RCOEM

Shri Ramdeobaba College of
Engineering and Management, Nagpur

SHRI RAMDEOBABA COLLEGE OF ENGINEERING AND MANAGEMENT, NAGPUR – 440013

An Autonomous College affiliated to
Rashtrasant Tukadoji Maharaj Nagpur University,
Nagpur, Maharashtra (INDIA)

PROGRAMME SCHEME & SYLLABI
2023 – 2024

M. Tech. (VLSI Design)

Published By

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ISO 9001 : 2015 CERTIFIED ORGANISATION

About the Department

The Department of Electronics and Computer Science established in 2022 offers a degree of B.Tech. in Electronics and Computer Science with an intake of 120. Electronics and Computer Science is the fusion of Computer Science and Electronics Engineering disciplines. Combining these two areas of study gives a solid foundation in both domains and qualifies for a variety of careers, in both or either fields.

Department Vision

Department endeavors to facilitate state of the art technical education in the field of Electronics and Computer Science to produce globally competent engineering professionals.

Department Mission

- To impart quality education in the field of Electronics and Computer Science Engineering.
- To foster mutually beneficial relationship with industries, academics and research organizations.
- To create an intellectually stimulating environment for learning, research and innovation with professional and ethical values.

About the Programme

M. Tech. (VLSI Design) is a full-time two-year programme offered by Electronics and Computer Science Department with an intake of 06 and started in year 2004. Programme is accredited by National Board of Accreditation, New Delhi, for the academic session 2016- 2019.

Programme is based on Choice Based Credit System (CBCS) where students can take courses of their choice, learn at their own pace, undergo additional courses, acquire more than the required credits and adopt an interdisciplinary approach to learning. The curriculum is well designed to expose the students to contemporary Digital, Analog, Embedded and RF system design using industry standard EDA tools and development platforms. Dedicated state - of - the - art laboratories include major software and hardware platforms for VLSI Design. Software tools such as Mentor Graphics backend and frontend suit, Tanner Tool, Keil MDK, COMSOL, SDSoC and hardware development platforms such as Xilinx, Altera, Freescale, Cypress, Texas are available.

In order to prepare post graduates to take gainful employment in core, allied sectors of Electronics Engineering, R & D organization and entrepreneurship, the curriculum components include hands-on training, core- elective courses and industry-oriented projects.

Students undergo their internship at various R & D organizations, reputed academic institutions and industries such as Indian Nano-electronics Users Program (INUP) at IIT Bombay, IIT Hyderabad, IIT Gandhinagar, ISRO, BARC, Godrej, NEERI, IIIT Jabalpur, VNIT Nagpur, Sankalp Semiconductor, Wizchip Design Technologies, RRCAT Indore etc.

Programme Objectives

1. To develop graduates with an ability to design and analyze VLSI Systems.
2. To prepare graduates to adapt to the evolving technical challenges by acquiring necessary skills to excel in their career.
3. To encourage life-long learning with commitment to ethical practices.

Programme Outcomes

PO1 : An ability to apply knowledge of VLSI Design to solve engineering problems.

PO2 : An ability to acquire skills to interpret, analyze and evaluate problems of VLSI Systems

PO3 : An ability to independently carry out research / investigation and development of work to solve socio - economic problems.

PO4 : An ability to write and present a substantial technical report /document.

Scheme of Examination of Master of Technology
M. Tech. (VLSI Design)
Semester - I

Sr. No.	Code	Course	L	P	Credits	Maximum Marks			Exam Duration (Hrs)	Category
						Continuous Assessment	End Semester Exam	Total		
1	ENT701	CMOS Digital Circuit Design	3	0	3	50	50	100	3 Hrs.	PC
2	ENT702	Digital System Design	3	0	3	50	50	100	3 Hrs.	PC
3	ENT703	Semiconductor Devices	3	0	3	50	50	100	3 Hrs.	FC
4	ENT704	Embedded System and RTOS	3	0	3	50	50	100	3 Hrs.	PC
5	ENT705	Programme Elective-1	3	0	3	50	50	100	3 Hrs	PE
6	ENP701	CMOS Digital Circuit Design Lab	0	2	1	50	-	50	----	PC
7	ENP702	Digital System Design Lab	0	2	1	50	-	50	----	PC
8	ENP706	Lab Practice - I	0	2	1	50	-	50	----	PC
9	ENP704	Embedded System and RTOS Lab	0	2	1	50	-	50	----	PC
10	ENT707	Audit course: I	2	0	0	50	-	50	----	AC
		Total	**17**	**8**	**19**					

Sr No	Course Code	Programme Elective-1
1	ENT705-1	MEMS Design and Fabrication
2	ENT705-2	Advanced Computer Architecture
3	ENT705-3	Advanced Digital Signal Processing
4	ENT705-4	Hardware Assisted Security
5	ENT705-5	Machine Learning

Scheme of Examination of Master of Technology
M. Tech. (VLSI Design)
Semester - II

Sr. No.	Code	Course	L	P	Credits	Maximum Marks			Exam Duration (Hrs)	Category
						Continuous Assessment	End Semester Exam	Total		
1	ENT751	Analog IC Design	3	0	3	50	50	100	3 Hrs.	PC
2	ENT752	System Verilog for Verification	3	0	3	50	50	100	3 Hrs.	PC
3	ENT753	Programme Elective-II	3	0	3	50	50	100	3 Hrs.	PE
4	ENT754	Programme Elective-III	3	0	3	50	50	100	3 Hrs.	GE
5	ENP751	Analog IC Design Lab	0	2	1	50	-	50	----	PC
6	ENP752	System Verilog for Verification Lab	0	2	1	50	-	50	----	PC
7	ENP755	Lab Practice - II	0	2	1	50	-	50	3 Hrs.	PC
8	ENP756	Seminar	0	2	1	50	-	50	----	PC
9	ENT757	Audit course: II	2	0	0	50	-	50	----	AC
10		Open Elective-I	3	0	3	50	50	100	3 Hrs.	OE
		Total	**17**	**8**	**19**					

Course Code	Programme Elective - II / III
ENT753-1/ENT754-1	VLSI Signal Processing
ENT753-2/ENT754-2	RF Circuit Design
ENT753-3/ENT754-3	Memory Technologies
ENT753-4/ENT754-4	Flexible Electronics and Sensors
ENT753-5/ENT754-5	Embedded Machine Learning
ENT753-6/ENT754-6	VLSI Physical Design
ENT753-7/ENT754-7	Industry Elective

Course Code	Open Elective - I
ENT758	Digital System Design with FPGA

Course Code	Audit Course - I / II
ENT707-1 / ENT757-1	Technical Communication
ENT707-2 / ENT757-2	Innovation and Entrepreneurship
ENT707-3 / ENT757-3	Personality Development

Scheme of Examination of Master of Technology
M. Tech. (VLSI Design)
Semester - III

Sr. No.	Code	Course	L	P	Credits	Maximum Marks			Exam Duration (Hrs)	Category
						Continuous Assessment	End Semester Exam	Total		
1	ENT801	Research Methodology & IPR	2	0	2	50	50	100	3 Hrs.	PC
2	ENT802	Programme Elective-IV	3	0	3	50	50	100	3 Hrs.	PE
3	ENT803	Programme Elective-V	3	0	3	50	50	100	3 Hrs.	PE
4	ENP804	Project Phase I	0	16	8	50	50	100	----	PC
		Total	**8**	**16**	**16**					

OR

Sr. No.	Code	Course	L	P	Credits	Maximum Marks			Exam Duration (Hrs)	Category
						Continuous Assessment	End Semester Exam	Total		
1	ENT801	Research Methodology & IPR	2	0	2	50	50	50	3 Hrs.	PC
		OR								
	ENT805	Research Methodology (MOOC/Any online platform			2			100		
2	ENT806	Industry Internship / Research Internship			14	100	100	200		PC
		Total			**16**					

Course Code	Programme Elective - IV / V
ENT802-1 / 803-1	Design for testability
ENT802-2 / 803-2	SoC Design
ENT802-3 / 803-3	Nano materials and Nanotechnology
ENT802-4 / 803-4	Low Power VLSI Design
ENT802-5 / 803-5	Mixed Signal Processing
ENT802-6 / 803-6	MOOC -I
ENT802-7 / 803-7	MOOC -II

Scheme of Examination of Master of Technology
M. Tech. (VLSI Design)
Semester - IV

Sr. No.	Code	Course	L	P	Credits	Maximum Marks			Exam Duration (Hrs)	Category
						Continuous Assessment	End Semester Exam	Total		
1	ENP851	Project Phase II	0	28	14	150	150	300	----	PC
		Total	**0**	**28**	**14**					

OR

Sr. No.	Code	Course	L	P	Credits	Maximum Marks			Exam Duration (Hrs)	Category
						Continuous Assessment	End Semester Exam	Total		
1	ENP852	Industry Internship / Research Internship	0	0	14	150	150	300	----	PC
		Total	**0**	**0**	**14**					

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENT701 **Course : CMOS Digital Circuit Design**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon completion of this course, students should demonstrate the ability to:

1. Apply the circuit models to investigate CMOS circuits.
2. Design moderately sized CMOS circuits/ sub-systems and compute timing, power and parasitic for various CMOS Logic structures.
3. Evaluate various micron, deep sub-micron and nanometer-scale technologies.

Syllabus

Introduction to MOS Transistors, Switches, CMOS Logic, Scaling and transistors structures for VLSI; Silicon-on-insulator transistors.

Static Load MOS Inverters, CMOS Inverter, the Tri State Inverter.

Circuit Characterization and Performance Estimation : Introduction, Resistance Estimation Capacitance Estimation, Switching Characteristics, Transistor Sizing, Power Dissipation, Sizing Routing Conductors, Charge Sharing.

