M.TECH – VLSI DESIGN

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Very Large Scale Integrated (VLSI) Circuit Design is the process of designing a large computer chip (more specifically, an integrated circuit, or IC), using computer-aided design (CAD) tools on a workstation or a personal computer (PC). The course demands learning the principles of VLSI design, designing and fabricating state-of-the-art VLSI chips, understanding the complete design flow and expertise to design CMOS chips for industrial requirements. The curriculum focuses on employing hierarchical design methods and understanding the design issues at the various levels of hierarchy. Students are exposed to various design softwares in this programme. Also, they learn to design, simulate, implement and test complex digital systems using FPGAs (Field Programmable Gate Arrays). The main objectives of this course are to analyze the electrical and design characteristics of transistors and gates and to study the issues and methodologies involved in the integration of these devices into complex high-performance systems.

With the recent and rapid upsurge in the areas like hardware software co-design, architectures for machine intelligence, network on chip etc. the programme is designed to cater to the needs in producing engineers trained in both hardware and software areas, bridging the gap between academia and industry. Students will be trained in several topics that cut across different domains, starting from the lowermost level of physical devices to the top level of application development.

Programme Outcomes

- Creation of expertise and work force in the microelectronics domain to deal with design, development, analysis, testing and evaluation of the critical aspects of integrated circuits and its core concepts to cater to the requirements of the industry and academia.
- Facilitate research opportunities in the integrated circuits domain aimed at developing state-of-the-art technologies with value based social responsibility.
- Developing professional competence in microelectronics domain and leadership qualities with a harmonious blend of ethics leading to an integrated personality development.
### First Semester

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* Non-credit course

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** Courses can also be taken from other departments

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** Credits **

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** Credits **

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64

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FC- Foundation Core; SC- Subject Core; E-Electives; P- Dissertation; P/F- Pass/Fail
List of Courses

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**18MA602 MATHEMATICAL METHODS FOR ENGINEERING** 3-0-2-4

(Common for VLSI Design, Communication Engineering& Signal Processing and Biomedical Engineering)

Objectives:
- To introduce the mathematical methods applied for VLSI, signal processing and communication systems.
- To provide a unified applied treatment of fundamental mathematics, seasoned with demonstrations using standard tools.
- To develop contemporary techniques for applications in the diverse areas to improve
the analytical skills.
• To comprehend the computational concepts learned in mathematical methods through numerical simulations and programming.

**Keywords:** Linear Algebra, Matrix Decompositions, Optimization, Random Process.

**Contents:**


Introduction to Probability concepts- Two dimensional jointly distributed random variables, stochastic random variables, convergence and limit theorems, multi variant probability distribution covariance, and regression models. Bayesian methods of estimation. Random process, power spectrum, discrete time process, spectrum estimation.

Lab component: Gram Schmidt orthonormalization on vector spaces, Solving a system of linear equations using QR decomposition , Image compression using Singular value decomposition, Computation of basis for four fundamental subspaces for a given system ,Optimization using Newton’s method with line search and Broydens update.

**Outcomes:**
• Understanding the mathematical methods and applying it to practical problems by investigating from different perspectives.
• Enabling an analytical approach towards developing mathematical models in various domains.
• To develop competency in implementation of algorithms and numerical analysis.

**TEXT BOOKS / REFERENCES:**

**18VL601 GRAPH THEORY AND APPLICATIONS 2-0-0-2**

**Objective:**
• To understand the basic concepts in graph theory.

**Contents:**
Outcomes:

- Apply graph theory concepts in VLSI Design.
- Enable an analytical approach for circuit design.

TEXT BOOKS / REFERENCES:


**18VL602 PHYSICS AND TECHNOLOGY OF MOS DEVICES 3-0-0-3**

Objectives:

- Understanding the basic semiconductor device physics of PN junctions.
- To understand operational principles of MOSFET.
- Understand the evolution of MOSFET structure and Technology.
- Understand the basic working of FinFETs.
- Use of MOSFET models directly into the circuit simulators for Analog/RFDigital systems.

Keywords: MOSFET, MOSCAP, Sub-Threshold, MOS Gate Stack, High-k dielectrics, Metal Gate Electrodes, Strained Silicon, Silicon-on-Insulator, FinFET.

Contents:


The ideal MOS Capacitor – Effect of Real Surfaces- MOSCAP Characteristics – MOSFET Characteristics - Threshold Voltage-Mobility-Substrate Bias – MOS Gate leakage - MOSFET parasitic capacitances-small signal model- Sub-threshold Characteristics - MOSFET Scaling and Short-channel Effects-DIBL, GIDL, Hot Carrier Effects

MOSFET structure evolution – High-k dielectrics, Metal Gate Electrodes, High mobility substrates (Strained Si, Ge), Elevated S/D - Silicon-on-Insulator structures – Ultra Shallow Junctions – Multiple Gate MOSFETs – Double Gate - Overview of CMOS Process flow-FinFETstructures and Operation – FinFET characteristics.

