

SEMESTER 3

Sl. No.	Course Code	Course Title	L	T	P	Credit
1	SCC-01	Mathematics III	3	0	0	3
2	SCC-02	Signal and System	3	0	0	3
3	SCC-08	Data Structures	3	0	2	3
4	PCC-01	Semiconductor Devices	3	0	2	3
5	PCC-04	Analog Circuits	3	0	2	3
6	SCC-07	Digital Logic Design	3	0	2	3
7	PRC-01	Group Project 1/ Research Project 1/Specialization Elective/Micro- credit Elective Course ***with Industry***	0	0	2	1
8	BS-06	Slot for BS Course				3
9	ML-01	Slot for Mandatory Learning Course (Audit Course)				0
		TOTAL				22

SEMESTER 4

S. No.	Course Code	Course Title	L	T	P	Credit
1	SCC-04	Computer and Processor Architecture	3	0	0	3
2	SCC-05	Quantum Devices and Circuits	2	0	0	2
3	SCC-03	Communication Engineering	2	0	2	3
4	PCC-02	Photonics and Optoelectronics Devices	2	0	2	3
5	PCC-03	Micro-fabrication and Semiconductor materials	3	0	0	3
6	SCC 06	Electromagnetism for VLSI	2	0	2	3
7	PRC-02	Group Project 2/ Research Project 2/Specialization Elective/Micro- credit Elective Course	0	0	2	1
8	HSM-03	Slot for HM Course				3
Total Credit						21

SEMESTER 5

S. No.	Course Code	Course Title	L	T	P	Credit
1	PCC-05	SOC Design: Design & Verification	2	0	2	3
2	PCC-06	Compound Semiconductor Devices	2	0	2	3
3	PCC-07	CMOS Integrated Circuits	3	0	4	5
4	PCC-08	Electronic System Design	3	0	4	5
5	PCC-09	MEMS and NEMS	2	0	0	2
6	PCC-10	Memory Design	2	0	0	2
7	PRC-03	Group Project 3/ Research Project 3 on Semiconductor Modelling and Simulations	0	0	2	1
8	HSM-04	Slot for HM Course				3
9	ML-03	Slot for Mandatory Learning Course (Audit Course)				0
		TOTAL				24

SEMESTER 6

S. No.	Course Code	Course Title	L	T	P	Credit
1	PCC-11	Mixed mode VLSI Circuit	3	0	2	4
2	PCC-12	IC Packaging	3	0	0	3
3	PCC-13	Semiconductor Materials Synthesis and Characterization	3	0	0	3
4	PCC-14	Semiconductor Manufacturing: Materials and Process	3	0	0	3
5	PRC-04	Group Project 4/ Research Project 4/Specialization Elective/Micro- credit Elective Course	0	0	4	2
6	PE-01	Program Elective-01	2	0	0	2
7	PE-02	Program Elective-02	3	0	0	3
		TOTAL				20

Program Elective-01

TFT

Display System Design

OLED and LCD

Program Elective-02

A. FPGA Programming

B. Logic Synthesis

C. Design for Testability

** BS= BASC SCIENCE
** SCC= COMMON CORE
**ES= ENGINEERING SCIENCE
**HSM= HUMANITIES AND SOCIAL SC.
**PCC=PROGRAM CORE
**PEC=PROGRAM ELCTIVE

SEMESTER 7

S. No.	Course Code	Course Title	L	T	P	Credit
1	OE-01	Open Elective-01 (Online)	3	0	0	3
2	OE-02	Open Elective-02 (Online)	3	0	0	3
3	OE-03	Open Elective-03 (Online)	3	0	0	3
6	HSM-5	Slot for HSM Course (Online)	3	0	0	3
7	XC-28	Internship/Foundry visits	0	0	10	2
8	XC-29	Final Year Project Phase -1	0	0	4	4
		TOTAL				18

Open Elective-01 (Online)

A. AI/ML for CAD VLSI
B. Device Modelling and Simulation
C. Device and Materials Reliability

Open Elective-02

A. Semiconductor Industry Practice & standards
B. Semiconductor business and marketing
C. Entrepreneurship in Semiconductors

Open Elective-02

A. IC Packaging Techniques
B. materials for Semiconductor Packaging
C. Package Design and Simulation Tool

SEMESTER 8

Sl. No.	Course Code	Course Title	L	T	P	Credit
3	XC-P3	Final Year Project Phase 2	0	0	36	18
TOTAL						18

1st

Semester Syllabus

1. Physics (BS-01)
(L-T: 3-0: Credit 3)

Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential; Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement; Bio-Savart law, Divergence and curl of static magnetic field.

Displacement current, Magnetic field due to time-dependent electric field and Maxwell's equations Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; displace current and magnetic field arising from time-dependent electric field; calculating magnetic field due to changing electric fields in quasi-static approximation. Maxwell's equation in vacuum and non-conducting medium; Energy in an electromagnetic field; Flow of energy and Pointing vector with examples. Qualitative discussion of momentum in electromagnetic fields.

Magnetization and associated bound currents; auxiliary magnetic field H; magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials; Qualitative discussion of magnetic field in presence of magnetic materials.

Faraday's law in terms of EMF produced by changing magnetic flux; equivalence of Faraday's law and motional EMF; Lenz's law; Electromagnetic breaking and its applications; Differential form of Faraday's law.

The wave equation; energy carried by electromagnetic waves and examples. Momentum carried by electromagnetic waves and resultant pressure. Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence.

TEXT BOOKS / REFERENCES:

1. David Griffiths, Introduction to Electrodynamics
2. W. Saslow, Electricity, magnetism and light
3. Quantum Physics- Aurhtur Beiser

1. Physics Lab (BS-091)
(L-T-P: 3-0-2: Credit 1)

Laboratory - Introduction to Electromagnetic Theory
Choice of experiments from the following:
● Experiments on electromagnetic induction and electromagnetic braking;
● LC circuit and LCR circuit;
● Resonance phenomena in LCR circuits;
● Magnetic field from Helmholtz coil;
● Measurement of Lorentz force in a vacuum tube.

NPTEL links:
1. http://vlab.amrita.edu/?sub=1&brch=75&sim=326&cnt=1
2. http://vlab.amrita.edu/?sub=1&brch=75&sim=330&cnt=1
3. http://vlab.amrita.edu/?sub=1&brch=75&sim=318&cnt=1
4. http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1
5. http://vlabs.iitkgp.ernet.in/asnm/exp12/index.htm
6. http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1

Mathematics (BS-02) (L-T-P: 3-0-0) Credit 3

Module 1: Basic Calculus: (6 hours)
Curvature, evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2: Single-variable Calculus (Differentiation): (6 hours)
Rolle’s Theorem, Mean value theorems and applications; Extreme values of functions; Linear approximation; Indeterminate forms and L'Hospital's rule.

Module 3: Sequences and series: (10 hours)
Limits of sequence of numbers, Calculation of limits, Infinite series; Tests for convergence; Power series, Taylor and Maclaurin series; Taylor theorem, convergence of Taylor series, error estimates.

Module 4: Multivariable Calculus (Differentiation): (8 hours)
Limit, continuity and partial derivatives, directional derivatives, gradient, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers.

Module 5: Multivariable Calculus (Integration): (10 hours)
Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular

parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Gradient, curl and divergence, Theorems of Green, Gauss and Stokes.

Basic Electrical Engineering (ES-01)

1. DC Circuits: Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems. Maximum Power Transfer theorem, Mesh and Node analysis, Transient response of RL, RC, and RLC circuits. Numerical on the Network theorem. Introduction to two port networks (H parameter, Z parameter, Y parameter and Hybrid parameters)

2. AC Circuits : Representation of the sinusoidal waveform, peak and rms value, Phasor representations, resonance. Three-phase balanced circuit, losses in the transformers, Analysis of single-phase AC circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three-phase balanced circuits, voltage and current relations in star and delta connection, Resonance and Coupled Circuits.

3 Transformers : Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

4 Electrical Machines :Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single-phase induction motor. Construction, working, torque-speed characteristic and speed control of separately excited dc motor. Construction and working of synchronous generators

5 Power Converters : DC-DC buck and boost converters, duty ratio control. Single-phase and three-phase voltage source inverters; sinusoidal modulation.

6. Filter Circuits: Low-pass, high-pass, band-pass, and band-reject filters; Design and analysis using operational amplifiers

Basic Electrical Engineering Lab (ES-01)

- Validate Thevenin's and Norton's theorems.
- Demonstrate the Superposition theorem.
- Apply the Maximum Power Transfer theorem.
- Measure resonant frequency, bandwidth, and quality factor.
- Determine Z, Y, and H parameters of given two-port networks.
- Analyze low-pass and high-pass filters.

- Study band-pass and band-stop filters.
- Use software tools like SPICE or Multisim for circuit simulation

	C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connection		
	3 **Transformers** Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.		
	4 **Electrical Machines** Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single-phase induction motor. Construction, working, torque-speed characteristic and speed control of separately excited dc motor. Construction and working of synchronous generators		
	5 **Power Converters** DC-DC buck and boost converters, duty ratio control. Single-phase and three-phase voltage source inverters; sinusoidal modulation.		
	6 **Electrical Installations** Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup.		

ES-091	**Basic Electrical Engineering Lab: Credit:1 (L0-T0-P2)**

English for Technical Writing (HSM-01)
Credits: 3 (L: 2, T: 0, P: 2)

Module I: Vocabulary Building
1.1. The concept of Word Formation
1.2. Root words from foreign languages and their use in English
1.3. Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.
1.4. Synonyms, antonyms, and standard abbreviations.

Module II: Basic Writing Skills
1.1. Sentence Structures
1.2. Use of phrases and clauses in sentences
1.3. Importance of proper punctuation
1.4. Creating coherence
1.5. Organizing principles of paragraphs in documents
1.6. Techniques for writing precisely

Module III: Identifying Common Errors in Writing
1.1. Subject-verb agreement
1.2. Noun-pronoun agreement
1.3. Misplaced modifiers
1.4. Articles
1.5. Prepositions
1.6. Redundancies
1.7. Clichés

Module IV: Nature and Style of sensible Writing
1.1. Describing
1.2. Defining
1.3. Classifying
1.4. Providing examples or evidence
1.5. Writing introduction and conclusion

Module V: Writing Practices
1.1. Comprehension
1.2. Précis Writing
1.3. Essay Writing
Module VI: Oral Communication

(This Module involves interactive practice sessions in Language Lab)

- Listening Comprehension
- Pronunciation, Intonation, Stress and Rhythm
- Common Everyday Situations: Conversations and Dialogues
- Communication at Workplace
- Interviews
- Formal Presentations

Text/Reference Books:

1. AICTE's Prescribed Textbook: English (with Lab Manual), Khanna Book Publishing Co.
2. Effective Communication Skills. Kul Bhushan Kumar, Khanna Book Publishing, 2022.
3. Practical English Usage. Michael Swan. OUP. 1995.
4. Remedial English Grammar. F.T. Wood. Macmillan.2007
5. On Writing Well. William Zinsser. Harper Resource Book. 2001
6. Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
7. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
8. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press.

Engineering Graphics & Design (ES-02)

Credits: 3 (L: 2, T: 0, P: 2)

Module I: Introduction to Engineering Drawing Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales;

Module II: Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes; Module III: Projections of Regular Solids Covering those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Module IV: Sections and Sectional Views of Right Angular Solids Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only).

Module V: Isometric Projections Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;

Module VI: Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids]

Module VII: Consisting of set up of the drawing page and the printer, including scale settings, setting up of Modules and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

Module VIII: Annotations, layering & other functions Covering applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation.