CMOS Circuit And Logic Design : CMOS Logic Gate Design, CMOS Logic Structures, Clocking Strategies, I/O Structures, Driving Large capacitive loads.

CMOS SubSystem Design : Data Path Operations-Addition/Subtraction, Parity Generators, Comparators, Binary Counters, ALUs, Multiplication, Shifters, Memory Elements, Control-FSM, Control Logic Implementation.

Memory elements: Read, write memory, RAM, Register files, FIFO, LIFO, SIPO, Serial access Memory, CAM, ROM.

Text Books

1. Principles of CMOS VLSI Design: N. Weste and K. Eshranghian, Addison Wesley, 2nd Edition
2. Digital Integrated Circuits: A Design Perspective: J. Rabaey, PHI, 2nd Edition
3. Basic VLSI Systems and Circuits: DouglesPucknell and K. Eshraghian PHI, 3rd Edition

Reference Books

1. VLSI Analog and Digital Circuit Design Techniques: Randel & Geiger TMH
2. Introduction to VLSI System: Carver Mead, Lynn Conway, Addison-Wesley, 1st Edition
3. CMOS Digital Integrated Circuits Analysis & Design: S M Kang, Yusuf Lablebici, TMH, 3rd Edition (2003)

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENP701 **Course : CMOS Digital Circuit Design Lab**

L : 0 Hrs., P : 2 Hrs., Per week **Total Credits : 1**

Practical / Case Studies/ Mini projects based on syllabus of ENT571

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENT702 **Course : Digital System Design**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcome

Upon the completion of this course, students will demonstrate the ability to:

1. Model the Digital Designs using HDL
2. Test the Digital Designs using HDL
3. Analyze the timing issues in Digital Designs
4. Optimize the Digital Designs for area, power and delay
5. Implement the Digital Designs on FPGA platforms

Syllabus

Hardware Description Languages

Introduction to HDL: Basic Language Elements, Syntax and Semantics HDL, Modeling Styles for building blocks, use of Procedures –functions / Task –function in designs, Attributes, Writing Test Benches, Handling Text files, Combinational & Sequential Design examples :Adders, Multipliers, ALU, Memories, FSM, FIFO

System Design Flow

Top-Down and Bottom-Up methodology, Word Length Determination, Data Path Control Path, Implementation of DSP algorithm

Synthesis - Analysis and Introduction to Optimization Techniques

Methodology, Logic Synthesis of HDL, Critical Path analysis, Speed, Area and Power optimizations at Architectural level,

Timing and Signal Integrity

Timing Basics and Signal integrity, Dealing with Clock Skew and Jitter, Synchronizers

Programmable ASICs

Technology Overview, CLBs, Architecture, Realization of functions in FPGA

Text books

1. A VHDL Primer, Third Edition: J. Bhasker, Prentice Hall, (1999).
2. Verilog HDL: A guide to Digital Design and Synthesis: Samir Palnitkar, Prentice Hall(1996).
3. Advanced Digital Design with the Verilog HDL: M.D. Ciletti, Prentice Hall, (2003).
4. Synthesis and Optimization of Digital Circuits, G. De Micheli, McGraw-Hill, (1994).

Reference books

1. The Verilog Hardware Description Language, Fifth Edition: Donald E. Thomas, Philip R. Moorby, Kluwer Academy Publisher. (2002).
2. Digital Systems Design Using VHDL, Second Edition: Charles H. Roth. Jr., L Kurian John, Cengage Learning, (2008).
3. Logic Synthesis using Synopsys, Second edition, P. Kurup and T. Abbasi, Kluwer, (1996).
4. Logic synthesis and verification algorithms: Gary D. Hachtel, Fabio Somenzi, Springer (1996).
5. An Engineering Approach to Digital Design: W. Fletcher. Prentice Hall.

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENP702 **Course : Digital System Design Lab**

L : 0 Hrs., P : 2 Hrs., Per week **Total Credits : 1**

Practical / Case Studies/ Mini projects based on syllabus of ENT572

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENT703 **Course : Semiconductor Devises**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon completion of this course, students should demonstrate the ability to

1. Estimate drift and diffusion carrier concentration in semiconductors, given the type and doping level of impurities.
2. Utilize the basic governing equations to analyze pn junctions &schottky junctions under various operating conditions.
3. Predict qualitative and quantitative operating conditions of MOS transistors & MOS Models and understand the concept of advanced MOSFET technology

Syllabus

Basic Semiconductor Physics

Crystal lattice, energy band model, density of states, distribution statics - Maxwell - Boltzmann and Fermi-Dirac, doping, carrier transport mechanisms, drift, diffusion, thermionic emission, and tunneling; excess carriers, carrier lifetime, recombination mechanisms - SHR, Auger.

p-n junction and metal-semiconductor junction

p-n junctions- fabrication, basic operation - forward and reverse bias, DC model, charge control model, I-V characteristics, steady-state and transient conditions, capacitance model, reverse-bias breakdown, SPICE model; metal-semiconductor junctions - fabrication, Schottky barriers, rectifying ad ohmic contacts, I-V characteristics.

MOS Capacitors and MOSFETs

The MOS capacitor - fabrication, surface charge - accumulation, depletion, inversion, threshold voltage, C-V characteristics - low and high frequency; the MOSFET - fabrication, operation, gradual channel approximation, simple charge control model (SCCM), Pao-Sah and Schichman - Hodges models, I-V characteristics, second-order effects - Velocity saturation, short-channel effects, charge sharing model, hot-carrier effects, gate tunneling; subthreshold operation - drain induced barrier lowering (DIBL) effect, unified charge control model(UCCM), SPICE level 1, 2, and 3, and Berkeley short-channel IGFT model (BSIM).

Advanced MOSFET technology

SOI MOSFET, high-k MOS devices, FinFETs and Multi gate MOSFETs

Text Books

1. Physics of Semiconductor Devices: S. M. Sze, Wiley Eastern, (1981).
2. Semiconductor physics and Devices, Donald Neamen, McGraw-Hill, 3rd edition.
3. Solid State Electronic Devices ,B. G. Streetman and S. Banerjee ,Prentice Hall India.

Reference Books

1. CMOS Circuit Design, Layout and simulation: J. Baker, D. E. Boyce., IEEE press.

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENT704 **Course : Embedded System and RTOS**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

1. Apply the knowledge of ARM architecture and organization for modern ARM Cortex-M devices.
2. Utilize knowledge, techniques and skill to integrate hardware and software component using Cortex-M.
3. Apply the concepts of Embedded OS.
4. Design an embedded system for given constraint.

Syllabus

Introduction to Embedded Systems, Concepts, Embedded System Design Issues. RISC Principles. The Cortex - M processor: Applications, Simplified view - block diagram, programming model - Registers, Operation modes, Exceptions and Interrupts, Reset Sequence, Instruction Set, Unified Assembler Language, Pipeline, Bus, Priority, Vector Tables, Interrupt Inputs and Pending behavior, Fault Exceptions, Supervisor and Pendable Service Call, Nested Vectored Interrupt Controller, SYSTICK Timer, Interrupt Sequences, Introduction to the Cortex microcontroller software interface standard (CMSIS), Interfacing of GPIOs, Timers, ADC, UART and other serial interfaces , PWM.

Concept and Fundamentals of RTOS

RTOS examples, Interrupts, Handling an Interrupt, Interrupt Service Routines, Context Switching, Process States, Communication Mechanism, Scheduling Algorithm, Priority Inversion, Priority Inheritance. Inter-task Communication: Shared Variables, Monitors, Messages, Events, Semaphores, Priority inversion problem, Deadlocks, Starvation.

Concepts, Structure of μCOS - II

Kernel Structure: Tasks, Task States, TCB, Ready List, Task Scheduling, Interrupts, Clock Tick, Initialization, Starting the OS, Task Management, Time Management, Event Control Blocks, Synchronization in μCOS - II: - Semaphore Management, Mutual Exclusion Semaphores, Event Flag Management, Communication in μCOS - II: - Message Mailbox Management, Message Queue Management, Memory management, Porting of μCOS - II.

Linux as an embedded OS, Tools and development, Applications and products, Building Linux Kernel.

Text Books

1. The Definitive Guide to the ARM Cortex-M0 : Joseph Yiu, Elsevier ,(1/E)2011
2. An embedded software primer: David E Simon, Pearson education Asia, 2001
3. Micro C/OS II The Real Time Kernel: Jean J. Labrosse, CMPBooks,(2/E) 2002
4. Embedded Linux Primer: christopher Hallinan, Pearson (1/E) 2007

Reference Books

1. ARM System Developer's Guide Designing and Optimizing System Software: Andrew N. Sloss, Dominic Symes, Chris Wright, Morgan Kaufmann publications, (1/E) 2004.
2. ARM system on chip Architecture: Steve Furber, Person Education Addison Wesley, (2 / E) 2000.

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENP704 **Course : Embedded System and RTOS Lab**

L : 0 Hrs., P : 2 Hrs., Per week **Total Credits : 1**

Practical / Case Studies/ Mini projects based on syllabus of ENT574

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENP706 **Course : Lab Practice - I**

L : 0 Hrs., P : 2 Hrs., Per week **Total Credits : 1**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

1. Apply fundamental principles to solve problems
2. Design and execute an experimental procedure, work independently, interpret experimental results
3. Draw a reasonable, accurate conclusion using suitable tools and technique

Practical / Case Studies / Mini projects

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENT705-1 **Course : MEMS Design and Fabrication**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to

1. Apply the principles behind the operation of MEMS devices.
2. Choose a micromachining technique for a specific MEMS fabrication process.
3. Design and fabricate MEMS devices or a microsystem.
4. Understand recent advancements in the field of MEMS and devices.

