**Machine Learning for VLSI Design and Automation**

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The course enables the students to understand the fundamentals of VLSI design concept in terms of fabrication steps, MOS device physics and Circuit designing. This course also focuses on the various aspects of machine learning methodologies for the effective utilization of processing steps and system design in VLSI.

Course Objectives:

* To familiarize the students about the VLSI Design flow
* To acquaint with different fabrication steps involved in IC manufacturing
* To introduce MOS FET behaviours in terms of its electrical characteristics.
* To expose concepts of circuit designing and integration
* To create awareness on machine learning methodologies
* To impart knowledge on present Machine learning scenarios on fabrication steps
* To understand the machine learning methodologies physical verification and design.

**Unit I: Introduction to Fabrication**

Introduction to MOS Technology: Evolution of integrated circuits, Semiconductor materials, nMOS fabrication, pMOS fabrication, CMOS fabrication, BJT fabrication BiCMOS Fabrication, Thermal aspects of fabrication, production of e-beam MASKS, GaAs technologies, VLSI Design Flow.

**Unit II: Electrical Characteristics of Devices**

Basic Electrical Properties of MOS and BiCMOS Circuits: Drain-to Source current vs. voltage relationships, aspects of MOS transistor threshold voltage, MOS transistor transconductance and output conductance, the pass transistor, the NMOS inverter, determination of pullup to pulldown ratio of NMOS transistor driven by another NMOS transistor, alternate forms of pullup, the CMOS inverter, MOS transistor circuit model, latch up in CMOS circuits

**Unit III: Sub-System Design**

Sub System Design and Layout: Architectural issues, switch logic, gate logic, examples of structural design (Combinational logic), some clocked sequential circuits. Memory register and aspects of system timing: Some commonly used storage/memory elements. Subsystem design process: General arrangement of 4-bit arithmetic processor, regularity. Design of an ALU subsystem.

**Unit IV: AL & ML and VLSI CAD**

What Is Machine Learning, Examples of Machine Learning Applications: Learning Associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning. Machine Learning Taxonomy, VLSI CAD Abstraction Levels, Machine Learning for Lithography: The Lithographic Patterning Process.

**Unit V: AL &ML in Physical Design**

Machine Learning for Mask Synthesis: Introduction, Machine Learning-Guided OPC, Machine Learning-Guided EPC, Machine Learning in Physical Verification design: Machine Learning in Physical Verification, Machine Learning in Mask Synthesis, Machine Learning in Physical Design.

**Learning Outcomes**

After completion of this course, the student will be able to

* Describe the different steps of NMOS and CMOS fabrication process and appreciate the role of mask layouts (L2).
* Explain the operating regions of MOSFET for different values of Vgs and Vds (L2).
* Draw the circuit diagram and explain the operation of NMOS and CMOS inverters (L3)
* Explain the concepts of AI & ML and abstraction levels involved in VLSI CAD (L2)
* Design sequential building blocks (Flip Flops, shift registers) using static and dynamic logic gates (L5).
* Understand the concepts of physical verification and mask synthesis with the help of AI &ML (L3)

**Textbooks:**

1. Douglas A, Pucknell, Kamran Eshraghian, Essentials of VLSI Circuits and Systems, 1/e, Prentice Hall, 2012
2. Ethem Alpaydin, Introduction to Machine Learning, Second Edition.
3. Ibrahim (Abe) M. Elfadel, Duane S. Boning and Xin Li (2019), Machine Learning in VLSI Computer Aided Design

**Reference books:**

1. Kang, Leblebici, CMOS Digital Integrated Circuits, 3/e, Tata McGraw

Hill,2001.

1. Gary S May, Simon M Sze, Fundamentals of Semiconductor Fabrication, 1/e, Wiley, 2004.
2. Machine Learning for Absolute Beginners by Oliver Theobald (2nd Edition)
3. Introduction to Machine Learning from Coursera

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Areas of Interest: Beyond CMOS, Nanoscale device design and modeling, Modeling and simulation of semiconductor devices, Carbon Nanotubes and novel 1D/2D materials, VLSI Circuits & Systems