M. Tech-ECE (VLSI Design)

First Semester

S. No.	Code	Subject	L-T-P	Credits	Category
1.	MVD-101	CMOS Analog Circuit Design	3-0-2	4	DCC
2.	MVD-103	Semiconductor Devices for Digital Integrated Circuits	3-0-2	4	DCC
3.	MVD-105	Hardware Description Languages	3-0-2	4	DCC
4.	MVD-107	Advanced IC Processing	3-1-0	4	DCC
5	GEC-101	Generic Open Elective	2-0-0 1-1-0 0-0-4	2	GEC
6.	ROC-101	Research Methodology	3-0-0	3	ROC
		Total credits		**21**	

Second Semester

S. No.	Code	Subject	L-T-P	Credits	Category
1.	MVD-102	Device Modeling & Circuit simulation	3-0-2	4	DCC
2.	MVD-104	Digital System Design with FPGA	3-0-2	4	DCC
3.	MVD-106	Deep Submicron CMOS ICs	3-1-0	4	DCC
4.	DEC1 xx	Departmental Elective Course ï 1	3-0-2 3-1-0	4	DEC
5.	DEC1 xx	Departmental Elective Course - 2	3-0-2 3-1-0	4	DEC
6	ROC-102	Research Ethics	3-0-0	3	ROC
		Total credits		**23**	

Third Semester

S. No.	Code	Subject	L-T-P	Credits	Category
1.	MVD-201	ASIC and SoC Design	3-0-2	4	DCC
2.	DEC-2xx	Departmental Elective-3	3-0-2 3-1-0	4	DEC
3.	DEC-2xx	Departmental Elective-4	3-0-2 3-1-0	4	DEC
4	GEC-201	General Open Elective	2-0-0 1-1-0 0-0-4	2	GEC
5.	MVD-251	Dissertation-1/Project Work	-	8	DCC
6.	MVD-253	Industrial Training/Internship	-	1	DCC
		Total credits		**23**	

Fourth Semester

S. No.	Code	Subject	L-T-P	Credits	Category
1.	MVD-252	Dissertation -2/Project Work	-	20	DCC
		Total credits		**20**	

List of Departmental Elective Courses

Category	**Course Code**	**Subject**	**Credits**
Departmental Elective Course-1	MVD-108 MVD-110 MVD-112 MVD-114 MVD-116	Semiconductor Memory Design Digital VLSI design Analog filter Design Digital Techniques for High Speed Design CMOS Mixed-Signal VLSI Design	3-0-2 3-0-2 3-0-2 3-1-0 3-0-2
Departmental Elective Course-2	MVD-118 MVD-120 MVD-122 MVD-124 MVD-126	Advanced Embedded System Design Analog Integrated Circuits Digital System Design using Verilog MEMS & Microsystems Internet of Things	3-0-2 3-1-0 3-0-2 3-1-0 3-1-0
Departmental Elective Course-3	MVD-203 MVD-205 MVD-207 MVD-209 MVD-211	Low Power VLSI Design VLSI Design Verification and Test Advance Image Processing Neural Networks in Embedded Applications Nature Inspired VLSI Circuits	3-0-2 3-1-0 3-0-2 3-1-0 3-1-0
Departmental Elective Course-4	MVD-213 MVD-215 MVD-217 MVD-219 MCS-221	VLSI Interconnects VLSI design Algorithms VLSI Design Techniques for Analog IC Artificial Intelligence Data Structures	3-1-0 3-1-0 3-1-0 3-0-2 3-0-2

CMOS ANALOG CIRCUIT DESIGN	
Course Code: MVD-101 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 1

Introduction: The course offers important topics for CMOS analog integrated circuits. It covers circuit operation, circuit analysis, design techniques and methodologies, implementation approaches and key building blocks for integrated circuit designs.

Course Objective:

- Understand, design, and model the CMOS analog circuits.
- Implement the design, simulate and analyse the circuit/results.
- Test the hand calculations using simple models.
- Understand the present hierarchical approach of sub-blocks, blocks, circuits, and systems.

Pre-requisite: Analog Electronics, Linear Integrated Circuits

Course Outcome: The student will be able to:

- Apply knowledge of mathematics, science, and engineering to design and analyse analog integrated circuits like current sources and voltage references for given specifications.
- Identify, formulate, and solve engineering problems in the area of analog integrated circuits.
- Analyse and design single stage MOS Amplifiers.
- Understand the techniques, skills, and modern programming tools such as Cadence, necessary for engineering practice.

Pedagogy: The class will be taught using theory and case based method. Students will be given problems based on design of CMOS integrated circuits. Technology Discussion sessions will be organized on current research challenges and various applications in microelectronics industry. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	10 Hours
Introduction to MOSFET device structure and operation, MOS as an amplifier, Biasing in MOS amplifier circuits, Small signal equivalent circuit model, Single stage MOS amplifiers, Characterizing amplifiers, MOS internal capacitance and High frequency model, Frequency response.	
UNIT-II	11 Hours
IC biasing-current sources, Current mirrors and current-steering circuits, Cascade and Wilson current mirror, Common Source, Common gate and Common drain IC amplifiers, Low frequency and High frequency response, noise performance, Multiple-Transistor IC amplifiers, Cascade configuration, Folded cascade and self cascade structure, Voltage	

follower, Flipped voltage follower.		
UNIT-III		11 Hours
MOS differential pair, Small signal operation, Differential gain, Common mode gain, Common mode rejection ration, Non ideal characteristics, Active loaded differential amplifier, Frequency response, Noise Spectrum - sources, types, Thermal and Flicker noise, Representation in circuits, Noise bandwidth, Noise figure.		
UNIT-IV		10 Hours
General feedback structure, Negative feedback, Four basic topologies, Loop gain, Stability, Effect of feedback on amplifier poles, Single pole response, Two pole response, Frequency compensation, Compensation Techniques, Pole splitting.		
Text Books:		
1	Sedra and Smith, ñMicroelectronic circuitsò, 7th Edition, Oxford University Press, 2017.	
2	Kenneth R. Laker and Willy M.C. Sansen, ñDesign of Analog Integrated Circuits and systemsò, 2nd Edition, McGraw-Hill, 2010.	
3	Philip E. Allen and Douglas R. Holberg, ñCMOS Analog Circuit Designò, 3rd Edition, Oxford University Press, 2012.	
Reference Books:		
1	Behzad Razavi, ñDesign of Analog CMOS Integrated Circuitò, 2nd Edition, Tata McGraw Hill, 2017.	
2	Gray R.Paul, Hurst J. Paul, Lewis H. Stephen and Meyer G. Robert, ñAnalysis and Design of Analog Integrated Circuitsò, 5th Edition, John Wiley and Sons, 2012.	
3	R. Jacob Baker,ò CMOS: Mixed-Signal Circuit Designò, 2nd Edition, John Wiley and Sons, 2009.	

SEMICONDUCTOR DEVICES FOR DIGITAL INTEGRATED CIRCUITS	
Course Code: MVD 103 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 1

Introduction: Semiconductor fundamentals, PN junctions, metal-semiconductor contacts, metal-oxide semiconductor capacitors and field-effect transistors, bipolar junction transistors.

Course Objective:

- To acquire knowledge about different types of semiconductor memories.
- To study about architecture and operations of different semiconductor memories.
- To comprehend the low power design techniques and methodologies.
- To understand the principles and fundamentals of semiconductor electronic and photonic devices and their applications.
- To provide students with the necessary basic understanding and knowledge in semiconductors so that they understand various applications in discrete and integrated analogue electronic circuits.