Syllabus

Micro-fabrication and Micromachining

Integrated Circuit Processes, Bulk Micromachining: Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA).

Physical Micro-sensors

Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples : Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors.

Micro-actuators

Electromagnetic and Thermal micro-actuation, Mechanical design of micro- actuators, Micro-actuator examples, micro-valves, micro-pumps, micro-motors-Micro-actuator systems : Success Stories, Ink-Jet printer heads, Micro-mirror TV Projector.

Surface Micromachining

One or two sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micromachined Systems: Success Stories, Micromotors, Gear trains, Mechanisms

Application Areas

All-mechanical miniature devices, 3 - D electromagnetic actuators and sensors, RF / Electronics devices, Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-arrays.

MEMS for RF Applications

Need for RF MEMS components in communications, space and defense applications.

Text Books

1. Micro and Smart Systems, Ananthasuresh, G. K., Vinoy, K. J. Gopala Krishnan, S., Bhat, K. N., Aatre, V. K., Wiley-India, New Delhi, 2010. 1st Edition.
2. RF MEMS and Their Applications: Vijay. Varadan, K. J. Vinoy, K. A. Jose, Wiley, 2002, 1st Edition.

Reference Books

1. Microsensors, MEMS and Smart Devices, Julian W. Gardner, Vinay K. Varadan, Osama O. Awadelkarim, Wiley, 2001, 1st Edition.
2. VLSI Technology, Sze S. M., Mc Graw Hill, 2nd Edition.

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENT705-2 **Course : Advanced Computer Architecture**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to

1. Define the principles of computer design and its performance enhancement measures.
2. Describe the operations of performance such as pipelines, dynamic scheduling branch predictions, caches.
3. Describe the modern architecture such as RISC, Scalar, VLIW, Multi core and multi CPU systems.
4. Compare the performance of different computer architectures.
5. Develop the applications for high performance computing systems.
6. Appraise memory organizations and modern computer architectures.

Syllabus

Classes of computers, Trends in technology, power and costs, dependability, quantitative principles of computer design, Models of parallel computer, multiprocessors and multi- computers, multi-vector and SIMP computers, PRAM and VLSI model, conditions of parallelism, data and resource dependencies, grain size and latency, grain packing and scheduling, program flow mechanisms, system interconnect architectures.

Principles of scalable performance, performance metrics and measures, speedup performance laws, advanced processor technology, superscalar and vector processors, cache memory organizations, shared memory organizations.

Pipeline and superscalar techniques, linear pipeline processors, reservation and latency analysis, collision free scheduling, pipeline schedule optimization, instruction pipeline design, arithmetic pipeline design, superscalar and super-pipeline design.

Multiprocessors and multi computers, multiprocessor system interconnects, cache coherence and synchronization mechanisms, message passing schemes.

Multi-vector and SIMD computers vector processing principles, compound vector processing, SIMD computer organizations scalable multithreaded and dataflow architectures.

Elementary theory about dependence analysis, techniques for extraction of parallelism.

Text Books

1. Advanced Computer Architecture: Kai Hwang; McGraw Hill.
2. Computer Architecture: A Quantitative Approach: J. Hennessy and D. Patterson, Morgan Kaufmann, 3rd edition, 2003.
3. Advanced Computer Architecture and Computing: S. S. Jadhav, Technical Publication, Pune.

Reference Books

1. Advanced Computer Architectures: A Design Space Approach: DezsoSima,Terence Fountain, Peter Karsuk, Pearson Education, 1st edition, 1997.
2. Advanced Computer Architecture: Richard Y. Kausi ; Prentice Hall of India.

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENT705-3 **Course : Advanced Digital Signal Processing**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

1. Analyze the multirate digital signal processing architectures
2. Describe the architecture of programmable DSP processor
3. Reduce the computational complexity of the signal processing algorithms
4. Illustrate the applications of DSP

Syllabus

Basics of Signal Processing and Multirate Signal Processing

Basics of signal Processing, Multirate Signal Processing: analysis of multirate structures, multistage design of decimator and interpolator, computationally efficient interpolator and decimator structures, Design of linear phase/poly-phase FIR filters.

Programmable DSP (P-DSP) Processor

Evolution of (P-DSP) processors and features, multiport memory , Architectural structural of (P-DSP) :MAC units, Barrel Shifters , Introduction to DSP processor family for multimedia signal processing, SIMD, MIMD, VLIW architecture.

Algorithmic strength Reduction in Filters

Parallel FIR filters: formulation using polyphase decomposition, Fast FIR algorithms.

Algorithm -Architecture Transformation

DCT -IDCT, Parallel Architecture for Rank order filters

Applications of DSP

Dual Tone Multifrequency Signal Detection, Spectral Analysis of Sinusoidal signal and non-stationary signals

Sound Processing

Echo filtering, reverberator architecture, flanging, chorus generator, Oversampling A/D and D/A convertor.

Text Books

1. Digital Signal Processing: Principles, Algorithms and Applications PHI publications 4th Edition, John G. Proakis, Dimitris G. Manolakis.
2. VLSI Digital Signal Processing Systems: Design and Implementation Wiley India Edition, By K.K. Parhi.
3. Digital Signal Processing: A computer Based Approach, Mcgraw Hill 3rd Edition , By Sanjit K Mitra.

Reference Books

1. Discrete Time Signal Processing, Pearson Prentice Hall India , 2nd edition, A. V. Oppenheim, R.W. Schaefer.

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENT705-4 **Course : Hardware Assisted Security**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

After completion of the course student will be able to:

1. Understand main security primitives typically used to develop defense mechanisms.
2. Examine different performance parameters of hardware security primitives.
3. Analyze attacks on security primitives & possible countermeasures.
4. Evaluate different security applications.

Syllabus

Primer on Cryptographic Primitives & Security Attacks : known security attacks on electronics systems, main cryptographic primitives typically used to develop defense mechanisms, motivation behind the development of hardware-based security solutions, physically un-clonable functions(PUF). PUFs Design Principles & Evaluation Metrics: the concept of physical disorder, PUF device using integrated circuit design techniques, the important metrics employed to assess the quality and usability of PUF circuit architectures.

Reliability Challenges of Silicon-based PUFs : The physical mechanisms of CMOS aging, typical temporal failure mechanisms, including radiation hits, electromagnetic interference, thermal noise, case study, Reliability Enhancement Techniques for PUFs.

Security Attacks on PUFs & possible Countermeasures : The design qualities one should consider when evaluating the security of a PUF design, adversary classification, principles of machine learning algorithms and how these can be employed to realize mathematical cloning attacks, side channel attacks.

Hardware - based Security Applications : Key generation, Authentication, Anti-counterfeiting Techniques.

Reference Books

1. Christofaar, JanPelzl, “Understanding Cryptography”, 2nd edition Springer, 2010.
2. Jonathan Katz and Yehuda Lindell, “Introduction to Modern Cryptography", 3rd Edition, CRC Press, 2021.
3. Ahmad-Reza Sadeghi, David Naccache, PimTuyls, “Towards Hardware-Intrinsic Security: Foundations and Practice” Springer , 2014.
4. RoelMaes, “Physically Unclonable Functions Constructions, Properties and Applications”, Springer , 2014.
5. IEEE Transactions on Information Forensics and Security.

Syllabus for Semester I
M. Tech. (VLSI Design)

Course Code : ENT705-5 **Course : Machine Learning**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon successful completion of the course, students will be able to:

1. Understand the fundamental concepts of machine learning, and get an insight of when to apply a particular machine learning approach.
2. Comprehend the underlying mathematical relationship within/across Machine Learning algorithms.
3. Apply machine-learning algorithms to complex engineering problems, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.
4. Design and implement deep neural networks for solving real-world problems in various domains and test them with benchmark data sets.

Syllabus

Foundations and paradigms of Machine Learning

Supervised learning: K-Nearest Neighbors, Decision trees, Linear and Logistic Regression – Bias/Variance Trade-off, Overfitting, Regularization, Variants of Gradient Descent, Support Vector Machines, boosting and bagging, Ensemble methods such as Random Forest and Ada Boost.

Artificial Neural Networks

Perceptron, Multilayer networks, Backpropagation algorithm, Optimization algorithms, Introduction to Deep Neural networks, Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), Brief introduction to ML applications in computer vision, and natural language processing using Tensorflow / Pytorch.

Probabilistic Machine Learning

Bayesian learning and Bayesian networks, Naive Bayes classifier; Bayes optimal classifiers, Maximum Likelihood Estimation, MAP; Gaussian Discriminant Analysis. Unsupervised learning: Clustering, Expectation Maximization, and Gaussian Mixture Models. Dimensionality Reduction-PCA, LDA, and Feature Selection, PAC Learnability.

Text Book

1. Understanding Machine Learning: From Theory to Algorithms, by Shai Shalev-Shwartz, Shai Ben-David, Third edition, Cambridge University Press, 2015.
2. Pattern Recognition and Machine Learning by Christopher M. Bishop, First edition, Springer, 2006.
3. The Elements of Statistical Learning Data Mining, Inference, and Prediction by Trevor Hastie, Robert Tibshirani, Jerome Friedman, Second Edition, Springer, 2009.

Reference Books

1. Machine learning, by Mitchell Tom, First edition, McGraw Hill, 1997.
2. Deep Learning by Ian Goodfellow, YoshuaBengio, Aaron Courville, & Francis Bach, MIT Press, 2017.
3. Machine Learning: An Algorithmic Perspective by Stephen Marsland, Second Edition, Chapman and Hall / CRC, 2014.
4. Richard O. Duda, Peter E. Hart, David G. Stork. Pattern classification, Wiley, New York, 2001.
5. Machine Learning: A Probabilistic Perspective by Kevin P. Murphy, Francis Bach; MIT Press, 2012.
6. Recent Research Papers from Reputed Journals and Conferences such as ICLR, NIPS, ICML, CVPR, PAMI etc.