Outcomes:

- Understand working principles of MOSFET and evolution of MOSFET structure.
- Ability to use the MOSFET for DC, I-V, CV characteristics and in Analog/RF Circuit simulations.
- Understanding principles of FinFET structures.

TEXT BOOKS/REFERENCES:

Objectives:
- To introduce the basic concepts of MOS transistors.
- To provide a platform for transistor level digital circuits design.
- To learn and practice different logical implementation and their significances.

Keywords: PMOS, NMOS, Static, Transmission Gates, Switching Threshold, Rise/Fall Time, Delay, Sizing, Pseudo, Dynamic, Logical Effort.

Contents:


Outcomes:
- Ability to design basic digital circuits in transistor level.
- Ability to choose the suitable logical styles for the given problems.
- Ability to analyse the transistor level circuits.
- Ability to measure delay and find optimized delay.

TEXT BOOKS / REFERENCES:

Objectives:
- To understand different logic and arithmetic functional units and their design.
To design and synthesize FSMs and data path and control path.
To learn asynchronous circuits and their design principles.
Learn and apply hardware Description Language (Verilog) and SoC design flow.

**Keywords:** Shift Registers, Memory, Multiplier, Finite State Machine, Arithmetic Processor, Data path, Control path, Asynchronous circuits, Approximate Logic.

**Contents:**


**Outcomes:**
- Understand advanced topics in digital logic design.
- Understand modelling and verification with hardware description languages.
- Design state machines and data path controllers.

**TEXT BOOKS / REFERENCES:**

18VL613 ANALOG IC DESIGN 3-0-2-4

**Objectives:**
- To provide exposure in using device models, biasing circuits, small-signal operations, high frequency performance analysis and op amp design concepts.
- To use circuit simulators in the design of electronic circuits based on active devices (particularly MOS device) and determination of circuit parameters.

**Key words:** MOS, SPICE Models, MOS Amplifier, Frequency Compensation.

**Contents:**
MOS Large-signal and Small-signal–High-frequencyModeling– Short-Channel–Sub-
threshold Operation – Leakage Current – MOS Diodes – Active Resistors – Capacitors.


Outcomes:
- To make expertise in SPICE based circuit simulators.
- Ability to design active loaded (IC), MOS based single/multi-stage, operational amplifier considering terminal impedance matching.

TEXT BOOKS / REFERENCES:

18VL631 VLSI DESIGN LABORATORY-I 0-0-4-2

Objectives:
- To Build basic designs and incorporate them into system level design.
- To do experiments using FPGA and other tools for various digital designs.

Keywords: Timing Diagrams, Synthesis Aspects, FPGA and ASIC Libraries, VLSI Tools, Simulation, Synthesis.

Contents:
- Design an adder and 4-bit full adder. Instantiate four 4-bit adders to add two 16 bit values, implement in FPGA using switches as input and LED as the output. Refer synthesis report regarding the area, power and speed.
- Using a simulator (SPICE/CADENCE/Synopsys) build a Fulladder schematic using built-in gates.
- Build standard libraries (Inverter, NAND, NOR and AOI) for a given technology using CADENCE/Synopsys. Do DRC, LVS and Extraction.
- Develop the behavioural style HDL code for D-Flip Flop using gated, positive edge and negative edge clock modes.
• Develop the behavioural style HDL code for 4-bit counter. Develop the structural style HDL code for 4-bit counter using T Flip Flop (use of generate statement, area-performance analysis after synthesize). Compile, synthesize and simulate each design entity and verify the functionality by creating vector waveform file.
• Design a traffic light controller for an intersection with a main street, a side street, and a pedestrian crossing or a Vending Machine (Implement it on FPGA)
• Using the NAND and NOR standard cells designed in Exp 3, draw the layout for D and SR latch. Do DRC, LVS and Extraction.
• Implement a 4-bit ALU.

Outcomes:
• Ability to implement the designs using front end design environment using top down and bottom up approach.
• Ability to verify the functionalities of the designs.
• Ability to analyse the area, delay trade-offs and performance metrics associated with simulation and synthesis.

TEXT BOOK/REFERENCE:
1. Lab manuals and online manuals for tools usage and language reference manuals of HDLs.

18VL614 DESIGN VERIFICATION 3-0-0-3

Objectives:
• To introduce verification of hardware designs.
• To provide a practical approach for verification of designs.
• To give an introduction to FPGA based verification and Emulation of VLSI systems.

Keywords: Verification, Randomization, Direct Programming Interface, Assertions Based Verification, OVM & UVM.

Contents:


Outcomes:
- Ability to familiarize verification process and its different methodologies.
- Ability to write test-benches using system verilog in an efficient way.
- Ability to develop algorithms which can automate the design verification process.

