Indian Institute of Technology Jodhpur

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Executive M. Tech. Program
in
Intelligent VLSI Systems

Curriculum Structure
for AY 2022-23 Onwards

Introduction

The proposed M.Tech program in Intelligent VLSI Systems is designed to provide working professionals with the state of the art knowledge in the domain of VLSI Systems, including semiconductor fundamentals, emerging devices and compact modelling, advanced circuits and systems, system on chip design, signal processing, on-chip machine learning algorithms, VLSI for communication and others. The program is planned to be in synchronous/asynchronous/campus immersion mode, and is open to all working professionals. The proposed Executive M. Tech programme for Intelligent VLSI Systems of IIT Jodhpur includes state of the art analog and digital VLSI circuits and systems, mixed signal circuits, testing and verification algorithms, issues with system integration for performance considerations, covering wide aspects of embedded and computing systems, and emerging applications. It will cover a wide aspect of fundamentals, design skills, hands on through physical/hybrid/online mode and current trends in the industry. It will lead the professionals to learn without a career break with classes conducted on weekends/weekdays evening in the synchronised mode. The education delivery methodology combines classroom and experiential learning. Experiential learning consists of lab exercises, assignments, case studies and work integrated activities.

Objectives

Main objective of this program is to upskill the working professionals by exposing them to the current era of VLSI systems with a deeper understanding of its various components: from devices to hardware design. By imparting extensive knowledge, the program focuses on novel approaches to processing and computation for energy- and memory-efficient hardware. With the availability of massive data acquisition and data processing, the current research and trend in future computing systems is oriented towards memory-driven and edge computing AI architectures. The other main objective of the program is to enable the graduates to innovate and to apply the gained knowledge in their working environment.

The graduates will eventually be contributing to all-encompassing areas of Intelligent VLSI Systems which include emerging semiconductor devices and modelling, analog & mixed-signal circuits, RF integrated circuits (ICs), ASIC and SoC Design, embedded intelligence, self-adaptive systems, flexible electronics, neuromorphic computing, hardware for AI, state of the art non-volatile memories, machine learning, 5G communication, Internet of things (IoT) and others. The course will rigorously train the professional graduates so as to enable them to take up new challenges and solve the problems in the domain of the current and future VLSI systems. The knowledge of theoretical concepts with in depth analysis and understanding of practical design issues will make their profession more refined and result oriented in the areas of next generation VLSI systems.

Various state of the art computational facilities are available in the institute like NVIDIA DGX2 which will help the candidates to learn high performance computing, to implement machine learning algorithms and learn the concepts of data analysis. Further, the candidates will also have access to various design/EDA tools like Cadence Virtuoso, Mentor Graphics, Synopsys etc for academic purposes only.

For cost intensive technology related hands-on sessions, the candidates are encouraged to avail the facilities of IITJ during their mandatory two weeks contact visit to IITJ per semester. The programme will run through synchronised learning platforms, will use a continuous evaluation system that will assess the learners over convenient and regular intervals. Such a system provides timely and frequent feedback and helps busy working professionals stay on course with the programme. Participants who successfully complete the programme will become members of an elite & global community of IIT Jodhpur Alumni.

The objectives of this program are summarised as follows:

- Insight of semiconductor device physics, modelling and fabrication.
- Theoretical as well as practical knowledge of circuits and systems
- System Design issues and challenges
- Embedded Intelligence
- Machine learning algorithms, signal processing and data acquisition
- Algorithm level and architectural level optimization and implementation
- State-of-the art system design methodologies as well as current trends in the industry
- Brain-Inspired Technologies
- Novel approaches to processing and computation for energy and memory-efficient hardware
- Development of testing and verification skills through state of the art algorithms
- Exposure to layout, floorplanning, placement and routing techniques
- High speed system design issues and performance considerations
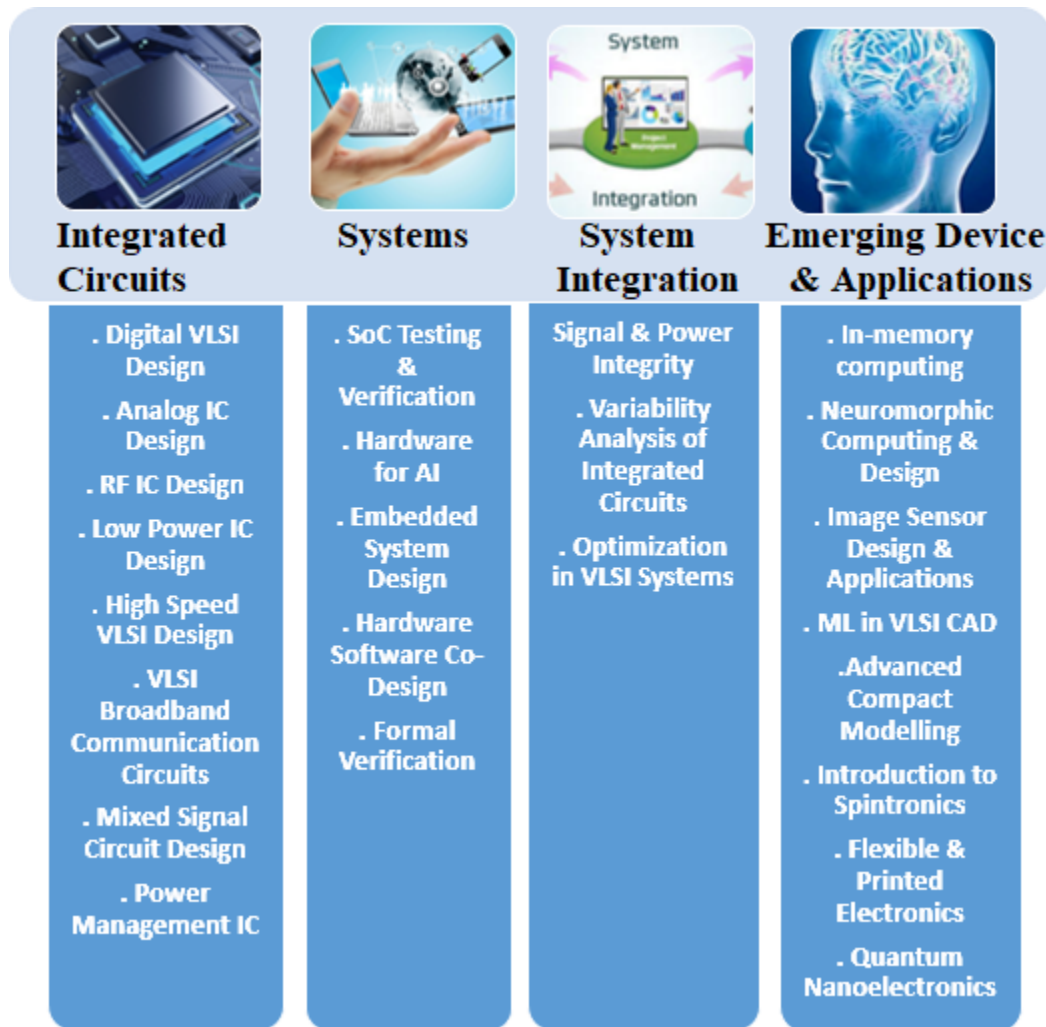
Graduate attributes

- Ability to follow a multidisciplinary approach for design and implementation of systems, involving various domains of Engineering, and Sciences.
- To learn top-to-bottom approach for IC design
- Exposure to computing for embedded intelligent systems
- To learn machine learning tool and its application in domains like VLSI for signal processing and communication
- To apply the skills and course aspects directly in the profession and working environment
- Exposure to design issues and challenges in ASIC and SoC Design
- Exposure to system level integration and challenges including packaging and PCB related issues

Learning outcomes

- Implement and development of own SPICE compact model for circuit simulations
- Exposure to state-of-the-art compact models, process and IC fabrication technology
- Ability to design digital, analog, mixed signal circuits
- Knowledge of ASIC flow for IC fabrication and tape out
- Knowledge of programming, algorithms and system development techniques
- Knowledge of state of the art non-volatile memories
- Able to design and implement algorithms for optimising hardware

- Knowledge of system integration and challenges associated with high speed designs
- Knowledge of VLSI design flow covering both front end and back end.