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT751 **Course : Analog IC Design**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

1. Understand basics of data converters.
2. Apply mathematical models of MOS transistors to evaluate their behavior in analog circuits.
3. Analyze MOS based analog building blocks.
4. Evaluate various analog IC performance parameters.
5. Design CMOS analog circuits by taking suitable design approaches for given specifications.

Syllabus

Introduction to analog VLSI and analog design issues in CMOS technologies

Basic analog building blocks: Switches, Active resistors, current, voltage sources and sinks, current mirrors, current and voltage reference, Bandgap references.

Amplifiers, Common Source, Source follower, Common Gate and Cascode amplifiers, Frequency Response.

Frequency Response of Amplifiers

Miller Effect, Association of Poles with nodes, Frequency Response of all single stage amplifiers

Differential Amplifier

Basic differential Pair, common mode response, CMRR, Differential Pair with MOS load, Gilbert Cell.

OPAMP Design

Single stage and two Stage OP-Amps, Frequency compensation.

Switch Capacitor circuits

General considerations, sampling switches, Switched capacitor integrator.

Data Converter Fundamentals

DAC/ADC Specifications, Data Converter Architectures: DAC architectures, Resistor String, Charge-Scaling DACs, Cyclic DAC, Pipeline DAC.ADC Architectures- Flash, The Two-Step Flash ADC, The Pipeline ADC, Integrating ADCs, The Successive Approximation ADC.

Text Books

1. Design of Analog CMOS IC: B Razavi, Tata Mcgrw Hill (2002)
2. CMOS Circuit Design, Layout and simulation: J. Baker, D.E. Boyce., IEEE press (2010).
3. VLSI Design techniques for Analog and digital Circuits: R.L. Geiger, P.E. Allen, D. R. Holberg, OUP, (2/E) McGraw Hill (2002)

Reference Books

1. VLSI Design techniques for Analog and digital Circuits: Randel Geiger, P Allen, N Strader, Tata Mcgraw, Hill, (2/E) (2010)
2. Analysis And Design Of Analog ICs : Paul R. Gray, Paul J. Hurst Stephen H. Lewis, Robert G. Meyer, J, Willy and Sons, (4/E) (2001)

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENP751 **Course : Analog IC Design Lab**

L : 0 Hrs., P : 2 Hrs., Per week **Total Credits : 1**

Practical / Case Studies/ Mini projects based on syllabus of ENT578

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT752 **Course : System Verilog for Verification**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon completion of this course, students should demonstrate the ability to

1. Describe the advantages and enhancements to System Verilog to support verification.
2. Describe object-oriented programming and create a class-based verification environment.
3. Utilize assertions to quickly identify correct behavior in simulation.
4. Create and utilize random data generation and functional coverage features of system verilog for simulation verification.

Syllabus

Verification Guidelines

Introduction, Verification Process, Verification Plan, Verification Methodology Manual, Basic Testbench Functionality, Directed Testing, Methodology Basics, Constrained-Random Stimulus, Functional Coverage, Testbench Components, Layered Testbench,

Data Types

Built-in Data Types, Fixed-Size Arrays, Dynamic Arrays, Queues, Creating New Types with type def, Creating User-Defined Structures, Enumerated Types, Constants, Strings.

Procedural Statements and Routines

Procedural Statements, Tasks, Functions, and Void Functions.

Basic OOP

Where to Define a Class, OOP Terminology, Understanding Dynamic Objects

System Verilog Assertions

Types of Assertions and examples

Threads and Inter-process Communication

Working with Threads, Inter-process Communication, Events, Semaphores, Mailboxes, Building a Testbench with Threads and IPC

Functional Coverage

Coverage Types, Functional Coverage Strategies, Simple Functional Coverage Example, Coverage Options, Parameterized Cover Groups, Analyzing Coverage Data, Measuring Coverage Statistics during Simulation.

Text Books

1. System Verilog for Verification: A Guide to Learning the Testbench Language Features, Chris Spear, Springer 2006.
2. Writing Testbenches Using System Verilog, Janick Bergeron, Springer, 2006.
3. System Verilog for Design: A Guide to Using System Verilog for Hardware Design and Modeling, 2nd Edition, Stuart Sutherland, Simon Davidman and Peter Flake, Springer.

Reference Books

1. Writing Testbenches: Functional Verification of HDL Models, Second edition, Janick Bergeron, Kluwer Academic Publishers, 2003.
2. Open Verification Methodology Cookbook, Mark Glasser, Springer, 2009.
3. Principles of Functional Verification, Andreas S. Meyer, Elsevier Science, 2004.
4. Assertion-Based Design, 2nd Edition, Harry D. Foster, Adam C. Krolnik, David J. Lacey, Kluwer Academic Publishers, 2004.

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENP752 **Course : System Verilog for Verification Lab**

L : 0 Hrs., P : 2 Hrs., Per week **Total Credits : 1**

Practical / Case Studies/ Mini projects based on syllabus of ENT579

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT753-1/ENT754-1 **Course : VLSI Signal Processing**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

1. Apply the concepts of pipelining, parallel processing, retiming, folding and unfolding to optimize digital signal processing architectures.
2. Analyze data flow in systolic architectures.
3. Minimize the computational complexity using fast convolution algorithms.

Syllabus

Introduction to Digital Signal Processing Systems

Introduction, Typical DSP Algorithms, Representations of DSP Algorithms.

Iteration Bound

Introduction, Data Flow Graph Representations, Loop Bound and Iteration Bound, Algorithms for Computing Iteration Bound, Iteration Bound of Multirate Data Flow Graphs.

Pipelining and Parallel Processing

Introduction, Pipelining of FIR Digital filters, Parallel Processing. Pipelining and Parallel Processing for Low Power.

Retiming

Introduction, Definitions and Properties, Solving System of Inequalities, Retiming Techniques.

Unfolding

Introduction, An algorithm for Unfolding, Properties of Unfolding, Critical Path, Unfolding and Retiming, Applications of Unfolding.

Folding

Introduction, Folding Transformation, Register Minimization Techniques, Register Minimization in Folded Architectures, Folding of Multirate Systems.

Systolic Architecture Design

Introduction, Systolic Array Design Methodology, FIR systolic Arrays, Selection of scheduling vector, Matrix-Matrix Multiplication and 2D Systolic Array Design, Systolic Design for Space Representations containing Delays.

Fast Convolution

Introduction, Cook - Toom Algorithm, Winogard Algorithm, Iterated Convolution, Cyclic Convolution, Design of Fast Convolution Algorithm by Inspection.

Text Books

1. VLSI Digital Signal Processing Systems: Keshab K. Parhi. Wiley-Inter Sciences. (1999).
2. Analog VLSI signal and information processing: Mohammed Ismail, Terri, Fiez, McGraw Hill. (1994).
3. VLSI Digital signal processing system Design and implementation: Keshab. Parthi, Wiley- Inter science, (1999).

Reference Books

1. VLSI and Modern signal processing: kung. S. Y., H. J. While house T. Kailath, prentice hall, (1985).
2. Design of Analog - Digital VLSI circuits for telecommunications and signal processing: JoseE. France, Yannis Tsividls, Prentice Hall, (1994).

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT753-2/ENT754-2 **Course : RF Circuit Design**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

1. Understand the architectures, operation and performance specifications/ tradeoff of a RF receiver and its building blocks.
2. Design and analyze impedance transformation networks using passive elements with smith charts and hand calculation.
3. Understand and evaluate various performance specifications for individual blocks of receiver like filters, LNA, Mixer, Power Amplifiers by hand calculations.
4. Understand the sources of nonlinearity, noise, process technology and its impact on the performance parameters of individual blocks of receiver and on receiver performance.
5. Demonstrate the tools and techniques to evaluate the performance specifications of RF building blocks.

Syllabus

Characteristics of passive components for RF circuits. Passive RLC networks. Transmission lines. Two-port network modeling. S-parameter model. The Smith Chart and its applications.

Active Devices for RF Circuits

SiGe MOSFET, GaAs pHEMT, HBT and MESFET. PIN diode. Device parameters and their impact on circuit performance.

Review of Analog Filter Design

Low-pass, high-pass, band-pass and band-reject filters. RF Amplifier design, single and multi-stage amplifiers.

Low Noise Amplifier Design

Noise types and their characterization, LNA topologies, power match vs noise match. Linearity and large-signal performance.

RF Power Amplifiers

General properties. Class A, B, AB, C, D, E and F amplifiers. Modulation of power amplifiers.

Analog Communication Circuits

Mixers, phase-locked loops, oscillators, Transreceiver Architecture and performance specification.

Text Books

1. The Design of CMOS Radio Frequency Integrated Circuits: Thomas H. Lee- Cambridge University Press.

Reference Books

1. RF Microelectronics: Behzad Razavi- McGraw Hill.
2. Design of Analog CMOS integrated circuits: Behzad Razavi- McGraw Hill.
3. RF Circuit Design: Theory & Applications: Reinhold Ludwig, Gene Bogdanov.

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT753-3/ENT754-3 **Course : Memory Technologies**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

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

1. Select architecture and design semiconductor memory circuits and subsystems.
2. Identify various fault models, modes and mechanisms in semiconductor memories and their testing procedures.
3. Knowhow of the state-of-the-art memory chip design

Syllabus

Random Access Memory Technologies : Static Random Access Memories (SRAMs), SRAM Cell Structures, MOS SRAM Architecture, MOS SRAM Cell and Peripheral Circuit, Bipolar SRAM, Advanced SRAM Architectures, Application Specific SRAMs.