TEXT BOOKS/REFERENCES:

18VL615 VLSI SIGNAL PROCESSING 3-0-0-3

Objectives:
- To introduce concepts in the design and implementation of DSP architectures.
- To realize architectures with high throughput, less area and less power.

Keywords: FIR Filter, IIR Filter, Pipelining, Parallel Processing, Folding, Retiming, Systolic.

Contents:


Bit-Level Arithmetic Architectures – Programmable Digital Signal Processors – Computational Accuracy in DSP Implementations – Adaptive Filters–Kalman Filters.

Outcomes:
- Ability to implement basic digital signal processing blocks like FIR and IIR filters.
- Ability to optimize the design by employing various algorithms.

TEXT BOOKS/REFERENCES:

18VL616 DESIGN FOR TEST AND TESTING 3-0-0-3

Objectives:
To introduce the concept of VLSI Testing and analyze the potential of ATPG algorithms.
To design for testability and explore the built-in-test concepts.
To learn and understand the challenges involved in scan design and test.

Key words: VLSI Testing, Design for Testability, Automatic Test Pattern Generation, Built-in-self-test, Boundary Scan.

Contents:


Testable Combinational Logic Circuit Design—Design of Testable Sequential Circuits—BIST Architectures—Test-Per-Clock—Test-Per-Scan—BIST Systems—Memory BIST—At-speed Testing—Boundary Scan Architecture—JTAG Standards.

Outcomes:
• Improves the knowledge level in the domain of VLSI Design and Test.
• Enhances the creativity to develop new ATPG Algorithms.
• Enables the student to design for testability.

TEXT BOOKS / REFERENCES:

18VL632 VLSI DESIGN LABORATORY-II 0-0-2-1

Objective:
• To use advanced tools to study front end and back end implementations.
• To build custom circuits using analog and digital environments.

Keywords: Area, Delay, Layout, Power, Timing Analysis, Digital, Analog Circuits Simulation and Analysis.

Contents:
• Data Path Circuits—State Machine in Front End for Simulation—Synthesis—Area and Delay Tradeoff—Layout Representation and Circuit Extraction in Backend.
• Analog Circuits and Mixed Signal Circuit Simulation and Analysis.
• Timing and Power Analysis of Standard Combinational and Sequential Circuits.
Verification examples using System Verilog.

Outcomes:
- Ability to analyze the circuits built in simulation, synthesis, timing and layout environments using VLSI tools from standard EDA companies.
- Ability to interface between front end and backend design flows, Post layout extraction and simulation.

TEXT BOOKS/REFERENCES:
1. Lab Manuals and online manuals for tools usage.
2. Language reference Manuals of HDLs.

18RM600 RESEARCH METHODOLOGY 2-0-0-2

Unit I:

Unit II:
Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:
Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:
Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V:

TEXT BOOKS/ REFERENCES:
ELECTIVE COURSES

ANALOG CIRCUITS AND DEVICES

18VL701 VLSI SIGNAL CONDITIONING 3-0-0-3

Objectives:
- To make the signal compatible for the next stage by manipulating the signal.
- To introduce Operational Trans-conductance amplifier and OTA based circuits.
- To understand \( \text{g}_m/\text{I}_D \) based designs and different signal conditioning circuits.

Keywords: OTA, \( \text{g}_m/\text{I}_D \), Gm-C, NAUTA, Q – tuning, Biquads, Filtering, Amplification.

Contents:
Operational Trans-conductance Amplifier basic Considerations – Application Requirements for OTAs used in Filters – The Case for Fully Differential Circuits – Transistor Models – \( \text{g}_m/\text{I}_D \)based Design – Single-stage OTAs.

Outcomes:
- Knowledge about \( \text{g}_m/\text{I}_D \) based design.
- Ability to Understand parameter tuning, filtering and various signal conditioning blocks.

TEXT BOOKS/REFERENCES:
2. Tony Chan Carusone, David A. Johns and Kenneth W. Martin, Analog Integrated
18VL702  SEMICONDUCTOR MEMORY DESIGN  3-0-0-3

Objectives:
- To learn and understand the Memory hierarchy and array structure in the system.
- To learn various types of architecture for semiconductor memories in detail to understand their limitations and improve them.
- To learn and understand the structures and various parameters associated with semiconductor memories.
- To familiarize with cadence and Synopsys in designing memories.
- To understand various aspects of reliability and fault modelling.

Key words: Memory Hierarchy, Memory Array, SRAM, DRAM, Flash Memory, Fault Modeling, Reliability, FRAM, MRAMs.

Contents:


Outcomes:
- Enable the student to understand the semiconductor memories, their working principle and implementation.
- Able to think innovatively in the related topics.
- Expertise in the area of semiconductor memory to carry out projects/research.

TEXT BOOKS / REFERENCES:

**18VL703**  
**OPTOELECTRONIC DEVICES**  
**3-0-0-3**

**Objectives:**
- To provide students with a view of principles of devices used in optoelectronics industry.
- To make students understand the physics and performance parameters in optoelectronic devices.
- To make students appreciate design principles by assignments.