Pre-requisite: Semiconductor fundamentals

Course Outcome: On successful completion of the course, the students will be able to

- Comprehend the properties of materials and its application in electronics
- Experiment the knowledge of semiconductors to illustrate the functioning of basic electronic devices.
- Analyse the application of the semiconductor devices.
- Construct the control applications using semiconductor devices.
- Define the fabrication methods of integrated circuits.
- Develop and construct the semiconductor devices for special applications.

Pedagogy : Learning modes will be PowerPoint slides, assignments and research paper discussion. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	10 Hours
Elemental and compound semiconductors, Narrow & wide energy gap semiconductors, Direct & Indirect semiconductors, Choice of semiconductors for specific applications, Review of semiconductor fundamentals, Energy band, Carrier transport phenomena, Recombination and generation, surface effects, traps.	
UNIT-II	11Hours
PN junction, Schottky junction, Ohmic contacts, BJT device design, nonideal effects, frequency limitations, MOSFET Operation, Subthreshold conduction, Mobility variation, Velocity saturation threshold voltage modifications, Threshold adjustment by ion implantation, Lightly doped drain MOS transistor, Breakdown voltage, Radiations and Hot electron effects.	
UNIT-III	11Hours

Introduction to modern VLSI Devices, Polysilicon emitter transistors, Heterojunctions, 2D electron gas, Band alignment, SOI MOSFETs, PDSOI, FDSOI, Source/drain engineering, Brief Introduction to HEMTS, MESFET (Metal semiconductor FET) and MODFET (Modulation doped FET).	
UNIT IV	10Hours
New VLSI device structures from bulk to SOI to multi-gate, Double gate MOSFET, FinFET, SiGe technology, Strain influence on electron mobility, Strain enhanced Si based transistors, Strained Si CMOS, SiGe HBTs, SiGe MODFETs, Nanowires.	
Text Books	
1	Donald A. Neamen, ñSemiconductor Physics and devicesò, 4^{th} Edition, Tata McGraw Hill, 2017.
2	Taur and Ning, ñFundamental of Modern VLSI Devicesò, 2^{nd} Edition, Cambridge Press, 2016.
3	Balbir Kumar, Shail B. Jain, ñElectronic Devices and Circuitsò, PHI Publication, 2013.
Reference Books	
1	Ben G. Streetman & S. Banerjee, ñSolid state electronic devicesò, 6^{th} Edition, Prentice Hall, 2010.
2	A. G. Milnes, ñSemiconductor Devices and Integrated Electronicsò, Springer, 2012.
3	Jan M.Rabaeyò Digital Integrated Circuits: A design perspectiveò, Pearson, 2016.

HARDWARE DESCRIPTION LANGUAGES	
Course Code: MVD 105 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 1

Introduction: This course teaches basics as well as advance topics of Verilog and basics of VHDL. The objective of this course is to introduce a hardware description language (HDL) for the specification, simulation, synthesis and implementation of digital logic systems. The students will have design practice sessions and will implement digital logic systems with electronic design automation (EDA) tools.

Course Objective:

- Understand a hardware description language (HDL) for the specification, simulation, synthesis and implementation of digital logic systems.
- Implement the design digital logic systems with commercial electronic design (EDA) tools.
- Understand the usage of digital systems.
- Develop the synthesis of digital systems for programmable logic VLSI.

Pre-requisite: Student must have studied

- Digital design fundamentals: Logic gates and boolean logic.
- Sequential circuit fundamentals: State machines and sequential logic.
- Basic programming skills as procedural programming in C.

Course Outcome:

- Implementation of logic fundamentals using hardware description languages.
- Comprehend the difference between procedural programming and hardware description languages.
- Develop synthesizable Verilog code for Combinational and Sequential logic circuits.
- Execute code state machines in a hardware description language.
- Analyse and develop basic logic pipelined machines.
- Understand basic programmable logic architectures.
- Synthesize working circuits using programmable logic.
- Understand sequential and combinatorial logic timing.
- Understand the impact of actual routing and circuit parasitics.

Pedagogy: Learning modes will be PowerPoint slides, assignments and research paper discussion. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	10Hours
Introduction to VHDL, Behavioural , Data flow, Structural models, Simulation cycles, Process, concurrent & sequential statements, Loops, Delay models, Library, Packages, Functions, Procedures, Test bench, Design of digital circuits using VHDL.	
UNIT-II	11Hours

Introduction to Verilog HDL, Hierarchical modelling concepts, Lexical conventions, Data types, System tasks and Compiler directives, Modulus and ports, Variable, Arrays, Tables, operators, Expressions, Signal assignments, Nets, Registers, Concurrent & Sequential Constructs, Tasks & Functions.	
UNIT-III	11Hours
Gate-level Dataflow and behavioural modelling using Verilog HDL, Advanced Verilog topics, Timing and delays, Delay models, Path delay modelling, Timing checks, Switch level modeling, User defined primitives, Programming language interface.	
UNIT-IV	10Hours
Logic Synthesis with hardware description language, Impact of logic synthesis, Synthesis design flow, RTL description, Technology mapping and optimization, Technology library, Design constraints, Introduction to System Verilog, Verification techniques	
Text Books	
1	J. Bhaskar, ñVerilog HDL Synthesis ï A Practical Primerò, 3^{rd} Edition, Star Galaxy Publishing 2008.
2	S. Palnitkar, ñVerilog HDL: A Guide to Digital Design and Synthesisò, 2^{nd} Edition, Prentice Hall, 2006.
3	Mintz, Mike, Ekendahl, Robert, ñHardware Verification with System Verilog: An Object-Oriented Framworkò, 1^{st} Edition, Springer, 2010.
Reference Books	
1	Peter J Ashenden, ñThe Designerõs Guide to VHDLò, 3^{rd} Edition, Morgan Kaufmann Publishers, 2011.
2	Stefan Sjoholm&LennartLindth, ñVHDL for Designersò, 2^{nd} Edition, Prentice Hall, 2008.
3	Michael D. Ciletti,ò Advanced Digital Design with the Verilog HDLò, 2^{nd} Edition, Prentice Hall, 2010.

ADVANCED IC PROCESSING	
Course Code: MVD 107 Contact Hours: L-3 T-1 P-0 Course Category: DCC	Credits: 4 Semester: 1

Introduction: This course will examine the process technology that has enabled the integrated circuit revolution and investigate new technologies and layout/circuit techniques aimed at sustaining the current rate of progress in integrated circuits. The course emphasizes the physical principles and mathematical models used to characterize fabrication and inspection processes in micro fabrication technology.

Course Objective:

- Integration density and performance of analog and digital integrated circuits have undergone an astounding revolution in the last couple of decades.
- To understand the clock frequencies of microprocessors
- To analyse both logic ICǿs and memories, integration complexity and density.
- The goal is to achieve a working knowledge of the driving and limiting factors in circuit performance, of the fabrication and design techniques that influence performance, and of likely future trends.

Pre-requisite: Basic solid-state device design, operation, physics, diodes, bipolar junction transistors, and MOS field-effect transistors, and methods for their wafer-level fabrication. Familiarity with integrated circuit processing techniques, including oxidation diffusion, ion implantation, epitaxy, deposition, and etching.

Course Outcome: After successful completion of the course student will be able to

- Understand about various types of modern technologies.
- Identify the working knowledge of the driving and limiting factors in circuit performance of the fabrication and design techniques.
- Implement the fabrication process for designing digital ICs.
- Compare the various analog and digital circuits.

Pedagogy: The course Advanced IC Processing has been designed to enable the student to keep them in pace with the integrated circuit revolution and investigate new technologies and layout/circuit techniques provide a thorough exposure to the topic with the opportunity for flexible scheduling. The course materials consist of four basic elements: the lecture, course notes, problems and solutions, and the textbook. These elements have been carefully integrated, with each having an important role in the overall effectiveness of the course.