DRAMs, MOS DRAM Cell, BiCMOS DRAM, Error Failures in DRAM, Advanced DRAM Design and Architecture, Application Specific DRAMs, SRAM and DRAM Memory controllers.

Non-Volatile Memories : Masked ROMs, PROMs, Bipolar & CMOS PROM, EEPROMs, Floating Gate EPROM Cell, OTP EPROM, EEPROMs, Non-volatile SRAM, Flash Memories.

Semiconductor Memory Reliability and Radiation Effects : General Reliability Issues, RAM Failure Modes and Mechanism, Nonvolatile Memory, Radiation Effects, SEP, Radiation Hardening Techniques. Process and Design Issues, Radiation Hardened Memory Characteristics, Radiation Hardness Assurance and Testing.

Advanced Memory Technologies and High-density Memory Packing Technologies : Ferroelectric Random Access Memories (FRAMs), Gallium Arsenide (GaAs) FRAMs, Analog Memories, Magneto Resistive Random Access Memories (MRAMs), Experimental Memory Devices.

Memory Hybrids (2D & 3D), Memory Stacks, Memory Testing and Reliability Issues, Memory Cards, High Density Memory Packaging

Text Book

1. Ashok K Sharma," Semiconductor Memories: Technology, Testing and Reliability, PHI 1997 2.Kiyoo Itoh, "VLSI memory chip design", Springer International Edition

Reference Book

1. Luecke Mize Care, "Semiconductor Memory design & application", Mc-Graw Hill. 2.Belty Prince, " Semiconductor Memory Design Handbook".
2. Ashok K Sharma, "Advanced Semiconductor Memories : Architectures, Designs and Applications", Wiley Interscience.

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT753-4/ENT754-4 **Course : Flexible Electronics and Sensors**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcome

The course will provide an insight of the technology and applications for printed and flexible electronics.

1. Acquire and develop basic concepts and understanding of thin-film electronic materials and device processing.
2. Develop an understanding of emerging materials, processes, device performance, and target applications for electronics , tools for flexible electronic systems.
3. Understand the basic concepts for integration of thin-film devices on flexible platforms.

Syllabus

Module - 1 Introduction to Flexible Electronics

Background and history, trends, emerging technologies, general applications, Introduction to Semiconductors & Circuit Elements: doping, band structure, thin-film electronic devices

Module - 2 : Materials for Flexible Electronics

Nanowire and nanoparticle synthesis, metal oxides, amorphous thin films, polymeric semiconductors, structure and property relationships, paper-based electronics, textile substrates, barrier materials,

Module - 3 : Thin-film Deposition

Processing Methods for Flexible Devices, CVD, PECVD, PVD, etching, photolithography, low-temperature process integration

Module - 4 : Solution-based Processes

Ink-jet printing, imprint lithography, spray pyrolysis, gravure, screen printing, multilayer patterning, and film characterization techniques, design rule considerations Module-5 Contacts and Interfaces: Schottky contacts, Ohmic contact, relevant defects, carrier recombination, conducting polymers, Carbon-based electronics, effect of applied mechanical strain Module 6: Applications of Flexible devices and sensors:

Thin Film Transistors : device structure and performance, electrical characterization methods for rigid and flexible devices, Displays, Organic sensors and arrays, memory devices, MEMS devices, lab-on-a-chip devices, photovoltaic, wearable sensors, Body/textile antennas, Energy Harvesting devices.

Text Books

1. William S. Wong, Alberto Salleo, Flexible Electronics: Materials and Applications, 2011, 1st Edition, Springer, New York.
2. SubhasMukhopadhyay ,Anindya Nag , Printed and Flexible Sensor Technology: Fabrication and applications, , 2021 edition, IOP Series in Sensors and Sensor Systems

Reference Books

1. Edward Sazonov, Michael R. Newman, "Wearable Sensors: Fundamentals, Implementation and Applications", 2014, 1st Edition, Academic Press, Cambridge.
2. Kate Hartman, "Make: Wearable Electronics: Design, prototype, and wear your own interactive garments", 2014, 1st Edition, Marker Media, Netherlands.

Web Sources

1. https://www.standardsuniversity.org/e-magazine/june-2017/fabrication-and-implementation-of- wearable-flexible-sensors/
2. https://www.nature.com/articles/micronano201643

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT753-5/ENT754 -5 **Course : Embedded Machine Learning**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon successful completion of the course, students will be able to:

1. Understand the key design considerations for embedded Machine Learning.
2. Understand tradeoffs between various hardware architectures and platforms.
3. Apply the techniques for designing of efficient hardware for machine learning algorithms.
4. Develop the DNN using hardware/software framework.
5. Analyze the architecture of DNN accelerators with given target area - power - performance metrics.
6. Summarize the principles of Problem solving, quantitative and/or qualitative decision making in complex situations.

Syllabus

Introduction to Machine Learning, Background and overview on Deep Neural Networks, Training versus Inference ,Applications of DNNs, Embedded versus Cloud, Key Metrics: Accuracy, Throughput and Latency, Energy Efficiency and Power Consumption, Hardware Cost, Flexibility, Scalability, Interplay Between Different Metrics.

Kernel Computation, DNN Accelerators, Operation mapping on specialized hardware

Co-Design of DNN Hardware and Algorithms

Precision reduction, Quantization , Sparsity, Activation and Weight, Compression and sparse dataflow

Computing platform: Processors- GPU, CPU, NPU

Embedded AI devices: PYNQ-Z2, Arduino UNO R3, Intel Movidius NCS2, Raspberry Pi 4, Google Coral USB Accelerator, NVIDIA Jetson Nano

Software Framework

Pytorch, TinyML, Keras, Tensorflow

Accelerator

Approximate Computing, FPGA-based Accelerators, Sparsity, Reduction precision, Systolic Arrays, HW-SW Co-Design.

Case Study : Real world machine learning application and implementation.

Designing of efficient DNN models for Resource constraint applications.

Text Book

1. Efficient Processing of Deep Neural Networks, Vivienne Sze, Yu-Hsin Chen, Tien-Ju Yang, and Joel S. Emer, Morgan &cLaypool publishers (2020).
2. Practical Deep Learning for Cloud, Mobile and Edge: Real-World AI & Computer-Vision Projects Using Python, Keras&Tensorflow by AnirudhKoul, Siddha Ganju, MehereKasam, O Reilly; Illustrated edition (2019).

Reference Book

1. IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security, 2nd Edition, by Perry Lea, Packt Publishing Limited; 2nd Revised edition.
2. Hardware Architectures for Deep Learning, by Masoud Daneshtalab , Mehdi Modarressi, Institution of Engineering and Technology.
3. Recent Research Papers from Reputed Journals and Conferences such as CVPR, ICLR, NIPS, ICML, PAMI etc.

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT753-6/ENT754-6 **Course : VLSI Physical Design**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcome

Upon successful completion of the course, students will be able to:

1. Describe the VLSI design flow and various VLSI design styles in detail
2. Use algorithmic graph theory and combinatorial optimization techniques, as per requirement, to correctly ormulate and solve VLSI design problems
3. Explain the algorithms for partitioning, floor planning, placement and routing of VLSI circuits and use them to solve simple VLSI design problems.
4. Describe the process of Static Timing Analysis of VLSI circuits.

Introduction to VLSI CAD : VLSI design methodologies, use of VLSI CAD tools, Algorithmic Graph Theory and computational Complexity.

High-level Synthesis : Hardware Models for High-level Synthesis, Internal Representation of the Input Algorithm, and Understanding RTL to Gate Level design mapping. Basic concept of Static Timing Analysis (STA).

Partitioning : Introduction, Types of Partitioning, Classification of partitioning Algorithm, KL algorithm.

Floor - planning : Introduction, Sliced and non-sliced planning, Polish expression, Power planning, IO Planning.

Placement : Introduction, classification of placement algorithms, partition based placement, timing / congestion aware Placement.

Clock Tree Synthesis : Different topologies of Clock Tree Structure. Overview on Clock Mesh implementation for High Performance designs.

Routing : Fundamental Concepts of Steiner trees, Two phases of Routing: Global routing & detailed routing, Routing Algorithms.

Low Power Physical Design : Understanding Various Power Optimization algorithms (dynamic and Leakage). Overview on implementation and complexities involved in low power PD.

SOC Physical Design : Re-convergent model of VLSI SOC Design, SOC Physical design, advanced physical design of SOCs.

Text Books

1. VLSI Physical Design Automation: Theory and Practice: Sadiq M. Sait, Habib Youssef, McGraw-Hill 2004
2. VLSI Physical Design: From Graph Partitioning to Timing Closure: Jin Hu, Jens Lienig, Igor L. Markov, Andrew B. Kahng, Springer, Dordrecht2011
3. Handbook of Algorithms for Physical Design Automation: Charles J Alpert, Dinesh P Mehta, Sachin S Sapatnekar, CRC Press, 2008.
4. A Practical Approach to VLSI System on Chip (SoC) Design, VeenaChakravarthi, Springer International Publishing 2020

Reference Books

1. Physical Design Essentials: An ASIC Design Implementation Perspective: Khosrow Golshan, Springer, (2007).
2. Static Timing Analysis for Nanometer Designs: A Practical Approach: J. Bhasker and Rakesh Chadha, Springer, (2009).
3. Practical Problems in VLSI Physical Design Automation, Sung Kyu Lim, Springer, (2008), ISBN 978-1402066269.
4. Algorithms for VLSI Design Automation: Sabih H. Gerez and John Wiley,(1998).
5. An Introduction to VLSI Physical Design: Majid Sarrafzadeh and C. K. Wong, McGraw Hill, (1996).
6. Algorithms for VLSI Physical Design Automation: Naveed Sherwani, Kluwer Academic Pub., (1999).