**Keywords:** Optics, Photonics, III-V semiconductor, optical modes, planar devices.

**Contents:**

Heterostructures, Confinement of Electron Waves, Optical Waveguides and mode theory; Semiconductor Optical Amplifiers (SOA) and Fabry-Perot Lasers - Coupled Mode Theory, DBR and DFB Lasers.

Silicon Photonics: Integrated Optical Passive and Active Components; Tunable Filters, Delay-Lines and Switching Circuits in SOI Platform; CMOS Technology: Electrical vs. Optical Interconnects. Special topic: high speed photonic devices. Mandatory mini-project to be evaluated as internal.

**Outcome:**
- Students in VLSI should have clarity of their applicability in opto-electronic industry;
- Students will gain sufficient background if pursuing a research career.

**TEXT BOOKS / REFERENCES:**

**18VL704**  
**MIXED SIGNAL VLSI DESIGN**  
**3-0-0-3**

**Objectives:**
- To give an insight in to the design and analysis of data converters, especially SAR ADC.
- To introduce Verilog AMS for modeling various basic blocks.
Contents:

Ideal ADCs- Quantization Noise and SNR. Non-idealities- Nonlinearity (DNL, INL) and offsets- SFDR- Nyquist ADC architectures- Flash ADC- Successive Approximation Register (SAR) ADC- Pipelined ADC- Design of SAR ADC- Capacitor array DAC- Matching of capacitors-Choice of unit capacitance.


Outcomes:
- Familiarization of the working of data converters, especially SAR ADCs.
- Ability to model and verify basic circuits with Verilog-AMS.

TEXTBOOKS / REFERENCES:

TESTING AND VERIFICATION
18VL711 VLSI HARDWARE SECURITY AND TRUST 3-0-0-3

Objectives:
- To explore the various security threats in ICs.
- To know various countermeasures to address security threats.

Keywords: Trojan Attacks, Detection and Isolation, Side-channel Attacks, Physically Unclonable Functions, Trusted Platform Modules.

Contents:


Outcomes:
- Ability to understand effects of hardware trojans.
- Ability to understand the difficulties in detecting and identifying security threats.
- Ability to understand various techniques for trusted designs.

TEXT BOOKS/REFERENCES:
2. J. Plusquellic, *Trojan Taxonomy*, University of New Mexico, http://www.ece.unm.edu/~jimp/HOST.

18VL712 STATIC TIMING ANALYSIS 3-0-0-3

Objectives:
- To learn basic concepts of static timing analysis and apply them to constrain a design.
- Apply these concepts to set constraints, calculate slack values for different path types, identify timing problems.
- Analyze reports generated by static timing analysis tools.

Keywords: Timing Analysis Concepts, Timing Exceptions, Timing Violations, Noise-crosstalk glitch.

Contents:


TEXT BOOKS / REFERENCES:

**Outcomes:**
- Ability to identify and apply timing arc information from a library.
- Ability to use wire-load information to calculate net delays.
- Ability to identify the properties of a clock, including period, edges, slew, and duty cycle.
- Ability to apply setup and hold checks to diagnose design violations.

18VL713 DESIGN FOR MANUFACTURABILITY 3-0-0-3

**Objectives:**
- To introduce basic concepts of industrial and large scale manufacturing process for Silicon industry.
- Graduate students to develop an understanding of considering manufacturability as a requirement of design itself and tailor their designs accordingly.

**Keywords:** Industrial DFM, product level DFM, design level DFM, DFM metrics and DFM tools.

**Contents:**
Introduction to DfM- Three Product Questions, SMART Goals and Is/Is Not- Migrating Industrial DfM into IC Manufacturing The Rule of 10- Concurrent Engineering- Doing it Right the First Time.

Product Level DfM- Product Definition, Product architecture, System on Chip vs. System in Package; Design Level DfM.


**Outcomes:**
- Ability to identify and apply timing arc information from a library.
- Ability to use wire-load information to calculate net delays.
- Ability to identify the properties of a clock, including period, edges, slew, and duty cycle.
- Ability to apply setup and hold checks to diagnose design violations.

**TEXT BOOKS / REFERENCES:**
Objectives:
- Learn about formal modeling and specification languages.
- Learn about main approaches in formal VLSI design verification.

Contents:

Symbolic DLL – Breadth first SAT - Decision Diagram Pre-processing and Circuit Based SAT - BED Pre-Processing – Circuit based SAT – BDD sweeping and SAT – Reachability-Reachability Analysis – BDDs at SAT leaves – SAT Based Symbolic Image and Pre Image - Equivalence Checking of Arithmetic Circuits.


Outcomes:
- Use automated and interactive tools to validate models and design.
- To be able to write and understand formal requirement specifications.