Module IX: Demonstration of a simple team design project that illustrates
Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

ES-093	**CAD Tool-I**

Credit 2; P(4)

1. Introduction to Cadence

Cadence Set up and Launch
DC Simulation: Resistive Inverter
AC and transient simulation - RC low-pass Filter
V-I Characteristics of the pn Diode
CMOS Inverter: DC and AC Analysis

2. Introduction to SYNOPSIS TCAD Tool
Synopsis Set up and launch
Introductions Model files
Simulation of pn diode and DC analysis

Simulation of pn diode and AC analysis

AU-01: Idea Workshop
CREDIT 0 (L: 2, T: 0, P: 4)

Sl. No.	Topics	
1	Electronic component familiarization, Understanding electronic system design flow. Schematic design and PCB layout and Gerber creation using EagleCAD. Documentation using Doxygen, Google Docs, Overleaf. Version control tools - GIT and GitHub. Basic 2D and 3D designing using CAD tools such as FreeCAD, Sketchup, Prusa Slicer, FlatCAM, Inkspace, OpenBSP and VeriCUT.	Introduction to basic hand tools - Tape measure, combination square, Vernier calliper, hammers, fasteners, wrenches, pliers, saws, tube cutter, chisels, vice and clamps, tapping and threading. Adhesives Introduction to Power tools: Power saws, band saw, jigsaw, angle grinder, belt sander, bench grinder, rotary tools. Various types of drill bits,
2	Familiarization and use of basic measurement instruments - DSO including various triggering modes, DSO probes, DMM, LCR bridge, Signal and function generator. Logic analyzer and MSO. Bench power supply (with 4-wire output) Circuit prototyping using (a) breadboard, (b) Zero PCB (c) 'Manhattan' style and (d) custom PCB. Single, double and multilayer PCBs. Single and double-sided PCB prototype fabrication in the lab. Soldering using soldering iron/station. Soldering using a temperature controlled reflow oven. Automated circuit assembly and soldering using pick and place machines. Mechanical cutting processes - 3-axis CNC routing, basic turning, milling, drilling and grinding operations, Laser cutting, Laser engraving etc. Basic welding and brazing and other joining techniques for assembly. Concept of Lab aboard a Box.	Familiarization and use of basic measurement instruments - DSO including various triggering modes, DSO probes, DMM, LCR bridge, Signal and function generator. Logic analyzer and MSO. Bench power supply (with 4-wire output) Circuit prototyping using (a) breadboard, (b) Zero PCB (c) 'Manhattan' style and (d) custom PCB. Single, double and multilayer PCBs. Single and double-sided PCB prototype fabrication in the lab. Soldering using soldering iron/station. Soldering using a temperature controlled reflow oven. Automated circuit assembly and soldering using pick and place machines. Mechanical cutting processes - 3-axis CNC routing, basic turning, milling, drilling and grinding operations, Laser cutting, Laser engraving etc. Basic welding and brazing and other joining techniques for assembly. Concept of Lab aboard a Box.
3	circuit building blocks including common sensors. Arduino and Raspberry Pi programming and use. Digital Input and output. Measuring time and events. PWM. Serial communication. Analog input. Interrupts programming. Power Supply design (Linear and Switching types), Wireless power supply, USB PD, Solar panels, Battery types and charging 3D printing and prototyping technology – 3D	circuit building blocks including common sensors. Arduino and Raspberry Pi programming and use. Digital Input and output. Measuring time and events. PWM. Serial communication. Analog input. Interrupts programming. Power Supply design (Linear and Switching types), Wireless power supply, USB PD, Solar panels, Battery types and charging 3D

	printing using FDM, SLS and SLA. Basics of 3D scanning, point cloud data generation for reverse engineering. Prototyping using subtractive cutting processes. 2D and 3D Structures for prototype building using Laser cutter and CNC routers. Basics of IPR and patents; Accessing and utilizing patent information in IDEA Lab	printing and prototyping technology – 3D printing using FDM, SLS and SLA. Basics of 3D scanning, point cloud data generation for reverse engineering. Prototyping using subtractive cutting processes. 2D and 3D Structures for prototype building using Laser cutter and CNC routers. Basics of IPR and patents; Accessing and utilizing patent information in IDEA Lab
4	Discussion and implementation of a mini project.	
5	Documentation of the mini project (Report and video).	

Laboratory Activities:

<u>No. List of Lab activities and experiments</u>

1. Schematic and PCB layout design of a suitable circuit, fabrication and testing of the circuit.
2. Machining of 3D geometry on soft material such as soft wood or modelling wax.
3. 3D scanning of computer mouse geometry surface. 3D printing of scanned geometry using FDM or SLA printer.
4. 2D profile cutting of press fit box/casing in acrylic (3 or 6 mm thickness)/cardboard, MDF (2 mm) board using laser cutter & engraver.
5. 2D profile cutting on plywood /MDF (6-12 mm) for press fit designs.
6. Familiarity and use of welding equipment.
7. Familiarity and use of normal and wood lathe.
8. Embedded programming using Arduino and/or Raspberry Pi.
9. Design and implementation of a capstone project involving embedded hardware, software and machined or 3D printed enclosure.

2ND Semester Syllabus

BS-03	Physics II (L3-T0-P2); CREDIT 4

Unit I: Solid State Physics: [12]
Crystal structure and Lattice, unit cell and translation vectors, Miller indices, Simple and close-packed crystal structures with examples, Crystal defects and imperfections, Origin of energy bands, Energy bands in solids, Kronig Penney Model (qualitative), E-K diagram, Brillouin Zones, Concept of effective mass and holes, Classification into metals, Semiconductors and insulators, Fermi-level and carrier concentration, Unbiased diode, Forward and reverse biased diodes – tunnel diodes, zener diode, Photodiode its characteristics, LED, Liquid crystals, Hall effect.

Unit II: Quantum Mechanics: [10]
Introduction: Wave-particle duality, Two-slit experiment, De Broglie waves, Electron diffraction, physical interpretation of the wave function, properties, Wave packet, group and phase velocity, the uncertainty principle, Time-dependent and Time-independent Schrodinger wave equation, Eigen values and Eigen functions, expectation values, simple Eigenvalue problems – solutions of Schrodinger equations for a free particle, Infinite well, Finite well, tunnelling effect, the scanning electron microscope, the quantum simple harmonic oscillator (qualitative), zero point energy.

Unit III Engineering Optics: [10]
Basics of Interference, Diffraction and Polarization, Lasers and characteristics, Coherence, Einstein's A and B coefficients, Population inversion, He-Ne laser, Semiconductor lasers, Basic principle and operation of a laser, He-Ne laser, Ruby laser, Applications of Lasers, Optical fibres, Numerical aperture, Classification of optical fibres, Fibre Losses, Fibre manufacturing, Applications of optical fibre in industry and communication.

Unit IV Nanotechnology and Quantum Computing: [8]
Introduction to quantum wells, wires and dots and their importance in modern semiconductor technology, Basic principles of quantum computation, Role of semiconductor materials in quantum computing devices (qubits, quantum gates).

BS-04	Mathematics-II **(L3-T0-P0); CREDIT 3**

Module 1: Matrices and Determinants [5]

Linear Systems of Equations; Linear Independence; Rank of a Matrix; Determinant, Inverse of a matrix, rank-nullity theorem; System of linear equations; Determinants; Eigenvalues and eigenvectors; Cayley-Hamilton Theorem.

Module 2: First-order ordinary differential equations: [8]

Exact, linear and Bernoulli's equations. Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type. Ordinary differential equations of higher orders, Second order linear differential equations with variable coefficients: Euler-Cauchy equations, solution by variation of parameters

Unit II Laplace Transforms: [12]

Definitions and properties, First Shifting Theorem (s-Shifting), Transforms of Derivatives and Integrals and Ordinary Differential Equations (ODEs), Unit Step Function (Heaviside Function), Second shifting theorem (t-Shifting), Short impulses, Dirac's Delta Function, Partial fractions, Convolution, Integral equations, Differentiation and integration of transforms, Solution of ODEs with variable coefficients, Solution of systems of ODEs, Laplace transform of unit step function, Unit impulse function and Periodic function, Inverse Laplace transform and its properties.

Unit III Fourier Analysis: [10]

Continuous and discrete Fourier transform, Fourier series, Even and Odd functions, Half-Range expansions, Sturm-Liouville problems, Fourier integral, Fourier Cosine and Sine transforms, Discrete Fourier transform, Use of Fourier analysis for solution of ODEs, Inverse Fourier transform and its properties.

ES-04	C and MATLAB Programming for Problem Solving

(L3-T0-P2); CREDIT 4

Course Contents:

Module I: Introduction to Programming; Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.) Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples. From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.

Module II: Arithmetic expressions and precedence.

Module III: Conditional Branching and Loops. Writing and evaluation of conditionals and consequent branching. Iteration and loops.

Module IV: Arrays, Arrays (1-D, 2-D), Character arrays and Strings

Module V: Basic Algorithms, Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

Module VI: Function, Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference

Module VII: Recursion, Recursion as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

Module VIII: Structures, Defining structures and Array of Structures

Module IX: Pointers, Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list (no implementation)

Module X: File handling (only if time is available, otherwise should be done as part of the lab).

BS-05	Basic Electronics (L3-T0-P2); CREDIT 4

Unit I

Introduction to Semiconductor Materials: Types of materials, Energy bands in solids, Mobility and conductivity, Intrinsic and extrinsic semiconductors, Doping process, Charge densities in semiconductors, Electrical properties of Ge and Si, Hall effect, Generation and recombination of charges, Drift and Diffusion, Continuity equation, Injected minority carrier charge.

[6]

Unit II

Junction Diode Characteristics: P-N junction formation and properties, forward and reverse bias operation, Diode characteristics curve, Breakdown of diodes, Diode applications- Rectifiers, Clippers, Clampers, Peak-to-peak detector, Voltage multiplier, Zener breakdown [8 Hrs]

Unit III

Bipolar Junction Transistor Characteristics: Structure and operation of NPN and PNP bipolar junction transistor (BJT), Active, saturation and cut-off regions, Current gain, Input and output characteristics, Common emitter, Common base and Common collector configurations, Small signal analysis of BJT, Gain and bandwidth, Frequency response characteristics, Need for biasing, Fixed-bias, Emitter-bias and Voltage divider bias, Stability of operating point, Q point, DC and AC load line, Thermal runaway, Compensation techniques, Bias stabilization,

[8Hrs]

Unit IV

Field Effect Transistor: Structure and working of MOSFET(Metal oxide semiconductor field effect transistor), N-channel and p-channel MOSFETs, Operation and characteristics of Junction field effect transistor (JFET), FET biasing, MOSFETs in VLSI technology, MOS capacitor

[6HRS]

Unit V: [12]

Differential Amplifier, Power Amplifier, push pull amplifier, Op-Amp characteristics, Virtual ground, Adder, subtractor, Multiplier, Log and Anti Log Amplifier using Opamp, Filter using opamp, Monostable and Astable Multivibrator using Opamp, Working principal of Feedback amplifier and Oscillator

Text books:

1. J. Millman and C. Halkias, Integrated Electronics, McGraw Hill, 2nd Edition, 2009
2. A. Sedra and C. Smith, Microelectronic Circuits: Theory and Applications, Oxford University Press, 2006

References:

1. Robert Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory" PHI; 8th Edition.200
2. Thomas L. Floyd, "Electronic Devices" 8th Edition, Pearson Education, Inc., 2007
3. Tyagi M.S., "Introduction to Semiconductor Materials and Devices", John Wiley & Sons, 1993.
4. Spencer and Ghausi, Introduction to Electronic Circuit Design, Pearson Education, 2003

ES-05	CAD Tool-II

1. Introduction to Cadence

a. Simulation of Common Source Amplifier
b. Simulation of Differential Amplifier
c. Simulation of CMOS NAND, NOR gates

2. Introduction to SYNOPSIS TCAD Tool
A Simulation of MOSFET and DC analysis
B. Simulation of MOSFET and AC analysis

SSC-10: Linux and Scripting

Course Description: 2L: 0T: 0P : 2 credits

VLSI design challenges.

Week 1-2: Introduction to Linux for VLSI Design
- Overview of Linux distributions and their relevance in VLSI design.
- Basic Linux commands and file system navigation.
- Introduction to shell scripting for VLSI applications.

Week 3-4: Advanced Linux Commands for VLSI Design
- Networking and system administration in a VLSI design environment.
- Version control systems (e.g., Git) for collaborative VLSI projects.

Week 5-6: Introduction to Python Programming for VLSI
- Basic Python syntax and data structures.
- Writing and executing Python scripts for VLSI design automation.

Week 7-8: Advanced Python Scripting for VLSI Design
- Interacting with EDA tools using Python.
- Data analysis and visualization in the context of VLSI design.

Week 9-10: Introduction to TCL Scripting for VLSI
- TCL fundamentals and scripting in VLSI applications.
- Integrating TCL with EDA tools for automation.