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT753-7/ENT754-7 **Course : Industry Elective**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

The course will be offered by an Industry expert on latest trends in Industry.

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENP755 **Course : Lab Practice - II**

L : 0 Hrs., P : 2 Hrs., Per week **Total Credits : 1**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to:

- Apply fundamental principles to solve problems
- Design and execute an experimental procedure, work independently, interpret experimental results
- Draw a reasonable, accurate conclusion using suitable tools and technique

Practical / Case Studies / Mini projects

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT758-2 **Course : Digital System Design with FPGA**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to :

1. Design and analyze combinational, sequential and arithmetic circuits.
2. Understand digital system design flow, timing, synthesis and FPGA implementation issues.
3. Solve engineering problems in the area of digital system design.

Syllabus

Basic Digital Systems : Combinational Circuits, Sequential Circuits, Timing.

Digital System Design : Top down Approach to Design, Case study, Data Path, Control Path, Controller behavior and Design, Case study Mealy & Moore Machines, Timing of sequential circuits, Pipelining, Resource sharing.

Hardware Description language : Introduction, Behavioral, Data flow, Structural Models, Simulation Cycles, Process, Concurrent Statements, Sequential Statements, Loops, Sequential Circuits, FSM Coding, Library, Packages, Functions, Procedures, Test bench.

FSM Design : Controller (FSM), metastability, synchronization, FSM issues, timing issues, pipelining, resource sharing, case study.

FPGA : FPGA Architecture Xilinx and Altera, Logic block and routing architecture.

Text Books

1. A VHDL Primer, Third Edition : J. Bhasker, Prentice Hall, (1999).
2. Digital Systems Design Using VHDL, Second edition. Lizy Kurian John, Charles H. Roth, Cengage ; (2012).
3. Fundamental of Digital Logic with VHDL Design, Third Edition, Stephen Brown, Zvonko Vranesic, McGraw Hill Education (2012).

Reference Books

1. An Engineering Approach to Digital Design : W. Fletcher, Prentice Hall.
2. VHDL for Engineers, Kenneth L. Short, Pearson Education (2009).

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENP756 **Course : Seminar**

L : 0 Hrs., P : 2 Hrs., Per week **Total Credits : 1**

Course Outcomes

Upon completion of this course, students should demonstrate the ability to

- Identify the contemporary topic pertaining to VLSI Design.
- Present the topics with good written and oral communication skills.

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT707-1/ENT757-1 **Course : Technical Communication**

L : 2 Hrs., P : 0 Hrs., Per week **Total Credits : 0**

Course Outcomes

Students will be able to:

1. Understand that how to improve Technical communication skills
2. Utilize the technical writing and presentation skill/ techniques for the effective Technical Communication

Syllabus

Basics of Technical Writing

Planning and preparation, Structuring Paragraphs and Sentences, Breaking up long sentences, Word order, tense and voice , Removal of red undancy and typos, Avoiding ambiguity and vagueness, Clarifying contributions, Highlighting your findings, Hedging and Criticizing, Paraphrasing.

Sections of report\articles

Types of Articles, strategy for writing various sections of research articles: Abstracts, Graphical abstract, Introduction, Review of the Literature, Methods, Results and Discussion, Conclusions, Supplementary data, biography and other sections.

Tools for Technical Writing

Plotting tools, info-graphics tools, reference management tools, Plagiarism tools, understanding plagiarism report, report \article drafting tool like LATEX, Grammar checking tools.

Identification of Journal

Understanding indexing, types of indexing, submission to publishing process flow, Selection of journal, criteria for selection, assistive tools.

Technical Presentation

Strategies & Techniques, interpersonal Communication, Class room presentation, Modes of Presentation, Methods of Presentation

Oral Communication & Voice Dynamics

Public Speaking methods, Stimulus & Response, Clarity of substance, Encoding - Decoding process, Pronunciation Etiquette, Vowel -consonant sounds; Rising tone; Falling Tone, Flow in Speaking, Audience analysis & retention of audience interest, Audience participation: Quizzes & Interjections, Professional Personality Attributes: Empathy; Considerateness; Leadership; Competence.

Case studies : C.V./Resume writing, Technical Proposal, Research articles and cover letter, Research funding proposal.

Reference Books

1. Technical Communication - Principles and Practices, Meenakshi Raman & Sangeeta Sharma, Oxford Univ. Press, 2007, New Delhi.
2. Personality Development and Soft Skills, Barun K. Mitra, OUP, 2012, New Delhi.
3. How to Write and Publish a Scientific Paper, Day R (2006), Cambridge University Press.
4. English for Writing Research Papers, Adrian Wallwork, Springer New York Dordrecht Heidelberg London, 2011.
5. Spoken English - A Manual of Speech and Phonetics, R. K. Bansal & J. B. Harrison, Orient Blackswan, 2013, New Delhi.

Syllabus for Semester II
M. Tech. (VLSI Design)

Course Code : ENT707-2/ENT757-2 **Course : Innovation and Entrepreneurship**

L : 2 Hrs., P : 0 Hrs., Per week **Total Credits : 0**

Course Outcomes

After attending the course students should be able to:

1. Understand the logic and mechanics of a business enterprise.
2. Determine if they have the mind-set & preparation to be an entrepreneur.
3. Develop an understanding of the entrepreneurial process from conceptual stage to becoming an established business.
4. Know about stages of technology evolution, product and business life cycles.
5. Develop an understanding of business functions essential for success of technology enterprises.
6. Present Business Plan. Objective: Search for a scalable, repeatable & profitable business model.

Syllabus

Unit - I

This module includes a welcome to the course, an orientation to our teaching approach and faculty, and an introduction to the fundamentals of innovation and entrepreneurship.

Introduction : entrepreneurship, entrepreneur, creativity, & innovation, The world's most innovative companies.

Types of innovation, case studies, Entrepreneurs and strategic decisions, The opportunity analysis canvas.

Unit - II : Entrepreneurial Mindset, Motivations, and Behaviors

This module explores entrepreneurial thinking with attention to entrepreneurial mindset, entrepreneurial motivations, and entrepreneurial behaviors.

Introduction to entrepreneurial mindset, motivations, and behaviors, Entrepreneurial motivations, Risk taking in entrepreneurial decision-making, Risk, uncertainty, and stakeholder involvement.

Unit - III : Industry Understanding

This module examines how to recognize entrepreneurial opportunities based on market conditions and industry factors.

Introduction to industry understanding, Knowledge, Demand conditions, Industry life cycle, Industry structure, Competitive advantage, Learning curve, Complementary assets, Reputation effects.

Unit - IV : Customer Understanding and Business Modeling

This module introduces approaches to understanding customers, developing compelling solutions, and crafting winning business models.

Exploring real market needs, Satisfying real market needs, Strategic positioning, Strategic planning, Opportunity identification, Business Models Canvas, business model, business plan

Reference Books

1. "The Innovator's Dilemma" by Clayton Christensenm.
2. "Out of Our Minds: Learning to be Creative" by Ken Robinson, Risk, uncertainty, and stakeholder involvement.
3. The Entrepreneurial Mindset: Strategies for Continuously Creating Opportunity in an Age of Uncertainty by Rita Gunther McGrath and Ian MacMillan.
4. "The E-Myth Revisited: Why Most Small Businesses Don't Work and What to Do About It" by Michael E. Gerber.
5. "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries.
6. "Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers" by Alexander Osterwalder and Yves Pigneur.
7. "Blue Ocean Strategy: How to Create Uncontested Market Space and Make Competition Irrelevant" by W. Chan Kim and Renee Mauborgne.

Syllabus for Semester I / II
M. Tech. (VLSI Design)

Course Code : ENT707-3/ENT757-3 **Course : Personality Development**

L : 2 Hrs., P : 0 Hrs., Per week **Total Credits : 0**

Course Outcomes

At the end of this course

1. Students will learn the importance and skills of verbal and non-verbal communication in a professional setting.
2. Students will learn and apply the skill to write effective professional / workplace documents.
3. Students will learn the generic skills required to work in a team.

Syllabus

Define Personality, Determinants of Personality Development, Perception - Definition, Perceptual Process

Factors of Association - Relationship, Personality Traits, Developing Effective Habits.

Emotional Intelligence

Motivation, Introspection, Self-Assessment, Self-Appraisal & Self-development, Sigmund Freud Id, Ego & Super Ego. Self Esteem and Maslow, Self Esteem & Erik Erikson, Mind Mapping, Competency Mapping & 360 Degree Assessment, Types of Personalities – Introvert, Extrovert &Ambivert person, Effective Communication & Its key aspects.

Assertiveness, Decision making skills, Conflict

Process & Resolution, Leadership & Qualities of Successful Leader. Interpersonal Relationship, Personality - Spiritual journey beyond management of change, Good manners & Etiquettes, Effective Speech, Understanding Body language, projective positive body language.

Attitude - Concept - Significance - Factors affecting attitudes - Positive attitude - Advantages - Negative attitude - Disadvantages - Ways to develop positive attitude, Carl Jung 's contribution to personality development theory.

Stress Management

Introduction, Causes, stress management techniques, Time management: Importance of time management, Techniques of time management, Time management styles.