TEXT BOOKS/REFERENCES:

COMPUTATIONAL VLSI

Objectives:
- To learn the VLSI Design methodologies.
- To understand the VLSI design automation tools.
- To understand placement, floor planning and routing and synthesis.

Contents:
Introduction to VLSI Design methodologies- Basics of VLSI design automation tools- Data structures for the representation of graphs-computational complexity-Graph algorithms- Combinatorial optimization problems-Decision problems - complexity classes - NP-completeness and NP-hardness-unit size placement problem- Back tracking and Branch-and-Bound.


Outcome:
- Ability to apply the algorithms for understanding the physical design flow.

TEXTBOOKS/REFERENCES:

18VL722 PHYSICAL DESIGN OF INTEGRATED CIRCUITS 3-0-0-3

Objectives:
- To develop algorithms for placement and power routing.
- To analyze the setup and hold times in physical domain.
- To decrease the timing cost by adopting new routing techniques.

Keywords: Placement, Timing Analysis, Power Planning, Multivoltage, Clock Tree Synthesis, Routing,RC Extraction.

Contents:


Outcomes:
• Familiarize with the latest techniques adopted in physical domain.
• Familiarize with the concepts of timing violation and fixing.

TEXT BOOKS/REFERENCES:

18VL723 EMERGING ARCHITECTURES FOR MACHINE LEARNING  3-0-0-3

Objectives:
• To introduce new paradigms in computing.
• To get an exposure to popular Cloud and IoT technologies.
• To introduce the potential of FPGAs in neural networks and bioinformatics.
• Provide hands on exposure in designing systems using state of the art computing tools.

Keywords: GPU, CUDA, Cloud and IoT, Machine Learning.

Contents:


Outcomes:
• Ability to design neural network and high performance bioinformatic database analysis systems.
• Ability to design solution for solving problems in a Big Data Cloud Environment.
• Ability to suggest GPU based solutions for dataflow intensive problems.
• Ability to use IoT technologies to design efficient applications.

TEXT BOOKS / REFERENCES:

**18VL724 WAVELETS AND APPLICATIONS 3-0-0-3**

**Objectives:**
- To study the analysis, design and applications of filter banks and wavelets.
- To get hands-on Experience with Software.

**Keywords:** CWT, DWT, Legendre Polynomials, Multi Wavelets, EZW.

**Contents:**
Introduction to wavelets-Vector Space-Functions and function spaces- Continuous time Fourier Transforms-Short time Fourier transforms-The uncertainty principle and time-frequency tiling-Discrete wavelet transforms-Scaling and Wavelet Functions – Filter Banks.


**Outcomes:**
- Ability to use wavelets for non stationary signals.
- Ability to use wavelets for various applications including wave propagation, data compression, signal processing, image processing, pattern recognition and computer graphics.

**TEXT BOOKS/REFERENCES:**

**18VL725 DATASTRUCTURES AND ALGORITHMS 3-0-0-3**

Online course/class room teaching
ARCHITECTURE

18VL731 VLSI ARCHITECTURES FOR MULTICORE AND HETEROGENEOUS COMPUTING 3-0-0-3

Objectives:
- To understand the performance of multi-core processors and high-performance computing systems.
- To understand the architectural considerations and VLSI implementation details.
- To introduce advance computer architectural techniques.

Key words: Parallelism, Scheduling, Power, Energy.

Contents:


Introduction to Markovian/Stochastic Models for Heterogeneous Computing – Operating System – Role of Multi-Cores – Case Study for Heterogeneous Architectures.

Outcome:
- Ability to analyze performance using state-of-the-art simulator for multi-core architectures.

TEXT BOOKS/REFERENCES:

18VL732 HARDWARE SOFTWARE CO-DESIGN 3-0-0-3

Objectives:
- To introduce the design of mixed hardware-software systems.
- To partition simple software programs into hardware and software components.
- To identify performance bottlenecks in a given hardware-software architecture and optimize them by transformations on hardware and software components.
Keywords: Co-Design Models, SystemC, Scheduling, Co-Simulation.

Contents:


Outcomes:
- Ability to analyze hardware-software co-design problems for systems with moderate complexity.
- Apply hardware-software co-design methods and techniques to practical problems.
- Applying different levels of abstractions and provide models for verification of the architecture and functionality for embedded co-design solutions.

TEXT BOOKS / REFERENCES:

18VL733 RECONFIGURABLE COMPUTING 3-0-0-3

Objectives:
- To introduce architecture that enables high performance computation as well as the supporting application mapping process.
- To familiarize wide range of reconfigurable architectures.
- To explore different opportunities for the use of reconfigurable architectures.

Key words: FPGA, Reconfiguration, high-level synthesis.

Contents:

Placement – Layout and Routing–Application Development–Case study with Applications and Solutions from Different Domains.

Outcomes:
- Ability to understand the fundamentals of FPGA and non-FPGA reconfigurable architectures and design.
- Explore to the state-of-the-art tools in reconfigurable computing.