Week 11-12: Advanced TCL Scripting for VLSI Design
- Developing complex TCL scripts for VLSI design tasks.
- Interfacing TCL with Python for enhanced functionality.

Week 13-14: Group Project - Integrated Scripting for VLSI Design
- Collaborative development of VLSI design projects using integrated Python and TCL scripting.
- Presentation and evaluation of group projects.

Week 15: Final Review and Exam Preparation
- Recapitulation of key concepts.
- Final exam preparation and assessment.

Recommended Books
- Practical Linux for Systems Administrators (6th Edition) by Mark G. Sobell
- Python for Data Analysis (2nd Edition) by Wes McKinney
- Mastering TCL/TK: A Comprehensive Guide to the Tcl Programming Language (3rd Edition) by Brent B. Welch
- Linux Command Line: A Complete Introduction (2nd Edition) by William Shotts
- Python Crash Course: A Hands-On, Project-Based Introduction to Programming (2nd Edition) by Eric Matthes
- TCL Programming for Beginners: A Hands-On Guide (2nd Edition) by Kevin T. Smith

HSM-02	**Universal Human Values (L3-T1-P0)** **Credit 3**

The syllabus for the lectures and practice sessions is given below:

Module 1 – Introduction to Value Education (6 lectures and 3 tutorials for practice session)

Lecture 1: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education)
Lecture 2: Understanding Value Education
Tutorial 1: Practice Session PS1
Sharing about Oneself
Lecture 3: Self-exploration as the Process for Value Education
Lecture 4: Continuous Happiness and Prosperity – the Basic Human Aspirations
Tutorial 2: Practice Session PS2
Exploring Human Consciousness

Lecture 5: Happiness and Prosperity – Current Scenario
Lecture 6: Method to Fulfill the Basic Human Aspirations
Tutorial 3: Practice Session PS3
Exploring Natural Acceptance
Expected outcome:

Module 2 – Harmony in the Human Being (6 lectures and 3 tutorials for practice session)

Lecture 7: Understanding Human being as the Co-existence of the Self and the Body
Lecture 8: Distinguishing between the Needs of the Self and the Body
Tutorial 4: Practice Session PS4
Exploring the difference of Needs of Self and Body
Lecture 9: The Body as an Instrument of the Self
Lecture 10: Understanding Harmony in the Self
Tutorial 5: Practice Session PS5
Exploring Sources of Imagination in the Self
Lecture 11: Harmony of the Self with the Body
Lecture 12: Programme to ensure self-regulation and Health
Tutorial 6: Practice Session PS6

Module 3 – Harmony in the Family and Society (6 lectures and 3 tutorials for practice session)

Lecture 13: Harmony in the Family – the Basic Unit of Human Interaction
Lecture 14: 'Trust' – the Foundational Value in Relationship
Tutorial 7: Practice Session PS7
Exploring the Feeling of Trust
Lecture 15: 'Respect' – as the Right Evaluation
Tutorial 8: Practice Session PS8
Exploring the Feeling of Respect
Lecture 16: Other Feelings, Justice in Human-to-Human Relationship
Lecture 17: Understanding Harmony in the Society
Lecture 18: Vision for the Universal Human Order
Tutorial 9: Practice Session PS9
Exploring Systems to fulfil Human Goal

Module 4 – Harmony in the Nature/Existence (4 lectures and 2 tutorials for practice session)
Lecture 19: Understanding Harmony in the Nature
Lecture 20: Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature
Tutorial 10: Practice Session PS10 Exploring the Four Orders of Nature
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Lecture 21: Realizing Existence as Co-existence at All Levels
Lecture 22: The Holistic Perception of Harmony in Existence
Tutorial 11: Practice Session PS11 Exploring Co-existence in Existence

Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics (6 lectures and 3 tutorials for practice session)

Lecture 23: Natural Acceptance of Human Values
Lecture 24: Definitiveness of (Ethical) Human Conduct
Tutorial 12: Practice Session PS12 Exploring Ethical Human Conduct

Lecture 25: A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order
Lecture 26: Competence in Professional Ethics
Tutorial 13: Practice Session PS13 Exploring Humanistic Models in Education
Lecture 27: Holistic Technologies, Production Systems and Management Models-Typical

Case Studies
Lecture 28: Strategies for Transition towards Value-based Life and Profession
Tutorial 14: Practice Session PS14 Exploring Steps of Transition towards Universal
Human Order

Practice Sessions for Module 1 – Introduction to Value Education

PS1 Sharing about Oneself
PS2 Exploring Human Consciousness
PS3 Exploring Natural Acceptance

Practice Sessions for Module 2 – Harmony in the Human Being
PS4 Exploring the difference of Needs of Self and Body
PS5 Exploring Sources of Imagination in the Self
PS6 Exploring Harmony of Self with the Body

Practice Sessions for Module 3 – Harmony in the Family and Society
PS7 Exploring the Feeling of Trust
PS8 Exploring the Feeling of Respect
PS9 Exploring Systems to fulfil Human Goal

Practice Sessions for Module 4 – Harmony in the Nature (Existence)
PS10 Exploring the Four Orders of Nature
PS11 Exploring Co-existence in Existence

Practice Sessions for Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics
PS12 Exploring Ethical Human Conduct
PS13 Exploring Humanistic Models in Education
PS14 Exploring Steps of Transition towards Universal Human Order

READINGS:
3-1-Text Book and Teachers Manual
a. The Textbook - A Foundation Course in Human Values and Professional Ethics, R R Gaur,
R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-9387034-47-1
b. The Teacher's Manual- Teachers' Manual for A Foundation Course in Human Values and
Professional Ethics, RR Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53
c. Professional Ethics and Human Values, Premvir Kapoor, ISBN: 978-93-86173-652, Khanna Book Publishing Company, New Delhi, 2022.

Reference Books
1. JeevanVidya: EkParichaya, A Nagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi

5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj – Pandit Sunderlal
9. Rediscovering India - by Dharampal

3rd Semester Syllabus

SCC-01	Mathematics III

1. Algebra of Sets: sets and classes, limit of a sequence of sets, rings, sigma rings, fields, sigma-fields, monotone classes.

2. Probability: Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence, problems

3. Random Variables: Discrete, continuous and mixed random variables, probability mass, probability density and cumulative distribution functions, mathematical expectation, moments, probability and moment generating function, median and quantiles, Markov inequality, Chebyshev's inequality, problems.

4. Special Distributions: Discrete uniform, binomial, geometric, negative binomial, hypergeometric, Poisson, continuous uniform, exponential, gamma, Weibull, Pareto, beta, normal, lognormal, inverse Gaussian, Cauchy, double exponential distributions, reliability and hazard rate, reliability of series and parallel systems, problems.

5. Function of a random variable, problems.

6. Joint Distributions: Joint, marginal and conditional distributions, product moments, correlation and regression, independence of random variables, bivariate normal distribution, problems.

7. Transformations: functions of random vectors, distributions of order statistics, distributions of sums of random variables, problems.

8. Sampling Distributions: The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions, problems

9. Descriptive Statistics: Graphical representation, measures of locations and variability

10. Estimation: Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for proportions, problems

11. Testing of Hypotheses: Null and alternative hypotheses, the critical and 8 acceptance regions, two types of error, power of the test, the most powerful test and Neyman-Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations, tests for proportions, Chi square goodness of fit test and its applications, problems.

References:

1. An Introduction to Probability and Statistics by V.K. Rohatgi & A.K. Md. E. Saleh.
2. Introduction to Probability and Statistics by J.S. Milton & J.C. Arnold.
3. Introduction to Probability Theory and Statistical Inference by H.J. Larson.
4. Introduction to Probability and Statistics for Engineers and Scientists by S.M. Ross
5. A First Course in Probability by S.M. Ross
6. Probability and Statistics in Engineering by W.W. Hines, D.C. Montgomery, D.M. Gpldsman & C.M. Borror
7. Lectures in Probability by M. Kac (for example on independent events)
8. C.K. Wong (1972) A note on mutually independent events. Annals of Statistics, V. 26, 27.(for example on independent events).
9. Measure Theory by P. Halmos (for algebra of sets)

SCC 02: Signals and Systems (3L)

Module I **6L**

Signals and systems as seen in everyday life, and in various branches of engineering and science. Energy and power signals, continuous and discrete time signals, Fundamental Signals, Random Signals, Operations on signals; System properties: linearity: additivity and homogeneity, Time-invariance, causality, stability.

Module II **6L**

LTI systems: impulse response and step response, convolution, input-output behaviour with random inputs. Characterization of causality and stability of LTI systems. System representation through differential equations and their analysis.

Module III **10L**

Periodic and Non Periodic inputs to the LTI system, Frequency response of a system, Fourier series representation, Line and Phase Spectrum; Fourier Transform and properties of the Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT).

Module IV **8L**

Z-transform (single-sided and Double-sided), The z-Transform for discrete-time signals and systems- eigen functions, region of convergence, z-domain analysis. The Laplace Transform, the notion of eigenfunctions of LSI systems, a basis of eigenfunctions, region of convergence, poles and zeros of system, , the solution to differential equations and system behaviour using Laplace Transformation

Module V **3L**

The Sampling Theorem and its implications- Spectra of sampled signals. Reconstruction: ideal interpolator, Aliasing and its effects.

Text/Reference books:

1. A.V. Oppenheim, A.S. Willsky and I.T. Young, "Signals and Systems", Prentice Hall, 1983.
2. Simon Haykin, Barry van Veen, "Signals and Systems", John Wiley and Sons (Asia).
3. Tarun K Rawat, “Signal and System”, Oxford Publishers, 2022.

4. Robert A. Gabel, Richard A. Roberts, "Signals and Linear Systems", John Wiley and Sons, 1995.
5. M. J. Roberts, "Signals and Systems - Analysis using Transform methods and MATLAB", TMH.

SCC 07: Digital Logic Design (Texus Austin University)

Explore boolean algebra; analysis and design of combinational and sequential logic circuits; state machine design and state tables and graphs; simulation of combinational and sequential circuits; applications to computer design; and hardware description languages (HDLs) and field-programmable gate arrays (FPGAs).

Weeks 1-2: Introduction to Digital Electronics
● Binary number systems and their applications
● Basics of digital logic and gates

Weeks 3-4: Combinational Logic Circuits
● Design and analysis of combinational circuits
● Multiplexers, demultiplexers, and encoders

Weeks 5-6: Sequential Circuits and State Machines
● Introduction to flip-flops and latches
● Analysis and design of sequential circuits, including state machines

Weeks 7-8: Memory Devices
● Types of memory devices and their characteristics
● Read-only memory (ROM) and random-access memory (RAM)
Weeks 9-10: Microprocessor Fundamentals
● Basics of microprocessor architecture

Weeks 11-12: Advanced Digital Circuits
● Shift registers and counters
● Digital comparators and arithmetic circuits

Weeks 13-14: Project Work and Practical Applications
● Hands-on project work applying concepts learned throughout the course
● Troubleshooting exercises and debugging practice

Week 15: Final Presentations and Assessment
● Final project presentations
● Comprehensive assessment and review

SCC-0907: Laboratory Course on Digital Logic Design

- Introduction to Digital Electronics Lab- Nomenclature of Digital Ics, Specifications, Study of the Data Sheet, Concept of Vcc and Ground, Verification of the Truth Tables of Logic Gates using TTL ICs.
- Implementation of the Given Boolean Function using Logic Gates in Both Sop and Pos Forms.
- Verification of State Tables of Rs, J-k, T and D Flip-Flops using NAND & NOR Gates

- Implementation and Verification of Decoder/De-Multiplexer and Encoder using Logic Gates.
- Implementation of 4x1 Multiplexer using Logic Gates.
- Implementation of 4-Bit Parallel Adder Using 7483 IC.
- Design , and Verify the 4- Bit Synchronous Counter
- Design, and Verify the 4-Bit Asynchronous Counter.
- Simulation of MOS Inverter with different loads using PSPICE software
- Simulation of CMOS Inverter for different parameters Kn, Kp as a design variable in suitable circuit simulator software.
- Design of a 4-bit Multiplexer using VHDL\Verilog
- Design of a decade counter using VHDL\Verilog.
- Design of a 3-input NAND gate and its simulation using suitable logic simulator

SCC 08: Data Structure

Data abstractions: elementary data structures (lists, stacks, queues, and trees) and their implementation using an object-oriented programming language. Solutions to a variety of computational problems such as search on graphs and trees. Elementary analysis of algorithms.