Reference Books

1. Seven Habits Of Highly Effective People - Stephen Covey.
2. You Can Win - Shiv Khera.
3. Three Basic Managerial Skills For All - Hall Of India Pvt Ltd New Delhi.
4. Hurlock Elizabeth B Personality Development Tata Mcgraw Hill New Delhi.
5. Understanding Psychology: By Robert S Feldman. (Tata McGraw Hill Publishing).
6. Personality Development and Career management: By R.M.Onkar (S Chand Publications).
7. Social Psychology: By Robert S Feldman. (Tata McGraw Hill Publishing).
8. Mcgrath Eh Basics Management Skills For All Printish Hall Of India Pvt Ltd New Delhi.
9. Wehtlel David A and Kin S Kemerron - Developing Managerial Skills - Pearson Education New Delhi.
10. Essentials of Business Communication - Rajendra Pal and J. S. Korlhalli - Sultan Chand & Sons, New Delhi.
11. Business Communication (Principles, Methods and Techniques) Nirmal Singh - Deep & Deep Publications Pvt. Ltd., New Delhi
12. Effective Business Communication - H. Murphy.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENT801 **Course : Research Methodology & IPR**

L : 2 Hrs., P : 0 Hrs., Per week **Total Credits : 2**

Course Outcomes

Upon the completion of this course, students will be able to:

1. Understand the research process & research problem formulation.
2. Develop hypothesis and utilize optimization methods for better research outcome.
3. Comprehend and deal with complex research issues in order to communicate their scientific results clearly for peer review.
4. Understand the importance of Intellectual Property Right for further research to create new and better products, leading to economic growth and social benefits.

Syllabus

Module - I (5 Hrs)

Introduction : Meaning of research; Types of research, Steps involved in research process; Ethics in research, research misconducts, codes and policies for research ethics. Selecting the research problem, Types of research designs.

Module - II (5 Hrs)

Sampling Fundamentals, Measurement and Scaling Techniques : Need for sampling; Steps in sampling design, Different types of sample designs, Concept of standard error; Estimating population mean and proportion, Determination of sample size Measurement scales, Sources of error, Tests of measurement Scaling, Important scaling techniques, Scale construction techniques.

Module - III (6 Hrs)

Data Collection Methods and Testing of Hypotheses : Methods for collection of data through questionnaires and schedules; Design of questionnaires; Data processing operations; Statistics in research; Analysis of Variance (ANOVA)- setting up ANOVA table, Important methods of factor analysis. Testing of hypotheses.

Module - IV (3 Hrs)

Report Writing and Presentation : Significance of report writing, Structure of the research report; Precautions for writing research reports, Oral presentation. Brief introduction to different commercially available software packages.

Module - V (6 Hrs)

Intellectual Property : Patents, Designs, Trade and Copyright. Process of Patenting and Development, Procedure for grants of patents, Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases, Administration of Patent System.

Text Books

1. C. R. Kothari and G. Garg. , "Research Methodology: Methods and Techniques", 4th Edition, New Age International, 2019.
2. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New
3. Technological Age", 2016.

Reference Books

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students".
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction".
3. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners".
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
5. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand , 2008.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENT802-1/ENT803-1 **Course : Design for Testability**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to :

1. Identify the problems associated with testing of semiconductor circuits at earlier design levels so as to significantly reduce the testing costs.
2. Analyze the various test generation methods for static & dynamic CMOS circuits.
3. Interpret the Memory Test Architectures and Techniques.
4. Propose the design for testability methods for combinational & sequential CMOS circuits.
5. Establish the BIST techniques for improving testability.

Syllabus

Scope of Testing

Fundamentals of VLSI testing, Verification v/s Test, Testing IPs, Digital Logic, Memories, Analog IPs, SoCs. Issues in test and verification of complex chips, embedded cores and SOCs, VLSI Technology Trends Affecting Testing, Test effectiveness metrics and economics

Fault modeling and Simulation

Fault Equivalence, Fault Collapsing, Fault Dominance, Algorithms for Fault Simulation, Serial Fault Simulation, Parallel Fault Simulation, Deductive Fault Simulation, Concurrent Fault Simulation, IDDQ testing, Delay Test: Launch Off Capture, Launch Off Shift, Path Delay, Small Delay Defects.

Testability Measures : controllability and observability SCOAP measures.

Test Generation For Combinational and Sequential Circuits : D Algorithm, PODEM Algorithm, FAN Algorithm, Sequential test pattern generation.

Memory BIST (MBIST)

Memory Test Architectures and Techniques - Introduction to Memory Test, Types of Memories and Integration, Embedded Memory Testing Model, Memory Test Requirements for MBIST.

Design for Testability

Trade Offs, Adhoc Design for Testability Techniques, Scan design. LSSD, Test interface, SoC Scan Architecture, Managing scan for IPs and SOCs, Boundary Scan Standard- TAP Controller and Port, Boundary Scan Test Instructions, Pin Constraints of the Standard, Pin Descriptions.

BuilT in Self-Test (BIST)

The Economic Case for BIST, Random Logic BIST: Definitions, BIST Process, Pattern Generation, Response Compaction, Built-In Logic Block Observers, Test-Per-Clock, Test-PerScan BIST Systems, Circular Self Test Path System.

Text Books

1. M. Bushnell and V.D. Agrawal "Essentials of Electronic Testing for Digital, Memory and Mixed - Signal VLSI Circuits": Kluwer Academic Publisher, 2000.

Reference Books

1. A. L. Crouch, "Design Test for Digital IC's and Embedded Core Systems", Prentice Hall International.
2. P. K. Lala, "Digital Circuits Testing and Testability", Academic Press
3. N. Jha & S. D. Gupta, "Testing of Digital Systems", Cambridge, 2003.
4. W. W. Wen, "VLSI Test Principles and Architectures Design for Testability", Morgan Kaufmann Publishers. 2006
5. Robert J. Feugate, Jr., Steven M. Mentyn, "Introduction to VLSI Testing", PHl, Englewood Cliffs, 1998.
6. D. Gizopoulos, (Editor), Advances in Electronic Testing: Challenges and Methodologies, Springer, 2005.
7. Miron Abramovici, Melvin A. Breur, Arthur D. Friedman, "Digital Systems Testing and Testable Design", Jaico Publishing House, 2001.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENT802-2/ENT803-2 **Course : SoC Design**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to :

1. Apply the knowledge of SoC architecture and organization in resource constrained environment
2. Analyze processor microarchitectures for SoC
3. Evaluate on chip interconnect structure for SoC
4. Apply the basic concepts of NoC architecture, topologies and router design
5. Investigate MPSoC using design metrics
6. Identify the requirement of SoC testing
7. Design SoC based Embedded System on FPGA

Syllabus

Introduction to the Systems Approach, Chip Basics : Time, Area, Power, Reliability and Configurability, Design Trade - Offs, Requirements and Specifications.

Processors : Processor Selection for SoC, Basic Concepts in Processor Microarchitecutre, Vector, Very Long Instruction Word (VLIW), and Superscalar Processors.

Memory Design : System - on - Chip and Board - Based Systems. Cache Memory, Virtual Memory, DRAM.

Interconnect : Bus Basic Architecture, SoC Standard Buses, AMBA, Bus Interface Units, Bus Sockets and Bus Wrappers.

Network - on Chip : Architecture, Topologies, Switching strategies, Routing Algorithm, Bufferless NoC.

MPSoCs : Concept of MPSoCs, Techniques for designing MPSoCs, Performance and flexibility for MPSoCs design.

SoC Testing : SOC Test Problems/requirements, JTAG Standard, IEEE P1500 Standard, SOC Test Methodology, Testable SOC Design Flow.

Design of ARM Based SoC, FPGA prototyping of hardware/software systems, SoC integration

Text Books

1. Computer System Design : System - on - Chip : Michael J. Flynn, Wayne Luk, Wiley India 2012.
2. Modern VLSI Design : IP-Based Design, Wayne Wolf, PHI Learning 4/E (English) 4th Edition.

Reference Books

1. Michael Keating, Pierre Bricaud, "Reuse Methodology Manual for System on Chip Designs", Kluwer Academic Publisher, 2E, 2008.
2. On-Chip Communication Architectures : System on Chip Interconnect : Sudeep Pasricha, NikilDutt , Morgan Kaufmann Publisher, 2008.
3. ARM University Program "System - on - Chip " Module.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENT802-3/ENT803-3 **Course : Nano Material and Nanotechnology**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

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

1. Understand the basic science behind the design and fabrication of nano scale systems.
2. Understand and formulate new engineering solutions for current problems and competing technologies for future applications.
3. Make inter disciplinary projects applicable to wide areas by clearing and fixing the boundaries in system development.
4. Gather detailed knowledge of the operation of fabrication and characterization devices to achieve precisely designed systems.

Syllabus

Introduction to Nanoscience and Nanotechnology

Background to Nanoscience : Definition of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challenges of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ratio, surface effects on the properties.

Types of Nanostructure and properties of Nanomaterials

One dimensional, two dimensional and three-dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical - physical - chemical properties.

Nanomaterial Synthesis

Chemical routes, Electrochemical methods, Vapor growth, Thin films methods: chemical vapor deposition, physical vapor deposition (sputtering, laser ablation), Langmuir - Blodgett growth, Mechanical methods: ball milling, mechanical attrition, Sol-gel methods, Special nanomaterials: carbon nanotubes, fullerenes, nanowires, porous silicon.

Bio-inspired synthesis, Nanocomposite fabrication, Nanolithography.

Characterization of Nanostructures and Nanomaterials

Scanning Electron Microscopy (SEM), Field Emission Scanning Electron Microscopy (FESEM), High Resolution Transmission Electron Microscope (HRTEM), Scanning Tunneling Microscope (STM), Atomic Force Microscopy (AFM), X-ray Photoelectron Spectroscopy (XPS), Raman Spectroscopy, Infrared Spectroscopy, X-Ray Diffraction, Photoluminescence Spectroscopy.

X- ray Fluorescence Method, Energy Dispersive Analysis of X-rays (EDAX), Thermogravimetry, Differential Thermal Analysis and Differential scanning calorimetry.

Application of Nanomaterial

Ferroelectric materials, coating, molecular electronics and nanoelectronics, biological and environmental, membrane-based application, polymer-based application.