TEXTBOOKS / REFERENCES:

18VL734 ELECTRONIC SYSTEM LEVEL DESIGN 3-0-0-3

Objectives:
- To learn Electronic System Level Design and Verification flow and tools.
- To understand virtual prototyping and its advantages.
- To familiarize SystemC based design and debug.
- To learn the basics of Transaction Level Modelling and High Level Synthesis.
- To familiarize on Accellera consortium, its activities and standards.

Keywords: Electronic System level design, Architecture Exploration, Open Source Languages, SystemC, ArchC, SpecC, Virtual Platform, Virtual Prototyping, Transaction Level Modelling, High level Synthesis and Accellera.

Contents:


Outcomes:
- Basic knowledge of Electronic System level Design and Verification.
- Ability to design and verify systems using SystemC.

TEXT BOOKS / REFERENCES:
18VL735 LOW POWER VLSI CIRCUITS 3-0-0-3

Objectives:
- To provide a comprehensive idea about different sources of power dissipation in VLSI circuits.
- To introduce power estimation methods.
- To understand different power optimization methods and challenges.
- To learn to apply low power techniques at all levels of design cycle and also during operation.

Keywords: Static power, switching power, short circuit power, probability, low power designs, Pareto Optimization, Dynamic Voltage Scaling, Dynamic Frequency Scaling, Power and clock gating.

Contents:


Outcomes:
- Understanding about various sources of power dissipation.
- Ability to estimate the power for given circuits.
- Ability to design low power digital VLSI circuits.

TEXT BOOKS / REFERENCES:
Objectives:
- To understand why there is a need for NoC in SoC.
- To understand and analyze the various types of NoC architecture available and its use in present day applications.
- To learn and understand about the various noise sources affecting the interconnection links and the design of low power interconnection link.
- To understand the working of various components used in NoC.
- To learn and understand the different types of switching, routing, addressing techniques and methods available for controlling the congestion and control flow in NoC.

Keywords: System on Chip(SoC), Network on Chip(NoC), Architecture, Topology, Signalling, Traffic patterns, Routers, Interconnection links, Switching, Routing, Addressing, Congestion control, Flow control, Network Interface.

Contents:


NoC Based System Integration – NOC Interface Design and Clock Distribution – Case Study on NoC Architecture for Mobile Application.

Outcomes:
- Ability to understand the need for NoC and the design anNoC architecture.
- Ability to select a suitable traffic pattern for the analysis of the architecture depending upon the traffic load of a given application.
- Ability to select a suitable switching and routing techniques for the transmission of information from one node to another node satisfying the performance needs.
- Ability to handle the congestion and flow control problems, which generally arises in anNoC architecture.

TEXT BOOKS / REFERENCES:

CYBERPHYSICAL SYSTEMS
Objectives:
- To learn the architecture of ARM Cortex-M Microcontroller for embedded design.
- To practice embedded software programming using KEIL platform.
- To learn and understand various design and implementation of simple embedded systems.

Keywords: Microcontroller, ARM, Embedded Systems, Software Architecture, RTOS, Semaphores, PLL, UART, Timer, ADC, DAC, Interrupts, Device Drivers.

Contents:


Outcomes:
- Ability to understand any other microcontrollers.
- Ability to design an optimised system considering both software and hardware aspects.
- Ability to analyse the necessity of a particular hardware.

TEXT BOOKS/REFERENCES:

Objectives:
- To understand FPGA Design Flow at the architectural and system design.
- Acquire a good background in block-based design using standard system level tools.
• Familiarization with embedded system design and debug using soft and hard processors in FPGA.

**Key words:** System Level Design, FPGA Design, Embedded Design.

**Contents:**
Review of FPGA Architecture and Design Flow-Introduction to Block Based Design.

Soft and Hard Processors-Single and Multiport Memories-IP Subsystems and IP Integration.


**Outcomes:**
• Understand block based design for building SoC systems on FPGAs.
• Ability to design simple SoCs on FPGA platform by integrating processor, memories, bus controllers and other IP subsystems, verify and implement them.
• Learn how to identify appropriate subsystems for implementing a given design problem.

**TEXT BOOKS / REFERENCES:**

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18VL743 CRYPTOGRAPHY 3-0-0-3

**Objective:**
• To study the fundamentals of cryptography

**Contents:**


Outcome:
- Application of the concepts of cryptography

TEXT BOOKS / REFERENCES:

RF INTEGRATED CIRCUITS

18VL751 CMOS RFIC DESIGN 3-0-0-3

Objectives:
- To learn the design of CMOS RF IC needed to build Transceiver (Transmitter and Receiver) for mobile/satellite/defense communication.
- To get hands-on training of designing of RF/Analog IC Design in Lab.

Keywords: Small Signal Model, Noise Analysis, Low Noise Amplifier, Broadband Amplifier, RF Oscillators, Mixers, Power Amplifiers.