Contents

UNIT-I	10 Hours
Overview of modern CMOS technology, Substrate selection, Active region formation, Device isolation, Well formation, Gate and source/drain formation, Contact and local interconnects, Multilevel metal formation, Comparison between bulk and SOI CMOS technologies.	
UNIT-II	11 Hours
Crystal growth, Crystal structure, Crystal defects, Raw materials and purification,	

Electronic grade silicon, Czochralski and float-zone crystal growth methods, Wafer preparation and specifications, SOI wafer manufacturing clean rooms, Wafer cleaning and gettering, Basic concepts, Manufacturing methods and equipment, Measurement methods.		
UNIT-III		10 Hours
Photolithography, Light sources, Photoresists, Wet and Dry oxidation, growth kinetics, Diffusion, Fickôs laws, Ion implantation, Chemical and physical vapour deposition, Epitaxial growth, Deposition of dielectrics and metals commonly used in VLSI, Wet etching, Plasma etching, Etching of materials used in VLSI, Contacts, Vias, Multi-level Interconnects, Silicided gates and S/D regions, Reflow & planarization		
UNIT-IV		10 Hours
Functions of packaging, Rentôs Rule, Packaging techniques, Through hole, Surface mount, Types of single chip packaging, Bond wire, Flip chip technology, Tape automated Bonding, Thermal Management, Interconnection topology, Introduction to system packaging, System-in-package, Multi-Chip Module, 3D Packaging, Future Trends		
Text Books		
1	James D. Plummer, M.D. Deal and P.B.Griffin, ñSilicon VLSI Technology, Fundamentals, Practice and Modelingò, 1^{st} Edition, Pearson Education, 2009.	
2	Sorab Ghandhi, ñVLSI Fabrication Principlesò, 2^{nd} Edition, John Wiley and Sons, 2008.	
3	Yasuo Tarui,ò VLSI Technology: Fundamentals and Applicationsò, Springer, 2011.	
Reference Books		
1	H. B. Bakoglu, ñCircuits, Interconnections, and Packaging for VLSIò, 1^{st} Edition, Addison Wesley Longman Publishing, 1990.	
2	S.M.Sze, ñVLSI Technologyò, 2^{nd} Edition, McGraw-Hill, 2017.	

DEVICE MODELING & CIRCUIT SIMULATION	
Course Code: MVD 102 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 2

Introduction: The course deals with the study of device models that are used in the design and analysis of circuits using any simulator.

Course Objective:

- To explain the fundamental knowledge of semiconductor devices.
- To provide an introduction to the basic semiconductor physics/solid-state physics needed to understand device modelling of electronic devices.
- To understand the operation of several basic semiconductor devices: p-n junctions, metal-semiconductor junctions, Diodes, metal oxide semiconductor field effect transistors (MOSFETs), Complementary MOSFETs (CMOS).
- To provide fundamental understanding of device modeling and numerical simulation techniques.

Pre-requisite: Basic course of VLSI design

Course Outcome: After successful completion of the course student will be able to

- Understand concepts of MOSFET modelling.
- Implement the device models on software.
- Design and implement the codes for device modelling.
- Implement the analog and digital circuit simulation.

Pedagogy: Learning modes will be Power Point slides, assignments and research paper discussion. Use of ICT modes and classroom teaching. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	10 Hours
Introduction to SPICE modelling, Growth of fables design industry, SPICE modelling of resistor, Capacitor, Inductor, Semiconductor devices such as Diode, BJT, FET, MOSFET.MOSFET model parameters, Introduction to MOSFET SPICE Level 1, Level 2 and Level 3 models. CAD tools, Introduction to Device simulators, Tools for simulating device performance, Introduction to Circuit simulators	
UNIT-II	10 Hours
Circuit simulation techniques, DC analysis, AC analysis, Transient analysis, Modelling of Process Variation, Process corners, Monte Carlo simulation, and Sensitivity/worst case analysis, Simulation of digital and analog circuits, Transfer function, Frequency response, Noise analysis, Distortion and Spectral analysis.	
UNIT-III	10 Hours
MOSFET DC model, Static model and dynamic model, MOSFET Models for Digital	

Design, performance considering short channel and narrow width effects, Mechanical stress etc. MOSFET Models for Analog Design, Long Channel MOS model, Short Channel MOS model. Large signal and Small signal model. Analog Circuit Performance Parameters: Impact of parasitic effects, Process /temperature variation, Device reliability effects. Effect of temperature on model parameters.	
UNIT-IV	11 Hours
Data Acquisition and model parameter measurements, MOSFET models for mixed Analog-Digital circuit design, MOSFET models for Radio frequency circuit design, Deep submicron MOSFET models, Power MOSFET Simulation Models, Advanced MOSFET Models for Circuit Simulators, Brief overview of BSIM and EKV model.	
Text Books	
1	Tor A. Fjeldly, Trond Ytterdal, Michael S. Shur, ñIntroduction to Device Modeling and Circuit Simulationò Wiley, Latest Edition.
2	Paul W. Tuinenga, ñSPICE: A Guide to Circuit Simulation and Analysis Using PSpiceò, 3rd Edition, Pearson, 2006.
3	Paolo Antognetti and Giuseppe Massobrio, ñSemiconductor Device Modeling with SPICEò, 2nd Edition, McGraw-Hill, 2010.
Reference Books	
1	Y. Tsividis, ñOperation and Modeling of MOS transistorsò, 3rd Edition, Oxford University Press, 2010.
2	Jacob Millman, ñMillman's Electronic Devices and Circuitsò, 4th Edition, McGraw Hill, 2015.
3	Muhammad H. Rashid, ñIntroduction to PSpice Using OrCAD for Circuits and Electronicsò, Pearson, 2015.

DIGITAL SYSTEM DESIGN WITH FPGA	
Course Code: MVD-104 Contact Hours: L-3 T-0 P-2 Course Category: DCC	Credits: 4 Semester: 2

Introduction: Digital Systems Design with FPGAs and CPLDs explains how to design and develop digital electronic systems using programmable logic devices (PLDs). This deals with case study designs using a variety of Field Programmable Gate Array (FPGA) and Complex Programmable Logic Devices (CPLD). They also involve the study of ASM chart and Arbiter Design for a range of applications.

Course Objective:
- To understand various complex programmable Logic devices of different families.
- To study Field programmable gate arrays and realization techniques.
- To study various architecture of combinational/ sequential circuits.

Pre-requisites: Basic knowledge of Programmable logic devices, combinational and sequential logic circuit design and memories.

Course Outcome: After successful completion of the course student will be able to
- Demonstrate the use and application of Boolean algebra in the areas of digital circuit reduction, expansion, and factoring.
- Design and analysis of combinational and sequential digital systems.
- Simulate and debug digital systems described in VHDL.
- Apply complex digital circuits at several levels of abstractions.
- Implement logic on an FPGA.
- Understand different memory types and technologies.
- Design and implement hardware digital systems incorporating memory modules.