Weeks 1-2: Introduction to Data Structures and Algorithms
- Overview of data structures and algorithms
- Importance and applications of data structures

Weeks 3-4: Arrays and Linked Lists
- Design and implementation of arrays
- Implementation and manipulation of linked lists

Weeks 5-6: Stacks and Queues
- Applications and implementation of stacks
- Queue operations and circular queues

Weeks 7-8: Trees and Binary Trees
- Introduction to tree structures
- Binary tree operations and traversal

Weeks 9-10: Balanced Trees and Graphs
- AVL trees and other balanced trees
- Basics of graph theory and graph representations

Weeks 11-12: Sorting and Searching Algorithms
- Comparison and analysis of sorting algorithms
- Searching techniques and their applications

Weeks 13-14: Recursion and Dynamic Programming
- Recursive problem-solving strategies
- Principles and applications of dynamic programming

Week 15: Review, Project Work, and Practical Applications
- Recap of key concepts and algorithms
- Application of data structures and algorithms in practical scenarios

● Final project work and assessment

Recommended Books

1. G.A Vijayalakshmi Pai. A textbook of Data Structures and Algorithms 1: Mastering Linear Data Structures. Wiley Online Library, 2023.
2. Steven S. Skiena. The Algorithm Design Manual. Springer, 2020.
3. Narasimha Karumanchi. Data Structures and Algorithms Made Easy. CareerMonk Publications, 2016.
4. Sachi Nandan Mohanty, Pabitra Kumar Tripathy. Data Structures and Algorithms Using C++: A Practical Implementation. Scrivener Publishing LLC, 2021.

SCC-0908: Laboratory Course on Data Structure

- Implementation of array operations:
- Stacks and Queues: adding, deleting elements Circular Queue: Adding & deleting elements
- Merging Problem : Evaluation of expressions operations on Multiple stacks & queues :
- Implementation of linked lists: inserting, deleting, and inverting a linked list.
- Implementation of stacks & queues using linked lists:
- Polynomial addition, Polynomial multiplication
- Sparse Matrices : Multiplication, addition.
- Recursive and Nonrecursive traversal of Trees
- Threaded binary tree traversal. AVL tree implementation
- Application of Trees. Application of sorting and searching algorithms
- Hash tables implementation: searching, inserting and deleting, searching & sorting techniques.

PCC 01: Semiconductor Devices

Teaching Schedule:

Week 1-2: Introduction to Semiconductor Physics

● Semiconductor fundamentals, Band Diagram, Fermi Statistics, Transport Equation, Quantum Tunneling.

● PN junction formation, depletion region, and forward/backward bias.

Week 3-4: PN Junction Diode Applications

● Diode characteristics and ideal diode equation.

● Diode circuits: rectifiers, clippers, and clampers.

Week 5-8: Field Effect Transistors (JFETs)

● JFET fundamentals: construction and operation, JFET characteristics and applications.

● MOSFET fundamentals: n-channel and p-channel MOSFETs.

● MOSFET characteristics and regions of operation.

Week 9-10: Short Channel effects in MOSFET and Emerging Devices

● MOSFET Scaling and Short channel effects

● Introduction to FinFET and Junctionless MOSFET, Operation and Characteristics

Week 11-12: MOSFET Applications
● MOSFET-based digital circuits, MOSFET as a switch and its role in digital systems.

Week 13-14: Overview of Bipolar Junction Transistors (BJTs)
● BJT fundamentals: construction and operation.
● BJT characteristics and comparison with MOSFETs.

Week 15: Advanced MOSFET Concepts and Final Review
● Final review of course content and preparation for the final exam.

Assessment Method:
Homework, quizzes, projects, exams

1. Advanced Semiconductor Fundamentals, Vol. VI in the Modular Series on Solid State Devices , 2nd Edition , R. F. Pierret , Prentice-Hall , 2002 , ISBN No. 978-0130617927.

2. Semiconductor Device Fundamentals, R. F. Pierret , Addison-Wesley , 1996 , ISBN No. 978-0201543933.

3. Solid State Device by Donald Neaman

PCC 0901: Laboratory Course on Semiconductor Device

1. Design and Simulation of the n type Bulk MOSFET
   - Observe V-I characteristics for different operating mode, Measure threshold voltage, SS.
   - Observe C-V characteristics
   - Observe the changes when the device parameters are changed.
   - Observe the power dissipation and the delay of the device

2. Design and Simulation of the p type Bulk MOSFET
   - Observe V-I characteristics for different operating mode, Measure threshold voltage, SS.
   - Observe C-V characteristics
   - Observe the changes when the device parameters are changed.
   - Observe the power dissipation and the delay of the device

PCC 04: Analog Electronics

Teaching Schedule Week Topic

1. Introduction to analogue circuits and network theory
2. Rectifier Circuits and Analog Filters
3. BJT and MOSFET Basic operations and VI characteristics, Switching circuits.

4. Amplifiers: Current Source and Current Mirror, Differential Op-Amp, Op-Amp and Power Amplifiers
5. Feedback Amplifier and Oscillators
6. Two-port networks: basic concepts and parameters; Two-port network design: filter networks
7. Multivibrator and wave shaping circuits
7. Advanced topics in analog circuits and network theory
8. Final project presentations

Recommended Books:

1. Electronic Devices and Circuits-Millman and Halkias (TMH)
2. Basic Electronics and linear circuits - Bhargava, Kulshreshta & Gupta TMH
3. A first course in Electronics-AA Khan and KK Dey-PHI
4. Electronic Devices and Circuit Theory-Robert L Boylestad& Louis Nashelsky
5. Pulse, Digital and Switching circuits by Milliman and Taub

PCC 0904: Laboratory Course on Analog Electronics

1. Conduct experiment to test diode clipping (single/double ended) and clamping circuits (positive/negative).
2. Design and set up the following rectifiers with and without filters and to determine ripple factor and rectifier efficiency:
(a). Full Wave Rectifier (b). Bridge Rectifier
3. Design and set up the BJT common emitter amplifier using voltage divider bias with and without feedback and determine the gain- bandwidth product from its frequency response.
4. Set-up and study the working of complementary symmetry class B push pull power amplifier and calculate the efficiency
5. Conduct an experiment on Series Voltage Regulator using Zener diode and power transistor to determine line and load regulation characteristics.
7. Design and set-up the following tuned oscillator circuits using BJT, and determine the frequency of oscillation.
R-C Phase shift Oscillator/Wien Bridge Oscillator
8. Plot the transfer and drain characteristics of n-channel MOSFET and calculate its parameters, namely; drain resistance, mutual conductance and amplification factor.
9. Design, setup and plot the frequency response of Common Source JMOSFET amplifier and obtain the bandwidth.

4th Semester Syllabus

SCC 03: Communication Engineering

Week 1-3: Analog Communication Systems

● Amplitude Modulation (AM) and Frequency Modulation (FM). Modulator and Demodulator Circuit. Calculation of Power spectral density in presence of Noise in AM and FM, Discussion on Bandwidth.

● Analog demodulation techniques.

Week 3-5: Digital Modulation and Demodulation Techniques

● Digital modulation schemes: Phase Shift Keying (PSK), Frequency Shift Keying (FSK), and Quadrature Amplitude Modulation (QAM).

● Digital demodulation techniques.

Week 6-7: Information Theory and Coding

Measurement of Information content, Entropy calculation, BSC channel, Channel Capacity calculations, Huffman and Shanon Fano Coding, Convolution Coding, Linear and Block coding

Week 8-11: Analog and Digital Filter (IIR and FIR Filter), DF1 and DFII structures.

Week 12-13: Communication Protocols and Emerging Technologies

● Overview of communication protocols.

● Exploration of emerging trends in communication technologies.

Week 14: Final Project and Review

● Application of signal processing and communication principles in a design project.
● Comprehensive review of the course content and preparation for the final exam.

Recommended Books
1. Simon Haykin, Communication System, 4^{th} Edition, John Wiley and Sons
2. Tarun K Rawat, Digital Signal Processing, Oxford Publisher

SCC 0903: Laboratory Course on Communication Engineering

- AM, PM, FM Transmitter and Receiver Set up and Spectrum Observation
- PCM, Delta and Adaptive Delta Modulation
- ASK, PSK and FSK
- QPSK
- Bit error rate Calculation
- Pseudo Random Sequence Generation
- FIR Filter
- IIR Filter

SCC 04: Computer Processor and Architecture

Weeks 1-3: Introduction to Computer Architecture
● Overview of computer architecture and design
● Instruction set architecture basics
● Processor design principles

Weeks 4-6: Memory Systems and Input/Output Systems
● Understanding memory hierarchies
● Input/output system organization

Weeks 7-9: Cache Memory and Pipelining
● Principles and types of cache memory
● Overview and analysis of pipelining

Weeks 10-12: Parallel Processing and Performance Evaluation
● Concepts of parallel processing in computer architecture
● Performance evaluation for architectures

Weeks 13-15: 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

Recommended Books

1. Yiu, Joseph. System-on-Chip Design with Arm® Cortex®-M Processors. Arm Education Media, 2019.
2. Furber, Stephen. ARM System-on-Chip Architecture. Pearson Education, 2000.
3. Sloss, Andrew. ARM System Developer's Guide. Elsevier, 2004.
4. Harris, Sarah. Digital Design and Computer Architecture, RISC-V Edition. Morgan Kaufmann, 2021.
5. Ledin, Jim. Modern Computer Architecture and Organization. Packt Publishing Ltd, 2022.
6. Dalrymple, Monte. Inside an Open-Source Processor. 2021

SCC05: Quantum device and Circuits

Week 1: Introduction to Quantum Technology
Overview of quantum computing, quantum communication, and sensing.
Historical context and significance of quantum devices.
Quantum vs classical systems: Key differences.
Week 2: Basics of Quantum Mechanics
Qubits: Superposition and entanglement.
Postulates of quantum mechanics.
Operators, eigenstates, and eigenvalues.
Quantum states representation (Dirac notation).
Week 3: Physical Implementations of Qubits
Superconducting qubits.
Trapped ions and neutral atoms.
Spin qubits and photonic systems.
Decoherence and noise in qubits.
Week 4: Quantum Circuits
Quantum gates: Single and multi-qubit gates (Pauli gates, Hadamard, CNOT, Toffoli).
Circuit representation of quantum algorithms.
Quantum Measurement: Projective measurement and POVM.
Week 5: Quantum Device Fabrication
Basics of nanofabrication: Lithography and deposition techniques.
Week 6-7: Superconducting Quantum Circuits
Josephson junctions and SQUIDs.
Quantum LC circuits and resonators.
Design principles of superconducting qubits (transmons, flux qubits).
Readout techniques for superconducting devices.
Week 8: Quantum Error Correction
Sources of errors in quantum circuits.
Quantum error correction codes: Shor, Steane, and surface codes.
Fault-tolerant quantum computing principles.
Week 9: Control and Measurement of Quantum Systems
Pulse sequences for gate operations (e.g., Rabi oscillations).
Role of microwave engineering in quantum circuits.
Measurement protocols for qubit states.
Week 10: Quantum Communication Devices
Quantum key distribution (QKD) protocols (BB84, E91).

Quantum repeaters and entanglement distribution.
Photonic components: Single-photon sources and detectors.
Week 11: Applications and Future Directions
Quantum algorithms (e.g., Grover's search, Shor's factoring).
Applications in optimization, cryptography, and material science.