Text Book

1. Edelstein A S and Cammarata R C, "Nanomaterials: synthesis, Properties and Applictions", Taylor and Francis, 2012.

Reference Book

1. Michael Wilson, Kamali Kannangara and Geoff Smith, "Nanotechnology - Basic Science and Emerging Technologies", A CRC Press Company, D.C, 2002.
2. Nanotechnology and Nanoelectronics - Materials, Devices, Measurement Techniques, W. R. Fahrner, 2006, Springer-Verlag Berlin, Germany.
3. Fundamental of Nanoelectronics, first Edition, George W. Hanson, Pearson education, prentice Hall, 2008.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENT802-4/ENT803-4 **Course : Low Power VLSI Design**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to :

1. identify the sources of power dissipation in CMOS.
2. optimize power dissipation specifically with low power methodology in digital systems
3. Design low - power CMOS circuits using varied strategies at different design levels.

Syllabus

Hierarchy of Limits of Power

Principles of low power design, hierarchy of limits - (fundamental, material, device, circuit & system), theoretical limits, practical limits.

Sources of power dissipation

Switching power dissipation, Short-circuit power dissipation. leakage power dissipation.

Voltage Scaling Approaches

Challenges in supply voltage scaling; Static voltage scaling approaches - device feature size scaling, architectural level approaches and transformations (parallelism & pipelining), voltage scaling through optimal transistor sizing, voltage scaling using high level transformations; Multi-level voltage scaling - Multiple Vdd circuits, Issues in multi-level voltage scaling; Voltage scaling using threshold reduction - Threshold voltage scaling, fabrication of multiple threshold voltages, Transistor stacking, Variable threshold voltage CMOS, Multi Threshold Voltage CMOS.

Adiabatic Switching

Conventional vs, Adiabatic charging, adiabatic amplification, adiabatic logic circuits, pulsed power supply, partially adiabatic circuits.

Minimizing Switched Capacitance

Hardware vs software approaches; Algorithmic optimization - minimizing number of operations (coding techniques, use of number systems)

Architectural optimization

optimizing data representation for arithmetic computation, ordering of input signals, reducing glitching activity, resource sharing; Clock gating - clock gating principle, improved clock gating circuit, clock gating at various levels (module-level, register level, cell level), challenges in massively

gated clocks ; State encoding - clock-gated FSM, FSM state encoding, FSM partitioning, Operand isolation, Pre-computation; Logic optimization - logic minimization and technology mapping; Circuit optimization - dynamic logic vs static logic, pass transistor logic vs conventional CMOS logic ; Physical Design - layout optimization.

Battery - driven System Design

Overview of battery technologies, principles of battery discharge, battery modeling, battery-aware scheduling and management.

Text Books

1. Low-Power CMOS VLSI Circuit Design: K. Roy. John Wiley & Sons Inc. 2003.

Reference Books

2. Low Power Digital CMOS Design : Chandrakasan, R. Brodersen Springer (I/E) (2006).
3. Low- Power Digital VLSI Design: Circuits and Systems: A. Bellaourar. M. Elmasry. Springer (I/E) (2006).
4. Low - Power VLSI Circuits and Systems: Pal. A. Springer Nature: (2014)
5. CMOS Digital Integrated Circuits - Analysis and Design - Sung-Mo Kang, Yusuf Leblebici, TMH, 2011.
6. Leakage in Nanometer CMOS Technologies - Siva G. Narendran, Anatha Chandrakasan
7. Low-Voltage, Low-Power VLSI Subsystems - Kiat-Seng Yeo, Kaushik Roy, TMH Professional Engineering.
8. Introduction to VLSI Systems: A Logic, Circuit and System Perspective - Ming-BO Lin, CRC Press, 2011
9. Practical Low Power Digital VLSI Design - Gary K. Yeap, Kluwer Academic Press, 2002.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENT802-5/ENT823-5 **Course : Mixed Signal VLSI Design**

L : 3 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Course Outcome

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

1. Apply the concept of Switched Capacitor Circuits, PLL, Data Converters in the domain of mixed signal VLSI design.
2. Analyze the basic building blocks in mixed signal VLSI processing.
3. Select suitable design approaches while trading off conflicting requirements for Mixed Signal circuits.
4. Investigate performance metrics for design of Mixed Signal circuits.

Syllabus

Introduction

Analog versus Discrete Time signals, A/D conversion, Sample and Hold Characteristics, DAC specifications, Nonlinearity, offset, gain error, latency, SNR, dynamic range. ADC specifications - Quantization error, nonlinearity, missing codes, Aliasing, aperture error. Mixed signal layout issues.

Switched Capacitor Circuits and Comparators

basic building blocks, Operation and Analysis, Non-ideal effects in switched capacitor circuits, switched capacitor integrators first order filters, switch sharing, Switched-capacitor amplifiers, switched capacitor integrator, switched capacitor common mode Feedback. Single stage amplifier as comparator, cascaded amplifier stages as comparator, latched comparators. Offset cancellation, Op Amp offset cancellation, Calibration techniques.

Phase Locked Loop

Basic PLL topology, Dynamics of simple PLL, Charge pump PLLs- Lock acquisition, Phase/Frequency detector and charge pump, Basic charge pump PLL, Non- ideal effects in PLLs-PFD/CP non-idealities, Jitter in PLLs, Delay locked loops, applications. Data Converters: DC and dynamic specifications, Quantization noise, Nyquist rate D/A converters- Decoder based Converters, Binary-Scaled converters, Thermometer-code converters, Hybrid converters.

Successive approximation converters, Flash converter, Two-step A/D converters, Interpolating A/D Converters, Folding A/D converters, Pipelined A/D converters, Time- Interleaved Converters.

Noise shaping modulators, Decimating filters and interpolating filters, Higher order modulators, Delta sigma D/A, Nonlinear Behavior in Delta Digma Modulators, Multistage Sigma Delta Modulation, Oversampled Sigma Delta Modulation, Quantization Noise Spectra

Text Book

1. BehzadRazavi, "Principles of data conversion system design", IEEE press, 1995.

Reference Book

1. R.Jacob Baker, "CMOS Mixed Signal circuit design", Wiley-IEEE press, 2008.
2. R. Schreier, G. Temes, "Understanding Delta-Sigma Data Converters", Wiley-IEEE Press, 2004.
3. Philip E. Allen and Douglas R. Holberg, "CMOS Analog Circuit Design", Oxford University Press, International 2nd Edition/Indian Edition, 2010.
4. David A. Johns,Ken Martin, "Analog Integrated Circuit Design", Wiley Student Edition, 2013.
5. Rudy Van De Plassche, "CMOS Integrated Analog-to-Digital and Digital-to-Analog converters", Kluwer Academic Publishers, 2003.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENT802-6/803-6/802-7/803-7 **Course : MOOC - I / MOOC - II**

L : 0 Hrs., P : 0 Hrs., Per week **Total Credits : 3**

Credit transfer from any MOOC course / Online platform course related to the pool of electives offered in III semester.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENP804 **Course : Project Phase - I**

L : 0 Hrs., P : 16 Hrs., Per week **Total Credits : 8**

Course Outcomes

Upon completion of this course, students will demonstrate the ability to :

1. Critically evaluate alternate assumptions, approaches, procedures, tradeoffs, and results related to engineering problems.
2. Apply engineering knowledge for design and implementation of VLSI based circuits and systems in an ethically responsible manner.
3. Use written and oral communications to document the research work and present results.
4. Engage in self & life - long learning in continuing professional development.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENP805 **Course : Research Methodology (MOOC/Any online Platform)**

L : 0 Hrs., P : 0 Hrs., Per week **Total Credits : 2**

Credit transfer from any MOOC course / Online platform course

Content of the course should cover following points

Introduction to research methodology

Literature Review and Formulating a Research Problem Data Collection and Analysis

Computing Tools and Techniques in Research Technical Writing and IPR

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENP806 **Course : Industry Internship - I / Research Internship - I**

L : 0 Hrs., P : 0 Hrs., Per week **Total Credits : 14**

Students opted for Industry Internship - Phase - I or Research Internship - Phase - I can select the appropriate problem statement in the appropriate field of VLSI Design.

Course Outcomes

Upon completion of this course, students will demonstrate the ability to :

1. Critically evaluate alternate assumptions, approaches, procedures, tradeoffs, and results related to engineering problems.
2. Apply engineering knowledge for design and implementation of VLSI based circuits and systems in an ethically responsible manner.
3. Use written and oral communications to document the research work and present results.
4. Engage in self & life - long learning in continuing professional development.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENP851 **Course : Project Phase - II**

L : 0 Hrs., P : 28 Hrs., Per week **Total Credits : 14**

Course Outcomes

Upon completion of this course, students will demonstrate the ability to :

1. Critically evaluate alternate assumptions, approaches, procedures, tradeoffs, and results related to engineering problems.
2. Apply engineering knowledge for design and implementation of VLSI based circuits and systems in an ethically responsible manner.
3. Use written and oral communications to document the research work and present results.
4. Engage in self & life - long learning in continuing professional development.

Syllabus for Semester III
M. Tech. (VLSI Design)

Course Code : ENP852 **Course : Industry Internship - II / Research Internship - II**

L : 0 Hrs., P : 0 Hrs., Per week **Total Credits : 14**

Students opted for Industry Internship-Phase-II or Research Internship-Phase-II can select the appropriate problem statement in the appropriate field of VLSI Design.

Course Outcomes

Upon completion of this course, students will demonstrate the ability to:

1. Critically evaluate alternate assumptions, approaches, procedures, tradeoffs, and results related to engineering problems.
2. Apply engineering knowledge for design and implementation of VLSI based circuits and systems in an ethically responsible manner.
3. Use written and oral communications to document the research work and present results.
4. Engage in self & life - long learning in continuing professional development.