Pedagogy: Classroom teaching will be supported by Learning Management System (LMS) and multimedia. Learning modes will include PowerPoint slides, assignments and research paper discussion. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	11 Hours
Introduction to VLSI Design, Review of Latch and Flip-Flops, Design of Combinational circuit and AOI Logic Implementation, Design of Adders, Multipliers, Code Convertors, Magnitude Comparator, Multiplexer and Demultiplexer, CMOS Adder Architectures, ALU, Verilog Modeling of Combinational Circuits.	
UNIT-II	11 Hours
Design of sequential circuits (Various Shift Registers and Counters), Review of state table and State diagram, Mealy and Moore state machines, Implementation of Sequential Circuits, Modeling of Verilog Sequential Circuits, Analysis and Synthesis of Sequential Circuits.	
UNIT-III	10 Hours
RTL coding guidelines, Coding organization- complete realization, Writing a test bench, System design using ASM chart, Micro programmed design, Design flow of VLSI	

Circuits, Simulation of combinational and sequential Circuits, Analysis of waveforms, Optimizing data paths.	
UNIT-IV	10 Hours
PCI Arbiter Design using ASM Chart, Semiconductor Memories- ROM, RAM, SRAM, EPROM, Memory classification, Organization and technologies, Design, Architecture, Implementation of ROM chip, HDL based memory design examples. Programmable logic devices, Programmable array logic, CPLD and FPGA.	
Text Books	
1	Ian Grout, ñDigital Systems Design with FPGAs and CPLDsò, 1^{st} Edition Newnes, 2011.
2	Manjita Srivastava, Mahesh C. Srivastava, and Atul K. Srivastava,òDigital Design-HDL Based Approachò, Cengage Learning, 2010.
3	Kevin Skahill, ñVHDL for Programmable Logicò, Pearson Education, 1^{st} Edition 2006.
Reference Books	
1	A. Anand Kumar, ñFundamentals of Digital Circuitsò, 3^{rd} Edition, PHI publication, 2014.
2	Roth Kinney, ñFundamentals of Logic Designò, 7^{th} Edition, CengagE Learning, 2015.
3	Wayne Wolf, ñFPGA-Based System Designò, Pearson Education , 2004

DEEP SUBMICRON CMOS ICS	
Course Code: MVD 106 Contact Hours: L-3 T-1 P-0 Course Category: DCC	Credits: 4 Semester: 2

Introduction: The course provides a solid and fundamental engineering view of digital system operation and how to design systematically well performing digital VLSI systems exceeding consistently, customer expectations and competitor fears. The aim is to teach the critical methods and circuit structures to identify the key 1 % of the circuitry on-chip which dominates the performance, reliability, manufacturability, and the cost of the VLSI circuit. With the current utilisation of the deep submicron CMOS technologies (0.25 micron and below design rules) the major design paradigm shift is associated with the fact that the interconnections (metal Al or Cu wires connecting gates) and the chip communication in general is the main design object instead of active transistors or logic gates. The main design issues defining the make-or-break point in each project is associated with power and signal distribution and bit/symbol communication between functional blocks on-chip and off-chip.

Course Objective: In this course we provide a solid framework in understanding: -

- To understand the Scaling of technology and their impact on interconnects.
- To explain the Interconnects as design objects.
- To understand the noise in digital systems and its impact on system operation.
- Power distribution schemes for low noise
- Signal and signalling conventions for on-chip and off-chip communication
- Timing and synchronisation for fundamental operations and signalling

Pre-requisite: Analog VLSI Design, VLSI Design

Course Outcome: After successful completion of the course student will be able to

- Understand the Deep Submicron CMOS Technology.
- Understand the basic Process technology.
- Apply and implement the Modelling systems.
- Understand the basic Analog blocks.
- Design CMOS Analog Circuits.
- Understand the concepts of Computer Aided Design (CAD).

Pedagogy: The class will be taught using theory and case based method. Since this is design course, students are given problems based on design of Deep Submicron CMOS signal circuits. Technology Discussion sessions are organized on current research challenges in design, their relevance and applications in microelectronics industry. Design using CAD tools in CMOS design will also be done.

Contents

UNIT-I	10 Hours
MOS scaling, classification, DSM (Deep submicron) effects on devices, physical and geometrical effects on the behaviour of MOS transistor, carrier mobility, channel length modulation, short channel, narrow channel effects, drain feedback, hot carrier effects.	
UNIT-II	11 Hours
MOS transistor leakage mechanisms, weak inversion behaviour, gate oxide tunnelling, reverse-bias junction leakage, Gate induced drain leakage, Impact ionization, overall leakage interactions and considerations.	
UNIT-III	11 Hours
Signal integrity, cross talk and signal propagation, power integrity, supply and ground bounce, substrate bounce, EMC, soft errors, Variability, spatial and time based variations, global and local variations, transistor matching, parameter, process corners, causes for variations.	
UNIT-IV	10 Hours
Deep submicron IC reliability, punch through, electromigration, hot carrier degradation, negative bias temperature instability, Latch-up, Electro-static discharge, charge injection during fabrication process, Effects of scaling on MOS IC design and consequences for the technology roadmap for Semiconductors.	

Text Books	
1	Harry Veendrick, ñDeep-Submicron CMOS ICsò, 2ndEdition, Kluwer Academic publishers,2000.
2	John Paul Uyemura, ñChip Design for Submicron VLSIò, 2ndEdition., Thomson, 2006
3	Digital integrated circuit Design from VLSI architecture to CMOS, Hubert Kaeslin 2008
Reference Books	
1	Wolfgang nebel and Jean mermet, ñLow power design in deep submicron electronicsò, NATO ASI series, Kluwer Academic publishers, 2012.
2	Analysis and design of Digital integrated circuit, David A. Hodges 2005.

SEMICONDUCTOR MEMORY DESIGN	
Course Code: MVD 108 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: This course gives basics of RAM, ROM etc in semiconductor field. Semiconductor memory design is an essential course of today's electronics and is used in any equipment that uses a processor of one form or another.

Course Objective:

- To acquire knowledge about different types of semiconductor memories.
- To study about architecture and operations of different semiconductor memories.
- To comprehend the low power design techniques and methodologies.
- To verify the theoretical concepts through laboratory and simulation experiments.

Pre-requisite: Basic SRAM, ROM memory knowledge

Course Outcome: After successful completion of the course student will be able to

- Analyze different types of RAM, ROM designs.
- Analyze different RAM and ROM architecture and interconnects.
- Analyze the design and characterization technique.
- Understand different memory testing and design for testability.
- Identify new developments in semiconductor memory design.

Pedagogy: Learning modes will be PowerPoint slides, assignments and research paper discussion. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	10Hours
MOS RAM technologies, SRAMs, architecture, SRAM cell and peripheral, Circuit operation, SRAM Technologies, SOI Technology, advanced SRAM architectures and technologies, DRAM technology development, CMOS SRAMs cell, Theory and advanced cell structures.	
UNIT-II	11Hours
Nonvolatile memories, MOS ROMs, PROMs, EPROMs, One-Time Programmable EPROMS, Electrically erasable PROMs, EEPROM technology and architecture, Nonvolatile SRAM-Flash Memories, advanced Flash Memory architecture.	
UNIT-III	10Hours
Memory failure modes, Reliability modelling, Prediction design for reliability, Reliability test Structure, Reliability screening and qualification, Radiation effects, Radiation hardening, Process and techniques, Radiation hardened memory characteristics, Soft errors.	
UNIT IV	11Hours
Ferroelectric random access memories (FRAMs), Gallium arsenide FRAMs, Analog memories, resistive RAMs, Experimental memory devices, Memory hybrids and MCMs (2D), Memory stacks and MCMs(3D), Memory cards, High density memory packaging.	
Text Books	

1	Ashok K. Sharma, ñAdvanced Semiconductor Memories: Architectures, Designs, and Applicationsò, 2^{nd} Edition, John Wiley, 2009.
2	A.K Sharma, ñSemiconductor Memories Technology, Testing and Reliabilityò, 1^{st} Edition IEEE Press, 2003.
3	Santosh K. Kurinec and KrzysztolIniewski, ñNanoscalesemiconducter Memoriesò, CRC Press, 2017.
Reference Books	
1	Luecke Mire Care, ñSemiconductor Memory Design and Applicationò, 1^{st} Edition, Mc-Graw Hill, 1999.
2	Belty Prince, ñSemiconductor Memory Design Handbookò, 1^{st} Edition, IEEE Computer Society, 2001.
3	William D. Brown, and Joe E.Brewer, ñNonvolatile Semiconductor Memory Technologyò, IEEE Press, 2018.