Topic Clouds and Course Mapping

Integrated Circuits	Systems	System Integration	Emerging Device & Applications
. Digital VLSI Design	. SoC Testing & Verification	Signal & Power Integrity	. In-memory computing
. Analog IC Design	. Hardware for AI	. Variability Analysis of Integrated Circuits	. Neuromorphic Computing & Design
. RF IC Design	. Embedded System Design	. Optimization in VLSI Systems	. Image Sensor Design & Applications
. Low Power IC Design	. Hardware Software Co-Design		. ML in VLSI CAD
. High Speed VLSI Design	. Formal Verification		.Advanced Compact Modelling
. VLSI Broadband Communication Circuits			. Introduction to Spintronics
. Mixed Signal Circuit Design			. Flexible & Printed Electronics
. Power Management IC			. Quantum Nanoelectronics

M Tech (Intelligent VLSI Systems)

Program Structure

Category	M.Tech. Compulsory (MC)	M. Tech. Elective (ME)	M. Tech. Open (MO)	M. Tech. Project (MP)	Non Graded (NG)	Total
Credits	20	16	6	16	4	62

Semester wise distribution of credits for part-time M.Tech program

Cat.	Course Title	L-T-P	GC	Cat.	Course Title	L-T-P	GC.
I Semester				**II Semester**			
MC	Digital VLSI Design	3-0-0	3	MC	From Core Bouquet Courses		3
MC	Analog IC Design	3-0-2	4	MC	Hardware for Artificial Intelligence	3-0-0	3
MC	Physics and Modelling of MOS Transistors	3-0-0	3	ME	Program Elective - 1	3-0-0	3
MC	IC Design lab	0-0-2	1	NG	Technical Communication	1-0-0	1
	Total GC		**11**		**Total GC + NC**		**10**
III Semester				**IV Semester**			
MC	From Core Bouquet Courses		3	ME	Program Elective -3	3-0-0	3
ME	Program Elective- 2	3-0-0	3	ME	Program Elective- 4	2-0-0	2
MO	Open Elective - 1	3-0-0	3	MP	Project – 1	0-0-4	4
NG	Innovation and IP Management	1-0-0	1	NG	Systems Engineering and Project Management	1-0-0	1
	Total GC + NC		**10**		**Total GC + NC**		**10**
V Semester				**VI Semester**			
ME	Program Elective- 5	3-0-0	3	MP	Project- 3	0-0-8	8

MO	Open Elective - 2	3-0-0	3	ME	Program Elective-6	2-0-0	2
MP	Project - 2	0-0-4	4				
NG	Ethics and Professional Life	1-0-0	1				
	Total GC + NC		**11**		**Total GC**		**10**

List of Compulsory Core Courses:

S. No.	Course Name	L-T-P	Credits
1	Digital VLSI Design	3-0-0	3
2	Analog IC Design	3-0-2	4
3	Physics and Modelling of MOS Transistors	3-0-0	3
4	Hardware for Artificial Intelligence	3-0-0	3
5	IC Design lab	0-0-2	1

List of Core Bouquet Courses (Students need to select any one CB):

S. No.	Course Name	L-T-P	Credits
	Digital Systems (CB)		
1	ML in VLSI CAD	3-0-0	3
2	Processor Design	3-0-0	3
	Analog Systems (CB)		
3	Mixed Signal Circuit Design	3-0-0	3
4	VLSI Broadband Communication Circuits	3-0-0	3

List of Programme Elective Courses

Course Title	L-T-P	Credits
High Level Synthesis	3-0-0	3
Power Management IC	2-0-0	2
Resource Constrained AI	3-0-0	3
Neuromorphic Computing and Design	3-0-0	3
Formal Verification	2-0-0	2
RF IC Design	3-0-0	3
Embedded System Design	3-0-0	3
In-memory Computing	1-0-0	1
Machine Learning for Communication	3-0-0	3
Signal and Power Integrity	3-0-0	3
Machine Learning	3-0-0	3
Deep Learning	3-0-0	3
Optimization in VLSI Systems	2-0-0	2
Hardware Software Co-Design	3-0-2	4
Electromagnetic Interference in ICs	1-0-0	1
Introduction to Spintronics	3-0-0	3
Low Power IC Design	2-0-0	2
High Speed Interfaces	2-0-0	2
Flexible and Printed Electronics	3-0-0	3
Non-Volatile Memory Technologies	2-0-0	2
Quantum Nanoelectronics	3-0-0	3

Variability Analysis of Integrated Circuits	1-0-0	1
Integrated Circuit Technology	3-0-0	3
Sensors and Measurement	3-0-0	3
Semiconductor Reliability	3-0-0	3
SoC Testing and Verification	3-0-0	3
Selected Topics in VLSI Systems-I	1-0-0	1
Selected Topics in VLSI Systems-II	2-0-0	2
Selected Topics in VLSI Systems-III	3-0-0	3