Contents:


Outcomes:
- Ability to design Receiver using LNAs, Oscillators and Mixers.
- Ability to design transmitter using Power Amplifiers.
- Course Project on 60 GHz 5G Receiver/Doherty PA design and development in Lab.
TEXT BOOKS / REFERENCES:

18VL752 COMMUNICATION SYSTEMS AND NETWORKS 3-0-0-3

Objectives:
- To study the basics of sampling and quantization, coding, modulation, signal detection and system performance in the presence of noise.
- To study the data networking concepts including multiple access, reliable packet transmission, routing and protocols of the internet.

Keywords: Digital Modulations, Signal Detection, Multiple Access, Routing Protocols.

Contents:


Outcomes:
- Ability to design a communication system with specific high level constraints.
- Ability to apply the concepts in the context of aerospace communication systems: aircraft communications, satellite communications, and deep space communications.
- Ability to evaluate and assess the performance of communication networks in real time setting.

TEXT BOOKS / REFERENCES:

TECHNOLOGY
Objectives:
- To understand the latest trends in the technology and principles of nano-electronics.
- To familiarize new material devices and their performances.

Keywords: Quantum Well, Wire, Graphene, FinFETs, CNT.

Contents:


Outcomes:
- Ability to understand the principles of scaling and limitations of silicon based devices and development of nano-electronic devices.
- Ability to use of wave – particle analysis in the development of transport properties.

TEXT BOOKS / REFERENCES:

Objectives:
- To understand the scientific principles involved in the fabrication process.
- To introduce the concept of clean rooms and understand the challenges and limitations involved in extending each fabrication process into the nano-era.
- To introduce some new fabrication concepts employed in industry recently.

Keywords: IC Fabrication, Silicon Processing, Crystal Growth, Photo Lithography, Oxidation, Diffusion, Etching, Copper Interconnects, CMOS Technology, Film Deposition.
Contents:


Outcomes:
- Familiarization with Silicon processing and IC fabrication.
- Clarity on the constraints and modifications needed in extending these processes to nano-era.
- Familiarization with some of the latest techniques used in semiconductor industry.

TEXT BOOKS / REFERENCES:

18VL763 ELECTRONIC PACKAGING AND RELIABILITY 3-0-0-3

Objectives:
- To introduce basic concepts and types in Microchip Packaging.
- To understand how packaging needs vary for various applications.
- To understand the thermal, mechanical, electrical and chemical degradation mechanisms which affect the reliability of packaged devices.
- To make VLSI Design students appreciate the importance of the package design.

Keywords:IC Fabrication, device assembly, packaging, CMOS Technology, flip chip, Ball Grid Array, hermitic package, infant mortality – bath tub curve, radiation hardening, SMT, Monolithic 3D.

Contents:
Component Packaging (Including Integrated Circuits, Opto, MEMS, RF and Solar Devices) –
Substrates used in Packaging – Electrical and Thermal Considerations.


Outcomes:
- Exposure to various IC packaging techniques.
- Understanding the constraints in each techniques and modifications needed in extending these to various applications.
- Understanding of the reliability issues in packaging.

TEXT BOOKS / REFERENCES:

18VL764 MEMS DESIGN AND FABRICATION 3-0-0-3

Objectives:
- Understanding the basics of Micro Electro Mechanical Systems and the processing technologies.
- To understand the concepts and principles of micro sensors, actuators and their fabrication techniques.
- Understand the applications of MEMS in various fields.

Keywords: Microelectronic Technologies, Smart Materials Systems, Micromachining.

Contents:

Silicon Bulk Micromachining - Silicon Surface Micromachining - Microsensors and Microactuators – Fabrication and Packaging of Smart Microsystems.


Outcomes:
- Able to understand the concept of MEMS based systems and devices.
• Able to understand the applications of MEMS in satellite, space technology, medical and aerospace.

TEXT BOOKS/REFERENCES:

FRACTAL ELECTIVES

ANALOG CIRCUITS AND DEVICES

18VL771 ANALOG LAYOUT 1-0-0-1

Objective:
• To study and practice layouts, and to understand its significance on circuit performance.

Contents:

Outcomes:
• Design and develop a compact CMOS transistor layouts following the design rules.
• Ability to analyse the parasitic associated.

TEXT BOOKS/REFERENCES

18VL772 FEEDBACK AMPLIFIERS 1-0-0-1

Objective:
• To study and analyse the CMOS realization of Feedback amplifiers.

Contents:
Outcome:
- Analysis of Feedback amplifiers.

TEXTBOOKS/REFERENCES:

18VL773 ANALOG FILTERS 1-0-0-1

Objective:
- To study and analyze and design analog filters.

Contents:
Bilinear Transfer function and Frequency response- Cascade design with first order circuits- Biquad circuits- Butterworth Filters.

Outcome:
- Ability to design analog filters.

TEXTBOOKS/REFERENCES:

18VL774 PHASE-LOCKED LOOPS 1-0-0-1

Objectives:
- To study and understand PLL design and phase noise parameters.