DIGITAL VLSI DESIGN	
Course Code: MVD-110 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: This course brings circuit and system level views on design on the same platform. The course starts with basic device understanding and then deals with complex digital circuits keeping in mind the current trend in technology. The course aims at covering the important problems/algorithms/tools so that students get a comprehensive idea of the whole digital VLSI design flow. VLSI Design: High level Synthesis, Combinational and Sequential Synthesis Logic Synthesis.

Course Objective:

- To introduce digital integrated circuits
- To provide an understanding of CMOS devices and manufacturing technology.
- To provide an understanding of CMOS logic gates and their layout.
- To design Combinational and sequential circuit.
- To provide an understanding of memory design.

Pre- requisites: Basic knowledge of MOSFET, CMOS, Digital design and Memory elements.

Course Outcome: After successful completion of the course student will be able to

- Analyse the CMOS layout levels, understand CMOS fabrication.
- Implement digital logic designs of various circuits.
- Analyse performance issues and the inherent trade-offs involved in system design

Pedagogy: The course materials consist of four basic elements: the lecture, course notes, problems and solutions, and the textbook. These elements have been carefully integrated, with each having an important role in the overall effectiveness of the course. Learning modes will be PowerPoint slides, assignments and research paper discussion. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	11 Hours
Review of micro electronics, MOS structure and operation, Introduction, Structure and operation of MOSFET, Threshold voltage, Inversion region, Current-voltage characteristics, CMOS Technology, MOS capacitance, CMOS fabrication process.	
UNIT-II	11 Hours
MOS inverter and its characteristics, Inverter, Static CMOS Inverter, Propagation delay, Power dissipation, Parasitic capacitances and resistances- input capacitance, Interconnect Line/ Wire, Parasitic resistance, Impact of resistance, RC delay model.	
UNIT-III	10 Hours
Combinational static logic circuits, MOS logic, Complementary logic, AOI and OAI gates, Pseudo- nMOS Logic, Sequential logic circuits, Introduction, Sequential logic circuit, Latch and Flip-flop, Registers and counters, Dynamic logic gates.	
UNIT-IV	10 Hours

Semiconductor Memory, RAM, SRAM, Non Volatile memory, Adder and Multiplier circuits, Adderôs Circuit, CMOS adder architecture, Subtractor, Multiplier, ALU.	
Text Books	
1	Ajay Kumar Singh, ñDigital VLSI Designò, Eastern Economy Edition, PHI publication, 2010.
2	Partha Pratim Sahu,ò VLSI Designò, 1^{st} Edition, McGraw Hill Education, 2013.
3	Randall L.Geiger, Phillip E. Allen, and Noel R. Strader, ñVLSI Design Techniques for Analog and Digital Circuitsò, Indian Edition, McGraw Hill Education.
Reference Books	
1	Weste and Eshraghian, ñPrinciples of CMOS VLSI Designò Addison Wesley, 3^{rd} Edition.
2	Bushnell and Agrawal, ñEssentials of VLSI Testing for Digital, Memory and Mixed-Signal VLSI Circuitsò, Kluwer Academic Publishers, 2002.
3	Debaprasad Das, ñVLSI Designò, Oxford, 2^{nd} Edition, 2016.

ANALOG FILTER DESIGN	
Course Code: MVD-112 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: This course covers the techniques of modern signal processing that are fundamental to a wide variety of application areas. Special emphasis is placed on the architectures and design techniques for active and passive filters.

Course Objective:

- To understand the active filter design
- To explain the normalization, Frequency and impedance scaling.
- Determination of the transfer functions of filters.
- Frequency transformations, design of highpass, bandpass and band reject filters
- Active RC realizations of the transfer function of the filter
- To analyse the Elliptic (Cauer) approximation and filter design
- Introduction of passive filter design
- Design of doubly terminated passive LC ladder Cauer approximations
- Active RC simulation of passive doubly terminated LC filters

Pre-requisite: Signals, Systems and Circuits, Operational amplifiers

Course Outcome: After successful completion of the course student will be able to

- Understand the operation of electronic filters and describe them in the frequency domain from their magnitude characteristics
- Design lowpass, highpass, bandpass and band reject passive and active RC filters with all pole and rational approximations using the appropriate mathematics or filter tables.
- Implement the software system simulation tools to verify filter specifications in the frequency domain
- Analyse software tools to design frequency selective electronic circuits.
- Collaborate with fellow students in a team, in order to solve complex filter design and implementation problems

Pedagogy: Learning modes will be PowerPoint slides, assignments and research paper discussion. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	10 Hours
Monolithic filters, Digital filters, Analog discrete-time filters, Analog continous-time filters, Introduction to analog filters, CMOS filters descriptive terminology, Filter transmission, Types and specifications, Filter transfer function, Relationship among the	

time domain, Frequency domain, s domain.		
UNIT-II		11 Hours
Active and passive filter synthesis. Standard low-pass approximations, Butterworth, Chebyshev, Inverse Chebyshev, Cauer, Bessel, Elliptical, Frequency transformations, First-order and Second order filter functions, Active filters, Inductor based filter, Two Integrator loop topology.		
UNIT-III		11 Hours
Switched capacitor filters, Basic principle and practical circuits, Continuous type filters MOSFET-C, OTA-C filters, Implementation techniques towards low power supply voltages and low distortion, Frequency and time domain relationship, Pole and Zero locations.		
UNIT-IV		10 Hours
Filter synthesis for very high frequencies, Synthesis methods, Biquads, Gyrators, Generalized immittance converter (GIC), Inductor simulation using GIC, Introduction to Log-domain filters, Analog adaptive filters, Low voltage Analog filters in nanometer CMOS.		
Text Books		
1	M. E. Van Valkenburg and Mac Elwyn Van Valkenburg, ñAnalog Filter Designò 1st Edition, Oxford University Press, 2000.	
2	Lawrence P. Huelsman, ñActive and Passive Analog Filter Design: An Introduction, volume 1ò, 1st Edition, McGraw-Hill, 1993.	
3	Williams and Fred Taylor, ñElectronics Filter Designò, McGraw-Hill Education, 4th Edition, 2006.	
Reference Books		
1	Larry D. Paarmann, ñDesign and Analysis of Analog Filters: A Signal Processing Perspectiveò, 1st Edition, Kluwer Academic Publishers, 2001.	
2	Arthur B. Williams, ñAnalog Filter and Circuit Design Handbookò McGraw- Hill Education, 2014.	
3	Rolf Schaumann, Haiqiao Xiao, Mac E. Van Valkenburg, ñDesign of Analog Filtersò, 2nd Edition, Oxford University Press, 2009.	

DIGITAL TECHNIQUES FOR HIGH SPEED DESIGN	
Course Code: MVD 114 Contact Hours: L-3 T-1 P-0 Course Category: DEC	Credits: 4 Semester: 2

Introduction: Digital techniques for high speed design, is a subject that deals with the basic theory of different trends in high-speed design, backplane configurations, signal integrity and signaling technologies. Further this course will give some idea of memory signaling technologies, differential and mixed-mode parameters, simulation, verification and layout of high speed designs and advances in their modelling and design.