SCC 06: Electromagnetics for VLSI

Course Outline
Unit 1: Fundamentals of Electromagnetics
Maxwell's Equations and Boundary Conditions
Electrostatics and Magnetostatics in Conductors and Dielectrics
Energy and Power in Electromagnetic Fields
Time-Varying Fields and Wave Propagation Basics
Unit 2: Transmission Lines and Waveguides in VLSI
Distributed Circuit Models for Interconnects
Transmission Line Equations and Solutions
Signal Integrity Issues in High-Speed VLSI Circuits
Impedance Matching and Reflection Coefficients
Waveguides in Semiconductor Devices
Unit 3: Interconnects and Parasitics
RC, RL, and RLC Models for Interconnects
Parasitic Capacitance, Inductance, and Resistance in IC Layouts
Crosstalk and Ground Bounce in Multilayer Interconnects
Modeling of Interconnect Delays (Elmore Delay Model)
Unit 4: Electromagnetic Compatibility (EMC) in VLSI
Basics of EMC in Integrated Circuits
Grounding and Shielding in ICs
Electromagnetic Interference (EMI) and Mitigation Techniques
Power Distribution Networks (PDNs) and Decoupling Capacitors
Unit 5: Electromagnetic Simulation and Tools
Finite Element Method (FEM) and Finite Difference Time Domain (FDTD) Methods
Tools for Electromagnetic Analysis in VLSI (e.g., Ansys HFSS, CST, COMSOL)
Case Studies of Electromagnetic Simulations in ICs
Unit 6: Applications in VLSI Design
On-Chip Antennas and RF Circuits
Signal Integrity in Clock Distribution Networks
Electromagnetic Considerations in Mixed-Signal IC Design
Thermal Effects and Electromagnetic Coupling

Reference Books:
"Engineering Electromagnetics" by William H. Hayt and John A. Buck, 9^{th} Edition, MGH Publisher
"The Finite Element Method in Electromagnetics" by Jian-Ming Jin, John Wiley and Sons

SCC 0906: Laboratory Course on Electromagnetics for VLSI

- Tools for Electromagnetic Analysis in VLSI (e.g., Ansys HFSS, CST, COMSOL)
- Simulate electric and magnetic field distribution using tools like COMSOL or ANSYS HFSS
- Measure EMI levels in a circuit using spectrum analyzers.
- Simulate ground bounce effects and propose mitigation strategies
- Use of EDA tools to extract interconnect parameters.
- Evaluate delay and loss in on-chip and off-chip interconnects.
- Cross Talk measurement

PCC02: Photonics and Optoelectronics Devices (Cornell University)

This is a comprehensive graduate level course on semiconductor optoelectronics.

Topics covered include,
fundamentals of optical interband transitions in semiconductors, spontaneous and stimulated emission of photons in semiconductors, non-radiative transitions
semiconductor materials for optoelectronics, optical absorption and gain, photodetectors, solar cells, fundamentals limits for solar cells, integrated optical waveguides and cavities.
semiconductor optical amplifiers, Understand the interaction of light with semiconductor materials.
In-depth Knowledge of Lasers and LED Technologies: Gain a deep understanding of the principles behind lasers and LED technologies, Analyze and design optoelectronic systems based on lasers and LEDs
Applications and Design of OLEDs: Explore the principles and applications of Organic Light light-emitting diodes (OLEDs) and design and implement systems utilising OLED technology.
LCD Technology and Display Systems: Understand the fundamentals of Liquid Crystal Displays (LCDs). Analyse and design LCD-based display systems.
Integration of Optoelectronic Technologies: Develop skills in integrating various optoelectronic technologies for specific applications. Design and implement projects that combine lasers, LEDs, OLEDs, and LCDs.

PCC O3: MICROFABRICATION AND SEMICONDUCTOR MATERIALS

The goal of this course is to give advanced undergraduates and beginning graduate students a thorough understanding of the design and process technology of modern integrated circuits. Included are several key aspects including direct hands-on exposure to all aspects of processing technology, experience in the design of semiconductor device processes, and a clear understanding of the economic and technical trade-offs inherent in this industry.

1. Microfabrication:
2. Introduction
3. Process integration
4. Silicon wafer
5. Oxidation
6. Photolithography
7. Etching processes
8. Junction diffusion
9. Diffusion technology
10. Chemical vapor deposition
11. Ion beam processing
12. Backend processes
13. Microfabrication for MEMS and sensors
14. Microfabrication for advanced technologies
15. Final project presentations

Recommended Books

1. Sze, S. M. (1981). VLSI technology (2nd ed.). New York, NY: McGraw-Hill.
2. Madou, M. J. (2002). Fundamentals of microfabrication (2nd ed.). Boca Raton, FL: CRC Press.

Jaeger, R. C. (2002). Introduction to microelectronic fabrication (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Sze, S. M., & Kwok, K. N. (2006). Physics of semiconductor devices (3rd ed.). Hoboken, NJ: Wiley

5^{th} Semester Syllabus

PCC 05: SOC: Design and Verification

Teaching Plan:

Weeks 1-2: Introduction to SoC Chip Design Flow
● Overview of the complete SoC chip design flow.
● Introduction to EDA tools: Synopsys, Cadence, Siemens, and open-source alternatives.

Weeks 3-4: Verilog-Based RTL Design
● In-depth study of Verilog syntax and constructs.
● Hands-on lab work on Verilog-based digital system design.

Weeks 5-6: Integration of Digital and Analog IPs in SoC Design
● Understanding digital and analog IPs.
● Techniques for integrating diverse IPs into a single SoC.

Weeks 7-8: RTL Verification using Simulation Methods
● Simulation-based verification techniques.
● Practical exercises using EDA tools.

Weeks 9-10: RTL Verification using Formal Methods
● Introduction to formal verification.
● Application of formal methods in RTL verification.

Weeks 11-12: Scripting Languages for Chip Design Automation*
● Introduction to scripting languages (TCL and Perl).
● Development of automation scripts for design tasks.

Weeks 13-14: Rapid Prototyping with FPGAs and Emulation Hardware Validation*
● Rapid prototyping using FPGAs.
● Validation of designs using emulation hardware.

Week 15: Project Work and Final Presentations*
● Individual or group projects demonstrating SoC design and verification skills.
● Final project presentations and review of key concepts.

Recommended Books

1. Cem Unsalan, Bora Tar. Digital System Design with FPGA: Implementation using Verilog and VHDL. McGrawHill, First Edition.
2. Nekoogar, Farzad. From ASICs to SOCs. Prentice Hall Professional, 2003.
3. Wolf, Wayne. Modern VLSI Design. Pearson Education, 2002.
4. Chakravarthi, Veena. A Practical Approach to VLSI System on Chip (SoC) Design. Springer Nature, 2019.

PCC0905: Laboratory on SOC: Design and Verification

- Design and simulate an arithmetic logic unit (ALU).
- Develop and simulate a UART communication module.

- Integrate a processor core with memory and I/O, Simualte and Verify the working
- Implement and simulate an AXI-based master-slave bus system.
- Develop a UVM testbench for a simple SoC component (e.g., ALU or UART).
- Implement a subsystem on an FPGA (e.g., Xilinx Zynq or Intel FPGA).

PCC06: Compound Semiconductor Devices

Weeks 1-2: 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.

Weeks 3-4: Crystal Structures and Properties of Compound Semiconductors*
● Crystal structures and properties of compound semiconductors.
● Comparison with elemental semiconductors.
● Lab sessions: Crystallography and material characterization.

Weeks 5-6: Device Physics of Compound Semiconductors*
● Device physics principles specific to compound semiconductors.
● Electronic devices: High-speed transistors and integrated circuits.
● Lab sessions: Simulation exercises for electronic device behavior.

Weeks 7-8: Optoelectronic Devices and Applications (Revision)
● Principles and applications of optoelectronic devices using compound semiconductors.
● Lasers, photodetectors, and light-emitting diodes (LEDs).
● Lab sessions: Hands-on experiments with optoelectronic devices.

Weeks 9-10: Fabrication Techniques for Compound Semiconductors*
● Epitaxial growth techniques for compound semiconductors.
● Lithography and etching processes specific to compound semiconductors.
● Project: Designing a fabrication process for a compound semiconductor device.

Weeks 11-12: Applications in High-Frequency Devices*
● Applications of compound semiconductors in high-frequency devices.
● Microwave transistors and communication devices.
● Lab sessions: Testing and characterization of high-frequency devices.

Weeks 13-14: Emerging Technologies in Compound Semiconductors*
● Latest developments and trends in compound semiconductor technology.
● Advanced applications and emerging technologies.
● Group projects: Exploring and presenting emerging technologies.

Week 15: Project Work and Final Presentations*
● Individual or group projects showcasing compound semiconductor applications.
● Final project presentations and demonstrations.
● Course review, feedback, and discussion of future developments in compound

semiconductor technology.

Recommended Books

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.

PCC0906: Laboratory course Compound Semiconductor Devices

- Design and Simulate any high-frequency optoelectronic device using SYNOPSYS and analyse the device characteristics.

- Design and Simulate any LED, Solar Cell device using SYNOPSYS and analyse the device characteristics.
- Hardware Testing (If possible)

PCC 07: CMOS Digital Integrated Circuits

Weeks 1-2: Introduction to CMOS Technology and Devices
● Overview of CMOS technology.
● Characteristics and behavior of CMOS devices; SPICE Models

Weeks 3-5: Analog CMOS Circuit Design - Part 1
● Design principles of CMOS Amplifiers (Common Source, Current Amplifier, Differential Amplifiers) Frequency domain analysis
● Lab work on analog CMOS circuit simulations.

Weeks :6-7 Analog CMOS Circuit Design - Part 2
● Design principles of voltage references in CMOS.
● Impact of process variations on analog circuit performance.

Weeks 8-10: Digital CMOS Logic Design - Part 1
● Principles of digital CMOS logic gates.
● Design and analysis of basic CMOS digital circuits (Combinational and Sequential)

Weeks 11-12: Digital CMOS Logic Design - Part 2
● Analysis of Power, Delay, Power Delay product and Optimization
● Timing Analysis, Cross talk and Overshoot

Weeks 13-14: Practical Applications and Project Work
● Application of CMOS design principles in real-world scenarios.

● Progress presentations on individual or group projects.

Week 15: Project Completion and Review
● Final project presentations.
● Review of key concepts in CMOS integrated circuit design.

Assessment Method:
Homework assignments, Term project, and Exams.

Required Text(s):
Digital Integrated Circuits: A Design Perspective , 2nd Edition , J.M. Rabaey, A. Chandrakasan, B. Nikolic , Prentice Hall , 2003 , ISBN No. 0-13-090996-3
Analog Integrated Circuit by B. Razavi

Recommended Text(s):
Circuits, Interconnects, and Packaging for VLSI , H. Bakoglu , Addison Wesley , ISBN No. 0-201-06088-6
Principles of CMOS VLSI Design: A Systems Perspective , 2nd Edition , N.H.E. Weste and K. Eshraghian , Prentice Hall , 1993 , ISBN No. 0-201-53376-6

PCC 0907: Laboratory Course on CMOS Digital Integrated Circuits using CADENCE

- Design and simulate CMOS NAND and NOR gates. Measure propagation delay, power consumption, and noise margins.
- Design a 4-bit binary adder using CMOS logic. Simulate and analyze the circuit for power and timing performance.
- Design and simulate a D flip-flop and a shift register. Verify timing constraints and power consumption.
- Design and simulate a 6T SRAM cell. Measure read/write operation delays and noise margins.
- Design and Simulate Common Source Amplifiers and Analyze the frequency domain
- Design and Simulate Differential Amplifiers and Analyze the frequency domain
- Design the layout for a CMOS inverter and NAND gate

PCC 08: Electronic System Design

Syllabus Module 1: Proficiency in VHDL/Verilog
● Overview of VHDL and Verilog languages.
● Writing and understanding VHDL and Verilog code.
● Practical Exercises: Implementing basic digital components.

Module 2: Digital System Design Principles
● Fundamental Principles of Digital System Design.

● Combinational Circuit Design using VHDL/Verilog.
● Sequential Circuit Design using VHDL/Verilog.
● Hands-On Projects: Analyzing and Designing Digital Systems.

Module 3: FPGA Implementation
● Introduction to Field-Programmable Gate Arrays (FPGAs).
● FPGA Architecture and Capabilities.
● Implementing Digital Systems on FPGAs using VHDL/Verilog.
● Lab Sessions: Programming FPGAs with VHDL/Verilog.

Module 4: Advanced FPGA Features
● Exploration of Advanced FPGA Features.
● Embedded Processors in FPGAs.
● FPGA Memory Architecture and Utilization.
● Designing Complex Systems with Advanced FPGA Features.