Contents:
A short history of PLLs- Linearised PLL models-Noise properties- Voltage Controlled Oscillators- Sequential Phase detectors- Analog Phase Detectors – Digital Phase Detectors - Frequency Dividers - LC Oscillators - Ring Oscillators -loop filters and charge pumps-Phase Noise- Synthesizer design examples- DECT applications.

TEXT BOOKS/REFERENCES:

Outcome:
- Ability to design a complete frequency synthesizer and analyse its performance.

TESTING AND VERIFICATION

18VL775 BUILT-IN SELF TEST 1-0-0-1
Objective:
- To understand the principles of memory testing.

Contents:

Outcome:
- To be able to identify optimum memory testing algorithms for different types of memories.

TEXTBOOKS/REFERENCES:

COMPUTATIONAL VLSI

18VL776 DEEP LEARNING TECHNIQUES 1-0-0-1

Objective:
- To develop expertise of the students in deep learning and its applications.

Contents:
Introduction to Artificial Neural Networks (ANNs)-Feedforward neural networks- Gradient descent-backpropagation learning-Stochastic gradient descent-Activation functions-regularization-batch normalization; Convolutional neural networks- Fundamentals-architectures-pooling-visualization;Recurrent neural networks (RNN)-fundamentals- Long-Short Term Memory (LSTM)-architectureand training; Deep generative models-fundamentals-Autoencoders-Architecture and training; case studies.

Outcomes:
- Training the students on the fundamentals of deep learning algorithms.
- Prepare them to apply these algorithms for their further study/research.

TEXT BOOKS / REFERENCES:

18VL777 INTERNET OF THINGS 1-0-0-1

Objective:
- To explore the knowledge in Internet of Things – Architecture, Protocols, Hardware and Software Technologies.
Contents:


Outcomes:
- Hands-on Exposure to Internet of Things Hardware and Software Technologies.
- Both theoretical and practical knowledge in IoT Architecture, Protocols and Applications.

TEXTBOOKS/REFERENCES:

RF INTEGRATED CIRCUITS

18VL778 LOW NOISE AMPLIFIER DESIGN 1-0-0-1

Objective:
- To study and understand LNA design and its noise parameters.

Contents:

Outcome:
- Ability to design power constrained noise optimized LNA and to analyse its parameters.

TEXT BOOKS/REFERENCES:

18VL779 OSCILLATOR DESIGN 1-0-0-1

Objective:
- To study, design and analyze CMOS oscillator.
Contents:
Oscillation criteria – CMOS oscillator design – Operation and analysis of RC phase shift, Ring Oscillator, Wienbridge, Hartely, colpitts, crystal Oscillator – Quadrature Oscillator - VCO.

Outcome:
- Ability to design CMOS based oscillators.

TEXTBOOKS/REFERENCES:

18VL780 SIGNAL INTEGRITY 1-0-0-1

Objectives:
- Establish a sound basis for signal and power integrity design rules.
- Understanding 3D electromagnetic simulation.

Contents:

Outcome:
- Knowledge of pitfalls in high frequency design.
- Efficient design for board level interface.

TEXT BOOKS/REFERENCES:

TECHNOLOGY

18VL781 FINFET ARCHITECTURE 1-0-0-1

Objective:
- Understand the importance of non conventional MOSFET structures in VLSI.

Contents:

Outcomes:
- Design and simulate FINFET based circuits
- Ability to use prototyped systems for various applications

TEXT BOOKS/REFERENCES:
Objective:
- To study the characteristics of GaN devices and the processing challenges ahead in the development of novel devices.

Contents:

Outcome:
- Ability to model, characterise and develop GaN based HEMT devices and nanotubes.

TEXT BOOKS/REFERENCES:
2. www.cree.com/

Objectives:
- To define the problem of the proposed work.
- To apply the concepts of VLSI design in the selected problem.
- To demonstrate the results of the design concept.

Contents:
Problems and concepts may be defined based on extensive literature survey by standard research articles. Significance of proposed problem and the state-of the art to be explored. VLSI Design tools may be used for demonstrating the results with physical meaning and create necessary research components. Publications in reputed journals and conferences may be considered for authenticating the results.

Outcomes:
- Creation of manpower in the VLSI domain and specialize in the state-of the art technology.
- Enable design aptitude and complex problem solving in the VLSI design aspects.
- Research publications and filing of patents.
Problems and concepts may be defined based on extensive literature survey by standard research articles. Significance of proposed problem and the state-of-the-art to be explored. VLSI Design tools may be used for demonstrating the results with physical meaning and create necessary research components. Publications in reputed journals and conferences may be considered for authenticating the results.

Outcomes:
- Creation of manpower in the VLSI domain and specialize in the state-of-the-art technology.
- Enable design aptitude and complex problem solving in the VLSI design aspects.
- Research publications and filing of patents.