Course Objective:

- To enhance the knowledge about the real challenges faced by the designers while preparing high speed designs.
- To meet thesignaling technologies of high speed devices as well as circuits.
- To provide some idea of good design principles, and to simplify the process for simulation, verification and layout of high speed designs.
- To understand the in-depth knowledge of effects of various parameterọs variations on the designed circuit.
- To utilize the knowledge to design high speed designs as per the given specifications.

Course Outcomes: After successful completion of the course student will be able to

- Understand the knowledge of different trends in high speed design.
- Understand the memory signalling technologies.
- Analyse all the differential and mixed mode S parameters needed to be considered in time domain.
- Understand the Advances in design, Modeling, Simulation and measurement validation of high performance interconnects.

Pedagogy: Classroom teaching which focuses upon relating the textbook concepts with real world phenomena, along with periodic tutorial classes to enhance the problem-solving ability.

Contents

UNIT-I	10 Hours
Trends in High-Speed Design, backplane configurations, SerDes technology, Signal integrity, Signaling technologies and devices, Gunning transceiver Logic, Low voltage differential signaling(LVDS), Bus LVDS, LVDS multipoint, High-speed transceiver logic and Stub-series terminated logic, ECL, Current-mode logic, FPGAs - 3.125 Gbps rocket IOs and Hard copy devices, Fiber optic components, High speed interconnects and cabling.	
UNIT-II	11 Hours
Memory device overview, memory signaling technologies, double data rate SDRAM (DDR, DDR2), GDDR3, ZBT, FCRAM, SigmaRAM, RLDRAM, DDR SRAM, Flash, FeRAM, and MRAM, Quad data rate SRAM, Direct Rambus DRAM(DRDRAM), Xtreme data rate DRAM, Flex Phase and ODR.	
UNIT-III	10 Hours
Differential and mixed-mode S parameters, Time domain reflectometry (TDR), Time	

domain transmission (TDT) and VNAs, Modeling with IBIS, Overview of EDA Tools for high-speed design, simulation, verification and layout.		
UNIT-IV		11 Hours
Advances in design, Modeling, Simulation and measurement validation of high performance Board-to-Board 5-to-10 Gbps Interconnects, High-Speed Fiber-Optic transceivers, SerDes transceivers, serializers and deserializers, WarpLinkSerDes system, Emerging protocols and technologies, Electrical Optical Circuit Board, Rapid IO, PCI Express and express card.		
Text Books		
1	Tom Granberg, ñHandbook of Digital Techniques for High-Speed Designò, 1stEdition, Prentice hall, 2012	
2	Stephen H. Hall and Howard L. Heck, ñ Advance Signal Integrity for High speed Digital Designsò, Willy, IEEE Press, 2009.	
Reference Books		
1	Howard Johnson and Martin Graham, ñHigh Speed Digital Design: A Handbook of Black Magicò, 2nd Edition, Prentice Hall, 2000	
2	Stephen H. Hall, Garrett W. Hall, & James A. McCall, ñHigh speed Digital system Designò, WILLY -IEEE Press, 2000.	

CMOS MIXED-SIGNALS VLSI DESIGN	
Course Code: MVD 116 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: The course will give practical aspect of mixed signal VLSI blocks such as comparators, data converters, oscillators and phase locked loop. As a part of this course, the students will use industry standard softwares and tools such as Cadence's Virtuoso schematic, Spectre simulator and MentorGraphics' Eldo and Calibre for post layout simulations along with the parasitic extractions. The design problems given in the form of assignments will be designed and simulated in a standard CMOS technology by students. The study will cover design issues on the PVT variations and statistical mismatches in temperature and process (MonteCarlo).

Course Objective:

- To understand the basic theory of analog circuits, design principles and techniques for analog ICs blocks implemented in CMOS technology.
- To explain the theory and design skills of CMOS op-amps, voltage reference circuits, switched capacitor circuits, sample-and- hold circuits, and A/D & D/A converters used in modern communication systems and consumer electronic products.
- To understand the design of core mixed-signal IC blocks: comparators and data converters and system level design flow: top-down and bottom-up design methodologies

Pre-requisite: Analog VLSI Design, VLSI Design

Course Outcome: After successful completion of the course student will be able to

- Understand analog and discrete-time signal processing
- Undersatnd the basics of Analog to digital converters (ADC) and Digital to analog converters (DAC).
- Analyse High-speed ADCs (e.g. flash ADC, pipeline ADC and related architectures) and successive approximation ADCs.
- Understand the concept of High-resolution ADCs (e.g. delta-sigma converters).
- Analyse Mixed-Signal layout and Interconnects.
- Understand the Phase locked loops.
- Demonstrate the ability to design practical circuits that perform the desired operations.

Pedagogy: The class will be taught using theory and case based method. Since this is design course, students are given problems based on design of CMOS mixed signal circuits. Technology Discussion sessions are organized on current research challenges in design, their relevance and applications in microelectronics industry. Design using CAD tools in CMOS design will also be done. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	10 Hours
Analog and discrete-time signal processing, analog integrated continuous-time and discrete-time filters, Analog continuous-time filters, passive and active filters, basics of analog discrete-time filters and Z-transform.	
UNIT-II	11 Hours
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 ADC, Pipeline ADC.	
UNIT-III	11 Hours
Hybrid ADC structures, high resolution ADC, DAC, Mixed signal layout, Interconnects and data transmission, Voltage-mode signaling and data transmission, Current-mode signaling and data transmission.	
UNIT-IV	10 Hours
Introduction to frequency synthesizers and synchronization, basics of (Phase Locked Loop)PLL, PLL implementation techniques, Digital and Analog PLL, performance parameters, Delay Locked Loop(DLL), characteristics, advantages over PLL, implementation techniques.	
Text Books	
1	R. Jacob Baker, ñCMOS mixed-signal circuit designò, 2^{nd}Edition, John Wiley, 2009
2	BehadRazavi, ñDesign of analog CMOS integrated circuitsò, McGraw-Hill, 2003.
3	R. Jacob Baker, ñCMOS circuit design, layout and simulationò 2^{nd}Edition, IEEE press, 2008.
Reference Books	
1	Phillip E.Allen,Douglas R.Holberg,òCMOS Analog Circuit Designò,2^{nd} Edition,Oxford University Press,2002.
2	Gray, Hurst, Lewis, and Meyer, ñAnalysis and Design of Analog Integrated Circuitsò, 5^{th}Edition Wiley, 2009.
3	Willy M.C. Sansen, ñAnalog Design Essentialsò, International Edition, Springer, 2006.

ADVANCED EMBEDDED SYSTEM DESIGN	
Course Code: MVD 118 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction of machine learning course: Embedded system design needs knowledge of hardware as well as software concepts. This course will pay attention to introduce some of the basic concepts of hardware and software designing of embedded systems with a well motivated perspective. The course will cover embedded hardware architecture, design process and approaches, interfacing techniques, buses and protocols, hardware and software interrupts, embedded software programming, modelling of programs, inter-process synchronization and real time operating systems.

Course Objective:

- To develop the ability of solving real world problems.
- To develop background knowledge and core expertise of microprocessor.
- To know the importance of different peripheral devices and their interfacing to microcontrollers.
- To understand the concept of embedded systems.
- To design various projects using the embedded system applications.
- To understand the knowledge of machine learning concepts and various methods.