Module 5: System-Level Design and Integration
● Principles of System-Level Design.
● Integrating Digital Components into Larger Systems.
● Project-Based Learning: Developing Complete Systems using VHDL/Verilog and FPGAs.
● Final Project: System-Level Design and Integration Showcase

PCC 0908: Laboratory Course on Electronic System Design

- Design and simulate a 4-bit binary adder.
- Design and simulate a priority encoder.
- Design and simulate a D flip-flop and a 4-bit counter.
- Design and simulate an one bit ALU
- Introduction to FPGA
- Map and implement a 4-bit adder and smaller sub circuit on an FPGA.
- Map and implement a 4-bit ALU on an FPGA.

PCC 09: MEMS and NEMS

Introduction and Historical Background, Scaling Effects. Micro/Nano Sensors, Actuators and Systems overview: Case studies. Review of Basic MEMS fabrication modules: Oxidation, Deposition Techniques, Lithography (LIGA), and Etching. Micromachining: Surface Micromachining, sacrificial layer processes, Stiction; Bulk Micromachining, Isotropic Etching and Anisotropic Etching, Wafer Bonding. Mechanics of solids in MEMS/NEMS: Stresses, Strain, Hookes's law, Poisson effect, Linear Thermal Expansion, Bending; Energy methods, Overview of Finite Element Method, Modeling of Coupled Electromechanical Systems.

PCC 10: Memory Devices

Weeks 1-2: Introduction to Emerging Memory Technologies* ● Overview of traditional and emerging memory devices. ● Historical context and evolution of memory technologies. ● Introduction to Resistive RAM, Phase Change Memory, and Magnetic RAM.

Weeks 3-4: Resistive Random-Access Memory (RRAM)* ● Principles and mechanisms of operation in RRAM. ● Applications and advantages of RRAM in data storage. ● Lab sessions: Hands-on experiments with RRAM devices.

Weeks 5-6: Phase Change Memory (PCM)* ● Detailed study of the principles behind PCM. ● Use cases and integration challenges of PCM in computing systems. ● Lab sessions: Experimental analysis of PCM behavior.

Weeks 7-8: Magnetic RAM (MRAM)* ● Mechanisms and characteristics of MRAM. ● Applications in non-volatile memory and real-time systems. ● Lab sessions: Hands-on experience with MRAM devices.

Weeks 9-10: Other Emerging Memory Technologies* ● Overview of additional emerging memory devices (e.g., Ferroelectric RAM, Memristors). ● Comparative analysis of various emerging memory technologies. ● Project: Evaluating the suitability of different emerging memories for specific applications.

Weeks 11-12: Integration Challenges and Compatibility* ● Challenges in integrating emerging memory devices into existing systems. ● Compatibility issues and strategies for addressing them. ● Group projects: Designing solutions for seamless integration.

Weeks 13-14: Experimental Analysis and Performance Evaluation* ● Advanced lab sessions: Experimental analysis of emerging memory devices. ● Performance evaluation and reliability testing. ● Group projects: Analyzing experimental data and drawing conclusions.

Week 15: Project Work and Final Presentations* ● Individual or group projects showcasing applications or improvements with emerging memory devices. ● Final project presentations and demonstrations. ● Course review, feedback, and discussion of future developments in emerging memory technologies.

Recommended Textbooks

1. Ielmini, Daniele. Resistive Switching. 2016.
2. Ye Zhou. Advanced Memory Technologies Functional Materials and Devices. Royal Society of Chemistry, 2023.
3. Redaelli, Andrea. Phase Change Memory. Springer, 2018.
4. Yu, Shimeng. Resistive Random Access Memory (RRAM). Springer Nature, 2022.
5. Tang, Denny. Magnetic Memory Technology. John Wiley & Sons, 2021.

6th Semester Syllabus

PCC 11: Mixed Mode VLSI Circuits

Analog and discrete-time signal processing, introduction to sampling theory; Analog continuous time filters: passive and active filters; Basics of analog discrete-time filters and Z-transform. Switched-capacitor filters- Nonidealities in switched-capacitor filters; Switched-capacitor filter architectures; Switched-capacitor filter applications. Basics of data converters; Successive approximation ADCs, Dual slope ADCs, Flash ADCs, Pipeline ADCs, Hybrid ADC structures, High-resolution ADCs, DACs. Mixed-signal layout, Interconnects and data transmission; Voltage-mode signaling and data transmission; Current-mode signaling and data transmission. Introduction to frequency synthesizers and synchronization; Basics of PLL, Analog PLLs; Digital PLLs; DLLs.

PCC0911: Mixed Mode VLSI Circuit Lab:

- Mixed-signal co-simulation using SPICE and HDL
- CMOS Inverter, Circuit design to Layout generation and parasitic extraction
- Design of a two-stage CMOS operational amplifier, Frequency response analysis
- Design and simulation of a 4-bit flash ADC, Accuracy and linearity
- Design of a simple PLL: Phase detector, VCO, and loop filter

PCC 12: IC Packaging

Teaching Plan:

Weeks 1-2: 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.

Weeks 3-4: Packaging Materials and Interconnection Techniques*
● Study of materials used in semiconductor packaging.
● Interconnection techniques: wire bonding, flip-chip, and solder bump technologies.
● Lab sessions: Hands-on experience with interconnection techniques.

Weeks 5-6: Thermal Management in IC Packaging*
● Principles of thermal management in IC packaging.
● Techniques for heat dissipation and cooling.
● Case studies: Analyzing thermal management strategies.

Weeks 7-8: Signal and Power Integrity Considerations*
● Signal integrity challenges in IC packaging.

● Power integrity considerations and solutions.
● Lab sessions: Simulation exercises for signal and power integrity.

Weeks 9-10: 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.
● Project: Designing a packaging solution considering trade-offs.

Weeks 11-12: Reliability in IC Packaging*
● Factors affecting reliability in IC packaging.
● Testing and validation techniques for packaged ICs.
● Lab sessions: Reliability testing exercises.

Weeks 13-14: Advanced Topics in IC Packaging*
● Emerging trends in IC packaging technologies.
● Advanced materials and techniques.
● Group projects: Exploring advanced IC packaging concepts.

Week 15: Project Work and Final Presentations*
● Individual or group projects showcasing IC packaging designs.
● Final project presentations and demonstrations.
● Course review, feedback, and discussion of future developments in IC packaging.

Recommended Books
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.

PCC 13: Semiconductor Materials Synthesis and Characterization

Course Outline
Unit 1: Introduction to Semiconductor Materials
- Overview of Semiconductors: Intrinsic and Extrinsic
- Crystal Structures and Band Theory of Semiconductors
- Common Semiconductor Materials: Si, GaAs, InP, III-V and II-VI Compounds
- Emerging Semiconductor Materials: Perovskites and 2D Materials

Unit 2: Semiconductor Synthesis Techniques
- Bulk Crystal Growth
- Czochralski Method
- Bridgman Technique
- Thin Film Deposition
- Chemical Vapor Deposition (CVD)
- Molecular Beam Epitaxy (MBE)
- Atomic Layer Deposition (ALD)
- Physical Vapor Deposition (PVD)
- Doping Methods: Diffusion and Ion Implantation

- Epitaxial Growth Techniques

Unit 3: Material Defects and Their Impact
- Types of Defects: Point Defects, Dislocations, Grain Boundaries
- Impact of Defects on Electrical and Optical Properties
- Strategies for Defect Mitigation

Unit 4: Characterization Techniques
- Structural Characterization
- X-Ray Diffraction (XRD)
- Scanning Electron Microscopy (SEM)
- Transmission Electron Microscopy (TEM)
- Optical Characterization
- Photoluminescence (PL)
- UV-Vis Spectroscopy
- Raman Spectroscopy
- Electrical Characterization
- Hall Effect Measurement
- Four-Point Probe for Resistivity
- Capacitance-Voltage Profiling
- Surface and Interface Analysis
- Atomic Force Microscopy (AFM)
- X-Ray Photoelectron Spectroscopy (XPS)

Unit 5: Applications and Future Trends
- Semiconductors in Electronics: CMOS, LEDs, and Lasers
- Photovoltaics and Energy Applications
- Semiconductor Applications in Quantum Computing
- Emerging Research Areas: Spintronics, Organic Semiconductors

Textbooks
"Semiconductor Material and Device Characterization" by Dieter K. Schroder
"Principles of Electronic Materials and Devices" by S.O. Kasap
"Physics of Semiconductor Devices" by Simon M. Sze and Kwok K. Ng

PCC 14: Semiconductor Manufacturing: Materials and Processes

Weeks 1-2: Introduction to Semiconductor Packaging Materials
● Overview of semiconductor packaging and the role of materials
● Historical development and key advancements in packaging materials

Weeks 3-4: Substrate Materials
● Properties and selection criteria for substrate materials (e.g., FR-4, ceramics)
● Fabrication processes for substrates, including PCB technologies

Weeks 5-7: Die Attach Materials
● Characteristics of die attach materials (e.g., adhesives, solders)
● Die attach fabrication processes and considerations for different device Types

Weeks 8-9: Encapsulant Materials
● Properties and selection criteria for encapsulant materials (e.g., epoxy, molding compounds)
● Molding and encapsulation processes in semiconductor packaging

Weeks 10-11: Interconnect Technologies
● Overview of wire bonding and flip-chip interconnects
● Material considerations for bonding wires and solder bumps
● Advanced interconnect technologies, including copper pillars and TSVs

Weeks 12-13: Thermal Management in Semiconductor Packaging
● Importance of thermal management in semiconductor packages
● Thermal interface materials (TIMs) and heat spreaders
● Design considerations for effective heat dissipation

Weeks 14-15: Project and Review
● Final project: Design a semiconductor package considering material selection and fabrication processes
● Review of key concepts and applications
● Discussion of current trends and emerging materials in semiconductor Packaging

Reference Books
1. Chen, Andrea. Semiconductor Packaging. CRC Press, 2016.
2. Chung, Deborah. Materials for Electronic Packaging. Elsevier, 1995.
3. Lau, John. Semiconductor Advanced Packaging. Springer Nature, 2021.
4. Lu, Daniel. Materials for Advanced Packaging. Springer, 2016

Program Elective (PE)

Program Elective-01
PE01A: TFT
PE01B: Display System Design
PE01C: OLED and LCD

Program Elective-02

PE02A: FPGA Programming
PEO2B. Logic Verification
PE02C. Design for Testability

Program Elective-03
PE03A. Low Power Circuit
PE03B. High Frequency IC
PE03C. AI Circuit

PE01A: TFT

Teaching Plan:
Weeks 1-2: Introduction to Thin Film Transistors
● Overview of Thin Film Transistors and their significance in electroni
● Historical perspective and evolution of TFT technology
Weeks 3-4: Principles of Operation
● Understanding the working principles of Thin Film Transistors
● Types of TFTs: amorphous, polysilicon, and organic TFTs
Weeks 5-7: Thin Film Deposition Techniques
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● Overview of thin film deposition methods: PVD, CVD, and atomic lay deposition (ALD)
● Material selection and considerations in thin film deposition for TF
Weeks 8-9: TFT Fabrication Processes
● Semiconductor layer deposition and patterning
● Gate dielectric and electrode fabrication
● Source and drain electrode deposition and contact formation
Weeks 10-11: Electrical Characterization of TFTs
● Measurement techniques for electrical parameters: mobility, threshold voltage, and on/off rat
● Role of thin film properties in electrical performan
Weeks 12-13: Optical Properties and Applications
● Optical transparency and its significance in TFT applicatio
● Applications of TFTs in flat-panel displays and senso
● Emerging trends in flexible electronics using TFT technolo
Weeks 14-15: Project and Review
● Final project: Design and simulate a Thin Film Transistor-based electronic device
● Review of key concepts and applications
● Discussion of current challenges and advancements in Thin Film Transistor technology

Recommended Books
1. Kagan, Cherie. Thin-Film Transistors. CRC Press, 2003.

