ECE4181: MODELING AND SIMULATION OF MOS TRANSISTOR

Programme: **B. Tech. (ECE)** Year: 4th Semester : **Odd**
Course: **Program Elective** Credits: **3** Hours: 40

Course Context and Overview (100 words):

The Metal oxide semiconductor (MOS) transistor is the dominant VLSI device. A course devoted to modeling and simulation of modern MOS transistor will be extremely helpful to those who want to use the device to design state-of-the-art circuit. This course provides basic understanding of many phenomena encountered in the operation of MOS transistors and how such phenomenon can be modeled analytically. This course will begin with discussion on preliminary materials necessary for the understanding of MOS structures. Then two and three terminal MOS structures and their region of operations will be discussed in depth. Further, several analytical models will be discussed along with the effects of device miniaturization. Finally design of modern MOS devices and their applications will be discussed as case studies.

Prerequisite Courses:

- Mathematics-I
- Basic Electronics
- Semiconductor Devices and Circuits

Course outcomes (COs):

On completion of this course, the students will have the ability to:
CO1: Understand how a MOS transistor operates
CO2: Predict MOS transistor behavior, in the presence of many real effects
CO3: Understand the principles and considerations behind modern CAD models for MOS transistors, and even begin to create such models yourself
CO4: Design high performance circuits using detailed device knowledge.
CO5: Simulate characteristics of a simple device using ATLAS/ SYNOPSYS

Course Topics:

Topics	Lecture Hours	
UNIT - I **1. Semiconductors, Junctions and MOSFET Overview**		5
1.1. Introduction, Semiconductors, Conduction, Transit time, Drift, Diffusion	2	
1.2. Contact Potentials, The PN Junction	1	
1.3. Overview of MOS Transistor, Basic Structure, MOS Transistor Operation, MOS Transistor Characteristics	2	
UNIT - II **2. Two-terminal and Three-terminal MOS Structures**		10
2.1. Flat-Band Voltage, Potential Balance and Charge Balance	2	
2.2. Effect of Gate-Substrate Voltage on Surface Condition, Flat-Band condition, Accumulation, Depletion	3	
2.3. General Relations and region of Inversion, Strong inversion, weak inversion, moderate inversion, Small signal capacitance	3	
2.4. Body Effect, Pinch-off Voltage	2	
UNIT – III **3. Long Channel MOS Transistor**		10
3.1. Transistor Regions of operation	2	
3.2. Complete Charge Sheet Model, Simplified Charge Sheet Model, Model based on Quasi-Fermi Potentials	3	
3.3. Strong Inversion Model, Weak Inversion Model	2	
3.4 Source Referenced vs Body Referenced Modeling	2	
3.5 Effective Mobility	1	
UNIT – IV **4. Small-Dimension Effects**		
4.1. Channel Length Modulation, Charge sharing, Drain induced Barrier lowering, Punch through	4	7
4.2. Carrier Velocity Saturation, Hot Carrier Effects, Scaling	3	
UNIT-V **5. Case Studies - Research Papers**		
5.1 Design of MOS Transistor using Device simulator	4	8
5.2 Project	4	

Text Book:

1. Y. Tsividis and C. McAndrew, *Operation and Modeling of the MOS Transistor*, 3rd Edition, Oxford University Press, 2011.

Reference Books:

1. C. Snowden, "*Introduction to Semiconductor Device Modeling*", World Scientific, 1986.
2. M. Lundstrom, "*Fundamentals of Carrier Transport*", Cambridge University, Press, 2000.
3. T.A. Fjeldly, T. Ytterdal and M. Shur, "*Introduction to device modeling and Circuit Simulation*", John Wiley, 1998.
4. Y. Taur and T.H. Ning, *"Fundamentals of Modern VLSI Devices*", Cambridge University Press, 1998.

Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):

1. https://nptel.ac.in/courses/117106091/#
2. https://nptel.ac.in/courses/117106033/#

Evaluation Methods:

Evaluation criteria will be shared by the concerned course instructor.

Prepared By: Kanjalochan Jena
Last Update: April 24, 2019