Course outcomes: After successful completion of the course student will be able to

- Understand the fundamental concepts that form the basis of hardware and software designing of embedded systems.
- Understands the widely used real time operating systems
- Design and program a system, interfacing techniques.
- Execute programs and software engineering practices of system design

Pedagogy: Classroom teaching which focuses upon relating the textbook concept with real world phenomenon, along with periodic lecture to enhance the problem-solving ability. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	10 Hours
INTRODUCTION AND REVIEW OF EMBEDDED HARDWARE Terminology, Gates, Timing diagram, Memory , Microprocessor buses ,Direct memory access, Interrupts, Built interrupts, Interrupts basis, Shared data problems, Interrupt latency, Embedded system evolution trends, Round-Robin, Round Robin with interrupt function, Rescheduling architecture, algorithm.	
UNIT-II	11 Hours
REAL TIME OPERATING SYSTEM Task and Task states, Task and data, Semaphore and shared data operating system services, Message queues timing functions , Events , Memory management, Interrupt	

routines in an RTOS environment , Basic design using RTOS.	
UNIT-III	10 Hours
EMBEDDED HARDWARE, SOFTWARE AND PERIPHERALS Custom single purpose processors: Hardware, Combination Sequence , Processor design, RT level design, optimizing software: Basic Architecture, Operation, Programmers view, Development Environment, ASIP, Processor Design, Peripherals, Timers, counters and watch dog timers, UART, Pulse width modulator, LCD controllers, Key pad controllers, Stepper motor controllers, A/D converters, Real time clock.	
UNIT-IV	11 Hours
MEMORY AND INTERFACING Memory write ability and storage performance, Memory types, composing memory, Advance RAM interfacing communication basic, Microprocessor interfacing I/O addressing, Interrupts, Direct memory access, Arbitration multilevel bus architecture, Serial protocol, Parallel protocols, Wireless protocols PROCESS MODELS AND HARDWARE SOFTWARE CO-DESIGN Modes of operation, Finite state machine, HCFSL and state charts language, state machine models, Concurrent process model, Concurrent process, Communication among process, Synchronization among process, Implementation, Data Flow model, Design technology, Automation synthesis, Hardware & software co-simulation, IP cores, Design Process Model.	

Text Books	
1	David. E.Simon, ñAn Embedded Software Primerò, 1st Edition, Pearson Education, 2002.
2	Frank Vahid and Tony Gwargie, ñEmbedded System Designò, Student Edition,John Wiley & sons, 2006.
3	W. Wolf, Computers as Components: Principles of Embedded Computing System Design, 2nd Edition, Burlington, 2008.
Reference Books	
1	Steve Heath, ñEmbedded System Designò, Elsevier, 2ndEdition, 2004
2	T Noergaard, Embedded Systems Architecture: A comprehensive Guide for Engineers and Prgrammers, 2nd Edition, Newness, 2013.
3	Wireless communication Networks and internet of things, AdamuMurtalaZungeru 2018.

ANALOG INTEGRATED CIRCUITS	
Course Code: MVD-120 Contact Hours: L-3 T-1 P-0 Course Category: DEC	Credits: 4 Semester: 2

Introduction: Analog integrated circuit design is used for designing operational amplifiers, linear regulators, oscillators, active filters, and phase locked loops. The semiconductor parameters such as power dissipation, gain, and resistance are more concerned in the designing of analog integrated circuit.

Course Objective:

- To understand the theoretical & circuit aspects of Op-amp, which is the backbone for the basics of linear integrated circuits
- To perform analysis of circuits based on linear integrated circuits.
- To design circuits and systems for particular applications using linear integrated circuits.
- Fundamentals of analog and digital integrated circuits.

Pre-requisite: Knowledge of mathematics on secondary education level (operations with fractions, solving system of the linear equations, algebraic handling with equations) and electronics (principles of the passive elements, describe simple circuit by using differential equations).

Course Outcome: After successful completion of the course student will be able to

- Understand fundamental properties of the electronic filters in time and frequency domain.
- Design passive as well as active filter for particular application including calculation of the values of circuit elements.
- Understand the differences between theoretical, practical & simulated results in integrated circuits.
- Interpret function of the crystal filters and structures with switched capacitors
- Analyse and design filtering networks.

Pedagogy: Learning modes will be PowerPoint slides, assignments and research paper discussion.

Contents

UNIT-I	10 Hours
Signals, Information, Interference and noise, signal classification, Dynamic range, S/N ratio, Functions in analog signal processing, Linear non-linear functions, Impedance adaptation, Amplitude and level matching, Terminal matching, Buffering filtering, Linearization, Domain conversions, Errors in analog signal processing,	
UNIT-II	11 Hours
Voltage amplification, Practical voltage amplifiers, Effects of finite input impedances,	

Building blocks for voltage amplifiers, Current to voltage and voltage to current conversion, Current Integrators, Mirrors, Amplifiers, and Conveyors.	
UNIT-III	11 Hours
CMOS analog integrated circuits, Analog building blocks, Op-amp design, Practical opamp characteristics and model, DC offset and DC bias currents, Gain, bandwidth and slew rate, Noise, Input stage, Output stage, CMOS OTA, Ideal model, OTA building block circuits, Design of simple OTA.	
UNIT-IV	10 Hours
Signal rectifications, AC/DC conversion, CMOS implementation of Adder, Subtractor, Squarer, Analog Multiplier, Analog Dividers, Differentiator and Integrator circuits, Impedance transformation and conversion, Analog multiplexers.	
Text Books	
1	Pallas Areny and John G.Webster, ñAnalog Signal Processingò, Student Edition, John Wiley, 2011.
2	Tlelo-Cuautle and Esteban, ñIntegrated Circuits for Analog Signal Processingò, 1^{st} Edition, Springer, 2013.
3	Behzad Razavi, ñDesign of Analog CMOS Integrated Circuitsò, 2^{nd} Edition, McGraw Hill, 2017.
Reference Books	
1	Ismail, Mohammed and Sawan, Mohamad, ñAnalog Circuits and Signal Processingò, The Springer International Series in Engineering and Computer Science, 2012.
2	M.Ismail and T. Fiez, ñAnalog VLSI Signal and Information Processingò, 2^{nd} Edition, McGraw Hill, 2000.
3	Tahira Parveen, ñTextbook of Operational Transconductance Amplifier and Analog Integrated Circuitsò, I.K International Publishing house Pvt. Ltd, 2013.

DIGITAL SYSTEM DESIGN USING VERILOG	
Course Code: MVD-122 Contact Hours: L-3 T-0 P-2 Course Category: DEC	Credits: 4 Semester: 2

Introduction: This course will teach the basics and advance topics of verilog digital system design

Course Objective: This course will enable students to:

- Understand the concepts of Verilog Language.
- Design the digital systems as an activity in a larger systems design context.
- Study the design and operation of semiconductor memories frequently used in application specific digital system.
- Inspect how effectively ICôs are embedded in package and assembled in PCBôs for different application.
- Design and diagnosis of processors and I/O controllers used in embedded systems.
- Design embedded systems using small microcontrollers, larger CPUs/DSPs, or hard or soft processor cores.
- Synthesize different types of processor and I/O controllers that are used in embedded system.

Pre-requisite: Any programming language.

Course outcomes: After successful completion of the course student will be able to

- Understand and construct the combinational circuits, using discrete gates and programmable logic devices.
- Design Verilog model for sequential circuits and test pattern generation.
- Design a semiconductor memory for specific chip design.
- Understand the memory designs.

Pedagogy: Learning modes will be PowerPoint slides, assignments and research paper discussion. To create a bridge between theory classes and practical to make the students understand better.

Contents

UNIT-I	10 Hours
Digital Systems and Embedded Systems, Real-World Circuits, Models, Design Methodology, Hierarical design flow, Designing Hardware with software. Memories: Concepts, Memories types, Error Detection and Correction.	
UNIT-II	11 Hours
Combinational Basics: Combinational Components and Circuits, Verification of Combinational Circuits, Sequential Basics: Sequential Datapaths and Control Clocked Synchronous Timing Methodology. SM Charts: Concept, Derivation of SM Charts, Realization of SM Charts.	
UNIT-III	11 Hours
Implementation Fabrics: Integrated Circuits, Programmable Logic Devices, Packaging and Circuit boards, Interconnection and Signal integrity, I/O interfacing: I/O devices, I/O controllers, Parallel Buses, Serial Transmission, I/O software.	