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

PE01B: Display System Design

Teaching Plan:
Weeks 1-2: Introduction to Display Systems Design
● Overview of display technologies and their applications
● Importance of user-centric design in display systems
Weeks 3-4: Display Technologies Deep Dive
● In-depth study of LCDs, OLEDs, and emerging display technologies
● Comparative analysis of characteristics and applications
Weeks 5-7: User Requirements and System Specificatio
● User-centered design principles
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● Translating user requirements into detailed specificatio
● Case studies

Weeks 8-9: Designing for Visual Quality
● Principles of visual quality in display systems
● Design considerations for contrast ratio, color accuracy, and viewing angles
● Application of design principles in practical scenarios

Weeks 10-11: Emerging Technologies Integration
● Overview of augmented reality (AR) and virtual reality (VR) technologies
● Integrating AR/VR into display system design
● Challenges and opportunities in adopting emerging technologies

Weeks 12-13: Prototyping Display Systems
● Prototyping methods for display systems
● Hands-on exercises in building display prototypes
● Evaluation criteria for prototype assessment

Weeks 14-15: Project and Review
● Final project: Design and prototype an innovative display system
● User testing and evaluation of the designed system
● Review of key concepts, project outcomes, and discussion of current trends in display systems design

Reference Books

1. Miller, Michael. Color in Electronic Display Systems. Springer, 2018.
2. Bennett, Kevin. Display and Interface Design. CRC Press, 2011.
3. Committee, G. 10TDS. Touch Interactive Display Systems: Human Factors Considerations, System Design and Performance Guidelines. 2019.
4. MacDonald, Lindsay. Display Systems. John Wiley & Sons, 1997.

PE01C: OLEDs and LCDs: Display Technologies

Teaching Plan:
Weeks 1-2: Introduction to Display Technologies
● Overview of display technologies, with a focus on OLEDs and LCDs
● Historical development and evolution of OLED and LCD technologies
Weeks 3-4: Principles of OLEDs
● Working principles of OLEDs
● Types of OLEDs: small molecule vs. polymer-based
● Emissive layer materials and device structure
Weeks 5-7: OLED Fabrication and Design
● Thin film deposition techniques for OLE
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● Patterning methods and post-processing steps
● Design considerations for OLED-based display systems
Weeks 8-9: 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 filte
Weeks 10-11: LCD Fabrication and Design
● Fabrication processes for LCDs
● Backlighting techniques and advancements
● Design considerations for LCD-based display systems
Weeks 12-13: 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
Weeks 14-15: Applications and Emerging Trends
● Diverse applications of OLEDs and LCDs in electronic devices
● Exploration of emerging trends in display technologies
● Final project: Comparative analysis and design considerations for an OLED and LCD-based display system

Reference Books
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.

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

PE02A: FPGA Programming

Teaching Plan:
Weeks 1-2: Introduction to FPGAs and Digital Design*
● Overview of FPGA technology and its applications.
● Basic concepts in digital design and logic circuits.
● Introduction to FPGA programming languages (VHDL and Verilog).
Weeks 3-4: FPGA Architecture and Configuratio
● In-depth study of FPGA architecture and internal components.
● Configuration processes and the role of bitstream fi
● Lab sessions: Basic FPGA programming exercises.
Weeks 5-6: VHDL and Verilog Programming for FPGAs*
● Comprehensive introduction to VHDL and Verilog programming.
● Hands-on exercises translating simple digital designs into VHDL/Verilog.
● Lab sessions: Basic programming tasks and simulations.
Weeks 7-8: Digital Circuit Design on FPGAs*
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● Techniques for designing digital circuits on FPGAs.
● Implementation of combinational and sequential logic circuits.
● Lab sessions: Design and implementation exercises.
Weeks 9-10: IP Cores and System-Level Design*
● Integration of IP cores into FPGA designs.
● System-level design practices for developing complex systems.
● Lab sessions: Incorporating IP cores into FPGA projects.
Weeks 11-12: Real-World Applications of FPGAs*
● Case studies of FPGAs in real-world applications (e.g., signal processing, communication).
● Exploration of industry trends and emerging applications.
● Lab sessions: Hands-on projects simulating real-world applications.
Weeks 13-14: Project Development*
● Initiation and planning of individual or group projects.
● Implementation and troubleshooting of FPGA-based projects.
● Lab sessions: Project work and consultations.
Week 15: Project Presentations and Course Review*
● Final presentations of individual or group projects.
● Course review, feedback, and discussion of advanced topics.
● Future trends in FPGA technology and applications.

Recommended Books

1. Rajewski, Justin. Learning FPGAs. "O'Reilly Media, Inc.," 2017.
2. Monk, Simon. Programming FPGAs: Getting Started with Verilog. McGraw Hill Professional, 2016.
3. Pellerin, David. Practical FPGA Programming in C. Prentice Hall, 2005.
4. Bruno, Frank. FPGA Programming for Beginners. Packt Publishing Ltd, 2021

PE02B. Logic Synthesis

Teaching Plan:
Weeks 1-2: Introduction to Logic Synthesis
● Overview of logic synthesis in digital circuit design
● Basic concepts of Boolean algebra
● Introduction to hardware description languages (HDLs)
Weeks 3-4: Combinational Logic Synthesis
● Combinational logic design using HDLs
● Two-level and multi-level logic optimization techniques
● Introduction to logic synthesis tools
Weeks 5-7: Sequential Logic Synthesis
● Design and synthesis of sequential logic circuits
● Finite state machine (FSM) design and optimization
● Timing analysis for sequential circuits
Weeks 8-9: Timing Constraints and Optimization
● Introduction to timing constraints in digital circuits
● Timing analysis and optimization techniques

● Area and power optimization strategies
Weeks 10-11: Technology Mapping and Retiming
● Advanced synthesis techniques: technology mapping
● Retiming to optimize sequential circuits
● Case studies and practical applications
Weeks 12-13: Logic Restructuring and Advanced Optimization
● Logic restructuring techniques for performance improvement
● Advanced optimization algorithms in logic synthesis
● Practical implementation and case studies
Weeks 14-15: Project and Review
● Final project: Design and optimize a digital circuit
● Review of key concepts and applications
● Q&A and discussion of emerging trends in logic synthesis

Recommended Books
1. Hachtel, Gary. Logic Synthesis and Verification Algorithms. Springer Science Business Media, 2007.
2. Barkalov, Alexander. Logic Synthesis for FSM-Based Control Units. Springer Science & Business Media, 2009.
3. Kurup, Pran. Logic Synthesis Using Synopsys®. Springer Science & Business

Media, 2013.
4. Hassoun, Soha. Logic Synthesis and Verification. Springer Science & Busine
Media, 2012.
5. Reis, André. Advanced Logic Synthesis. Springer, 2017.

PE02C: Design for Testability

Weeks 1-2: Introduction to Design for Testability*
● Overview of the importance of design for testability in modern electronic systems.
● Historical context and evolution of testability strategies.
● Introduction to key concepts: fault models, testing methodologies, and industry standards.

Weeks 3-4: Built-in Self-Test (BIST) Techniques*
● Principles and implementation of built-in self-test techniques.
● Advantages and limitations of BIST in electronic circuit testing.
● Lab sessions: Simulations and exercises focusing on BIST.

Weeks 5-6: Scan Chains and Serial Testing*
● Concept of scan chains and their role in serial testing.
● Implementation and optimization of scan chains for improved testability.
● Lab sessions: Hands-on exercises with scan chain design and testing.

Weeks 7-8: Fault Modeling and Simulation*
● Development of fault models for electronic circuits.
● Utilization of simulation tools to predict and analyze potential faults in a
design.
● Lab sessions: Fault simulation exercises.

Weeks 9-10: Design for Testability Strategies*
● Exploration of various design for testability strategies.
● Case studies: Analyzing successful implementations of design for testability.
● Lab sessions: Designing circuits with testability considerations.

Weeks 11-12: Industry Standards in Testability*
● Overview of industry standards related to testability.
● Compliance and certification requirements for testable design
● Lab sessions: Assessing designs against industry standards.

Weeks 13-14: Advanced Topics and Emerging Trends in Design for Testability*

● Emerging trends in design for testability.
● Advanced components and techniques for enhancing testability.
● Group projects: Exploring and presenting emerging trends in design for testability.

Week 15: Project Work and Final Presentations*
● Individual or group projects showcasing designs with enhanced testability.
● Final project presentations and demonstrations.
● Course review, feedback, and discussion of future developments in design for testability.

Recommended Books

1. Tripathi, Suman. Advanced VLSI Design and Testability Issues. CRC Press, 2020.
2. Wang, Laung-Terng. VLSI Test Principles and Architectures. Morgan Kaufmann, 2006.
3. Huhn, Sebastian. Design for Testability, Debug and Reliability. Springer Nature, 2021

7TH

Semester

Syllabus

Open Elective-01 (Online)

A. AI/ML for CAD VLSI

B. Device Modelling and Simulation

C. Device and Materials Reliability

Open Elective-02

A. Semiconductor Industry Practice & standards

B. Semiconductor business and marketing

C. Entrepreneurship in Semiconductors

Open Elective-02

A. IC Packaging Techniques

B. materials for Semiconductor Packaging

C. Package Design and Simulation Tool

OE01A: AI/ML for CAD VLSI

Weeks 1-2: Introduction to AI and ML in VLSI CAD

● Overview of AI and ML applications in VLSI CAD

● Basics of supervised and unsupervised learning

● Introduction to neural networks and decision trees

Weeks 3-4: Pattern Recognition in VLSI CAD

● Application of AI for pattern recognition in IC design

● Feature extraction and classification techniqu

● Case studies on pattern recognition in layout design

Weeks 5-7: Optimization Techniques with ML
● Optimization algorithms in VLSI design
● Genetic algorithms, simulated annealing, and particle swarm optimization
● Application of ML for automatic optimization in CAD tools

Weeks 8-9: Design Rule Checking with ML
● Enhancing design rule checking using Machine Learning
● Classification and regression models for D
● Case studies on DRC optimization with ML

Weeks 10-11: Automated Layout Generation
● AI/ML techniques for automated layout generation
● Considerations for area, power, and signal integrity in layout design
● Case studies on automated layout generation.

Weeks 12-13: Performance Prediction with ML Models
● Developing ML models for performance prediction
● Power, speed, and reliability prediction using Machine Learning
● Validation and accuracy assessment of ML models

Weeks 14-15: Project and Review
● Final project: Implement AI/ML techniques in a VLSI CAD tool
● Review of key concepts and applications
● Discussion of current trends in AI and ML for VLSI CAD

Recommended books
1. Joobbani, R. An Artificial Intelligence Approach to VLSI Routing. Springer Science Business Media, 2012.
2. Sait, Sadiq. VLSI Physical Design Automation. World Scientific, 199
3. Kumar, Abhishek. Machine Learning Techniques for VLSI Chip Design. John Wiley & Sons, 2023.
4. Elfadel, Ibrahim. Machine Learning in VLSI Computer-Aided Design. Springer, 2019.
5. Lu, Bing. Layout Optimization in VLSI Design. Springer Science & Business Media, 2001.
6. Kahng, Andrew. VLSI Physical Design: From Graph Partitioning to Timing Closure. Springer Nature, 2022.
Ren, Haoxing. Machine Learning Applications in Electronic Design Automation. Springer Nature, 2023.

OE01B: Device Modelling and Simulation

Teaching Plan:
Weeks 1-2: Advanced Semiconductor Physics

● Carrier statistics in semiconductors
● Quantum effects and their impact on device behaviouror
● Advanced topics in semiconductor physics

Weeks 3-4: Diode Modeling Beyond Ideal Behavior
● Reverse-bias breakdown and avalanche effects
● High-frequency diode behavior
● Modeling temperature-dependent characteristics

Weeks 5-7: 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
Weeks 8-9: Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET Modeling
● Advanced MOSFET models for nanoscale technologies
● Quantum effects in MOSFE
● Compact modeling for variability analysis

Weeks 10-11: Advanced Transistor Structures
● FinFET and nanowire transistor modeling
● Tunnel FETs and other emerging transistor technologies
● Trade-offs and advantages of advanced transistor structure

Weeks 12-13: Simulation Challenges and Solutions
● Simulation challenges in advanced semiconductor devices
● Monte Carlo simulations for statistical variability
● Case studies and practical solutions

Weeks 14-15: Project and Review
● Final project: Model and simulate an advanced semiconductor device
● Review of key concepts and applications
● Discussion of current trends in semiconductor device modelling

Recommended Books
1. Wu, Yung-Chun. 3D TCAD Simulation for CMOS Nanoelectronic 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.

OE01C: Device and Materials Reliability

Syllabus Outline
Module 1: Introduction to Device and Materials Reliability
Overview of reliability in VLSI systems
Importance of reliability in nanoscale devices
Reliability metrics: MTTF, FIT rates, and failure distributions
Module 2: Failure Mechanisms in Semiconductor Devices
Intrinsic Mechanisms:
Bias Temperature Instability (BTI)
Hot Carrier Injection (HCI)
Time-Dependent Dielectric Breakdown (TDDB)
Negative Bias Temperature Instability (NBTI)
Extrinsic Mechanisms:
Electrostatic Discharge (ESD)
Electromigration (EM)
Thermal runaway
Module 3: Materials Reliability in VLSI
Interconnect materials: Cu, Al, and emerging materials
Dielectrics: Low-k and high-k materials
Packaging materials and thermal interfaces
Reliability of new materials in FinFETs, 3D ICs, and beyond-CMOS technologies
Module 4: Testing and Characterization for Reliability
Reliability testing techniques: accelerated stress tests, HTOL, and HAST
Characterization tools: SEM, TEM, XPS, and AFM
Modeling and simulation of reliability
Module 5: Emerging Trends in Device and Materials Reliability
Challenges with scaling in advanced nodes (7nm, 5nm, and beyond)
Reliability concerns in flexible and organic electronics
AI-driven reliability prediction models
Module 6: Case Studies and Industry Perspectives
Analysis of real-world failure cases in VLSI systems
Reliability considerations in IoT, automotive, and wearable devices
Industry standards and guidelines (JEDEC, IEEE, etc.)

OE02A: A. Semiconductor Industry Practice & standards

Syllabus Outline
Module 1: Overview of the Semiconductor Industry
History and evolution of the semiconductor industry
Value chain: design, manufacturing, packaging, and testing
Major players and industry segments (IDMs, Foundries, Fabless, OSATs)
Industry challenges and trends
Module 2: Standards in the Semiconductor Industry
Role of standards organizations (JEDEC, ISO, SEMI, IEEE)

Standard frameworks for:
Device design and modeling (e.g., SPICE, IBIS)
Manufacturing processes (e.g., SEMI standards for cleanrooms and wafers)
Quality and reliability (e.g., JEDEC standards for IC reliability testing)

Module 3: Semiconductor Design Practices

Design flows: RTL to GDSII
Standard practices for IP development and integration
Design for manufacturability (DFM)
EDA tools and industry-standard workflows

Module 4: Semiconductor Manufacturing Standards

Wafer fabrication process standards
Lithography and patterning standards
Advanced packaging standards (2.5D, 3D-IC)
Environmental standards in semiconductor manufacturing (Green practices and ISO 14001)

Module 5: Testing and Quality Assurance Standards

Semiconductor testing workflows: wafer, die, and final product testing
JEDEC standards for thermal, electrical, and mechanical stress testing
Failure analysis and reliability characterization standards

Module 6: Supply Chain and Sustainability Practices

Standards for global supply chain management (ISO 9001, RoHS, REACH)
Traceability in semiconductor supply chains
Impact of sustainability practices on the semiconductor industry

Module 7: Emerging Trends in Semiconductor Standards

Standards for AI/ML-driven semiconductor workflows
Advanced nodes and their challenges (e.g., 3nm and beyond)
Standards for heterogeneous integration and chiplets
Security standards for hardware design (e.g., TCG, IEEE P2851)

Reference Books:

- *Semiconductor Manufacturing Handbook* by Hwaiyu Geng.
- *Quality and Reliability in Semiconductor Devices* by M. Yilmaz and R. Subramanian.

OE02B: Semiconductor business and marketing:

Syllabus Outline

Module 1: Introduction to the Semiconductor Business

Overview of the semiconductor industry
Business models: IDMs, Foundries, Fabless, OSATs
Value chain and stakeholders: EDA providers, equipment manufacturers, and end-users
Key players and market segmentation (logic, memory, analog, RF, etc.)

Module 2: Market Trends and Competitive Landscape

Industry growth drivers and challenges
Emerging markets: IoT, automotive, AI/ML, and 5G

Competitive analysis: SWOT and Porter's Five Forces
The role of M&A and partnerships in shaping the semiconductor market

Module 3: Semiconductor Product Lifecycle and Marketing
Product lifecycle management (PLM) in the semiconductor industry
Market research techniques for identifying customer needs
Positioning semiconductor products (e.g., chips, IPs, EDA tools)
Marketing strategies: B2B vs. B2C in semiconductors

Module 4: Business Strategies in Semiconductor Industry
Pricing models: NRE costs, licensing, royalties, and volume discounts
Supply chain management and logistics in semiconductors
Geopolitical influences on semiconductor trade
Intellectual property (IP) and patent strategies

Module 5: Sales and Distribution Channels
Distribution networks: direct sales, distributors, and online platforms
Building strategic partnerships with OEMs and ODMs
Sales funnel management for semiconductor products
Key performance indicators (KPIs) in semiconductor sales

Module 6: Business Ethics, Sustainability, and Corporate Responsibility
Ethical practices in the semiconductor business
Environmental regulations and green marketing in semiconductors
Corporate social responsibility (CSR) in the semiconductor industry

Module 7: Case Studies and Practical Applications
Real-world business challenges in semiconductor marketing
Case studies on successful marketing campaigns in the semiconductor industry
Developing a go-to-market strategy for a new semiconductor product

OE02C: Entrepreneurship in Semiconductors

Syllabus Outline

Module 1: Introduction to Entrepreneurship
Definition and importance of entrepreneurship
Characteristics of successful entrepreneurs
Entrepreneurial mindset and its relevance to semiconductors
Overview of the global semiconductor ecosystem

Module 2: Identifying Opportunities in the Semiconductor Industry
Market research and opportunity identification
Emerging trends: IoT, AI, automotive, 5G, and quantum computing
Problem-solving and innovation in semiconductor startups

Value proposition and competitive advantage

Module 3: Business Models in Semiconductors
Types of business models: Foundries, fabless companies, IP providers
Revenue streams: Licensing, royalties, and product sales
Building a minimum viable product (MVP)
Case studies of successful semiconductor startups
Module 4: Technology to Market Transition
Translating technical innovation into commercial products
Design for manufacturability and scalability
Prototyping and testing in semiconductor startups
Managing the transition from research to production

Module 5: Funding and Financial Planning
Types of funding: Bootstrapping, venture capital, angel investors
Financial planning and budgeting for startups
Preparing a pitch deck for investors
Cost structures and revenue models in the semiconductor business

Module 6: Intellectual Property and Legal Considerations
Importance of intellectual property in semiconductors
Patents, trademarks, and trade secrets
Licensing agreements and technology transfer
Regulatory and compliance requirements

Module 7: Scaling and Sustaining a Semiconductor Business
Challenges in scaling a semiconductor startup
Building effective teams and leadership in technical ventures
Partnerships and collaborations in the semiconductor ecosystem
Sustaining innovation and competitiveness

Module 8: Entrepreneurship Case Studies and Future Trends
Analysis of semiconductor startups like ARM, Nvidia, and TSMC
Lessons learned from failures in the industry
Opportunities in emerging markets and regions
Future outlook for semiconductor entrepreneurship

OE03A: IC Packaging Techniques

Teaching Plan:

Weeks 1-2: Introduction to IC Packaging Technologies*
● Overview of IC packaging and its significanc
● Historical context and evolution of packaging technologies.
● Introduction to packaging types: through-hole, surface-mount, ball grid array.

Weeks 3-4: Packaging Materials and Interconnection Techniques*
● Study of materials used in semiconductor packaging.
● Interconnection techniques: wire bonding, flip-chip, and solder bu technologies.
● Lab sessions: Hands-on experience with interconnection techniques.

Weeks 5-6: Thermal Management in IC Packaging*
● Principles of thermal management in IC packaging.
● Techniques for heat dissipation and cooling.
● Case studies: Analyzing thermal management strategies.

Weeks 7-8: Signal and Power Integrity Considerations*
● Signal integrity challenges in IC packaging.
● Power integrity considerations and solutions.
● Lab sessions: Simulation exercises for signal and power integrity.

Weeks 9-10: Packaging Types and Trade-off
● In-depth study of through-hole, surface-mount, and ball grid array packaging.
● Trade-offs involved in selecting packaging type
● Project: Designing a packaging solution considering trade-off

Weeks 11-12: Reliability in IC Packaging*
● Factors affecting reliability in IC packagin
● Testing and validation techniques for packaged ICs.
● Lab sessions: Reliability testing exercises.

Weeks 13-14: Advanced Topics in IC Packaging*
● Emerging trends in IC packaging technologies.
● Advanced materials and techniques.
● Group projects: Exploring advanced IC packaging concepts.

Week 15: Project Work and Final Presentations*
● Individual or group projects showcasing IC packaging designs.
● Final project presentations and demonstrations.
● Course review, feedback, and discussion of future developments in IC packaging.

Recommended Books
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.

OE03B: Materials for Semiconductor Packaging
Teaching Plan:

Weeks 1-2: Introduction to Semiconductor Packaging Materials

● Overview of semiconductor packaging and the role of materials
● Historical development and key advancements in packaging materials

Weeks 3-4: Substrate Materials
● Properties and selection criteria for substrate materials (e.g., FR-4,ceramics)
● Fabrication processes for substrates, including PCB technologies

Weeks 5-7: Die Attach Materials
● Characteristics of die attach materials (e.g., adhesives, solders)
● Die attach fabrication processes and considerations for different device types

Weeks 8-9: Encapsulant Materials
● Properties and selection criteria for encapsulant materials (e.g., epoxy,moulding compounds)
● Molding and encapsulation processes in semiconductor packaging

Weeks 10-11: Interconnect Technologies
● Overview of wire bonding and flip-chip interconnects
● Material considerations for bonding wires and solder bumps
● Advanced interconnect technologies, including copper pillars and TSVs

Weeks 12-13: Thermal Management in Semiconductor Packaging
● Importance of thermal management in semiconductor packages
● Thermal interface materials (TIMs) and heat spreaders
● Design considerations for effective heat dissipation

Weeks 14-15: Project and Review
● Final project: Design a semiconductor package considering material
selection and fabrication processes
● Review of key concepts and applications
● Discussion of current trends and emerging materials in semiconductor packaging

Reference Books
1. Chen, Andrea. Semiconductor Packaging. CRC Press, 2016.
2. Chung, Deborah. Materials for Electronic Packaging. Elsevier, 1995.
3. Lau, John. Semiconductor Advanced Packaging. Springer Nature, 2021.
4. Lu, Daniel. Materials for Advanced Packaging. Springer, 2016.

OE03C: Package Design and Simulation Tool

Teaching Plan:
Weeks 1-2: Introduction to Package Design and Simulation Tools
● Overview of semiconductor package design and the role of simulation tools
● Introduction to industry-standard software tools and their applications

Weeks 3-4: Thermal Analysis Tools
● Introduction to thermal analysis in semiconductor packages
● Hands-on exercises using thermal simulation tools for heat dissipation optimization

Weeks 5-7: Signal Integrity Analysis

● Fundamentals of signal integrity in semiconductor packages
● Practical application of signal integrity analysis tools for optimal data transmission

Weeks 8-9: Power Integrity Simulation
● Principles of power integrity and its significance in package design
● Simulation exercises for power distribution network optimization

Weeks 10-11: 3D Modeling for Package Design
● Introduction to 3D modeling tools and techniques
● Creating realistic 3D models of semiconductor packages for spatial analysis

Weeks 12-13: Multi-Physics Simulations
● Integration of thermal, signal integrity, and power integrity simulations
● Hands-on exercises in multi-physics simulations for comprehensive package analysis

Weeks 14-15: Project and Review
● Final project: Design and simulate a semiconductor package using integrated tools
● Review of key concepts and applications
● Discussion of current trends and emerging technologies in package design and simulation

Reference Books

1. Greig, William. Integrated Circuit Packaging, Assembly and Interconnections. Springer Science & Business Media, 2007.
2. Li, Suny. SiP System-in-Package Design and Simulation. John Wiley & Sons, 2017.
3. Zhang, Hengyun. Modeling, Analysis, Design, and Tests for Electronics Packaging beyond Moore. Woodhead Publishing, 2019.
4. Liu, Sheng. Modeling and Simulation for Microelectronic Packaging Assembly. John Wiley & Sons, 2011.