UNIT IV	10 Hours
Design Methodology: Design flow, Design optimization, Design for testability, HDL based Synthesis-technology independent design, Styles for synthesis of combinational and sequential logic	

Text Books	
1	Peter J. Ashenden, ñDigital Design: An Embedded Systems Approach Using VERILOGò, Elesvier, 2010.
2	Samir palnitkar, ñVerilog HDL, A Guide to Digital Design and Synthesisò, 2^{nd}edition, Prentice Hall, 2003
Reference Books	
1	Nazeih Botros ,òHDL Programming Fundamentals :VHDL and Verilogò , Dreamtech Press,2006
2	Vaibbah Taraate ,òDigital logic design using Verilogò ,Springer, 2016
3	John Williams ,òDigital VLSI design with Verilogò , 2^{nd} Edition, Springer, 2008

MEMS AND MICROSYSTEMS	
Course Code: MVD 124 Contact Hours: L-3 T-1 P-0 Course Category: DEC	Credits: 4 Semester:2

Introduction: This course teaches basics of MEMS, with emphasis on MEMS sensors

Course Objective: The objective of this course is

- To understand basic knowledge on overview of MEMS (Micro electro Mechanical System) and various fabrication techniques.
- To study the design, analysis, fabrication and testing the MEMS based components.
- To understand various opportunities in the emerging field of MEMS.
- To study and implement various applications of MEMS.

Pre-requisite: Electronic circuits, basic knowledge of material science, Basic physics, chemistry, electronics and mechanics at the sophomore level. Understanding of basic physics. Understanding of engineering materials of basic level. Understanding of electronics and semiconductors to the basic semiconductors and electronics.

Course Outcome: After successful completion of the course student will be able to

- Understand new applications and directions of modern engineering.
- Apply the techniques for building microdevices in silicon, polymer, metal and other materials.
- Understand the physical, chemical, biological, and engineering principles involved in the design and operation of current and future micro devices.
- Analyze microsystems technology for technical feasibility as well as practicality.
- Describe the limitations and current challenges in microsystems technology.

Pedagogy: Learning modes will be PowerPoint slides, assignments and research paper discussion.

Contents

UNIT-I	10 Hours
Introduction to MEMS & Microsystems, Introduction to Microsensors, Evaluation of MEMS, Microsensors, Market survey, application of MEMS, MEMS Material, MEMS materials properties, microelectronics technology for MEMS, micromachining technology for MEMS.	
UNIT-II	11Hours
Micromachining process, Etch stop techniques and microstructure, surface and quartz Micromachining fabrication of micromachined microstructure, Microstereolithography MEMS microsensors, thermal micromachined microsensors, Mechanical MEMS, Pressure and flow sensor, Micromachined flow sensors, MEMS inertial sensors.	
UNIT-III	11 Hours

Micromachined microaccelerometers for MEMS, MEMS accelerometers for avionics, Temperature drift and damping analysis, Piezoresistive accelerometer technology, MEMS capacitive accelerometer, MEMS capacitive accelerometer process.		
UNIT IV		10 Hours
MEMS gyro sensor, MEMS for space application, Polymer MEMS & carbon nano tubes(CNT),Wafer bonding & packaging of MEMS, Interface electronics for MEMS, MEMS for biomedical application (Bio-MEMS) .		
Text Books		
1	Adams, Thomas M., Layton, Richard A.,ò Introductory MEMS: Fabrication and Applicationsò, Springer, 2010.	
2	MinhangBao,òAnalysis and design principles of MEMS deviceò, 1st Edition, Elsevier Science, 2005.	
Reference Books		
1	Tai-Ran Hsu, ñMEMS and Microsystems: Design and Manufactureò, 1st Edition, McGraw-Hill, 2002.	
2	Ghodssi, Reza: Lin, Pinyen, ñMEMS Materials and Processes Handbookò, 1st Edition, Springer, 2011.	
3	Mohamed Gad-el-Hak, ñMEMS: Introduction and Fundamentalsò, 1st Edition, Taylor and Francis, 2006.	
4	Jan Korvink and Oliver Paul, ñMEMS: A Practical Guide to Design, Analysis and Applicationsò, 1st Edition, Springer, 2006.	

INTERNET OF THINGS	
Course Code: MVD 126 Contact Hours: L-3 T-1 P-0 Course Category: DEC	Credits: 4 Semester: 2

Introduction: Internet of Things is currently a hot technology across the globe. It has a vast application domain which includes agriculture, space, healthcare and manufacturing. IoT based applications such as innovative shopping system, infrastructure management in both urban and rural areas, remote health monitoring and emergency notification systems and transportation systems are gradually relying on IoT based systems. Wide application domain necessitates learning of the emerging technology. The course covers the following areas Internet in general and Internet of Things: layers, protocols, packets, services, performance parameters of a packet network as well as applications

Course Objective: The purpose of this course is

- To understand the knowledge on IoT architecture and various protocols, study their implementations.
- To explain in a concise manner how the general Internet as well as Internet of Things work.
- To understand constraints and opportunities of wireless and mobile networks for Internet of Things.
- To use basic measurement tools to determine the real-time performance of packet based networks.
- Analyse trade-offs in interconnected wireless embedded sensor networks.

Pre-requisite: Basic programming knowledge

Course Outcome: After successful completion of the course student will be able to

- Understand the Architectural Overview of IoT.
- Understand the IoT Reference Architecture and Real World Design Constraints.
- Understand the various IoT Protocols (Data link, Network, Transport, Session, and Service).
- Design and implement the security protocols on IoT based circuits.

Pedagogy: The course Internet of things has been designed to enable the student to understand constraints and opportunities of wireless and mobile networks for Internet of Things. A variety of teaching and learning tools may be employed including readings, videos, discussion, and simulations. Complete and actively participate in weekly discussions with timely initial posts and responses. Completion of other course assignments.

Contents

UNIT-I	11Hours
IoT-An Architectural Overviewï Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data	

management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management.		
UNIT-II		11Hours
IoT Architecture-State of the Art ï Introduction, State of the art, Reference Model and architecture, IoT reference Model - IoT Reference Architecture, Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control.		
UNIT-III		10Hours
PHY/MAC Layer(3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART,Z-Wave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP.		
UNIT-IV		10Hours
Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) ï Session Layer-HTTP, CoAP, XMPP, AMQP, MQTT ,Service layer Protocols & Security, Service Layer -oneM2M, ETSI M2M, OMA, BBF ï Security in IoT Protocols ï MAC 802.15.4 , 6LoWPAN, RPL, Application Layer.		
Text Books		
1	Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, ñFrom Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligenceò, 1st Edition, Academic Press, 2014.	
2	Peter Waher, ñLearning Internet of Thingsò, PACKT publishing, 2015	
3	RajkumarBuyya, Amir Vahid Dastjerdi ,òInternet of Things: Principles and paradigmsò,Elsevier, 2016	
Reference Books		
1	Daniel Minoli, ñBuilding the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communicationsò, Wiley Publications,2013.	
2	Vijay Madisetti and Arshdeep Bahga, ñInternet of Things (A Hands-on Approach)ò, 1st Edition, Universities Press, 2015.	
3	Qusay F Hassan ,òInternet of Things A TO Z: Technologies and Applications ñ, Wiley Publication,2018	