GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Electronics & Communication (VLSI System Design)

Course / Subject Code : ME01000361

Course / Subject Name : MOSFET modeling for VLSI Circuits

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PCC

Prerequisite:	Basic Fundamental knowledge of semiconductor physics and devices, mathematics.
Rationale:	The students need to learn in ME-VLSI must possess a good understanding of concepts of modelling of MOSFET. Students also need to learn about various short channel effects and its modeling. This is one of the foundation courses which are required for designing stateof-art MOSFET based circuits for applications demanding low-power, low-voltage, and high speed application

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Understand basics of Semiconductor physics.	U
02	Understand MOS capacitor modeling and effects of frequency on C-V characteristic.	U
03	Study and analyze MOSFET modeling techniques.	N
04	Analyze Short-channel effects and its modeling.	N
05	Study and analyze MOSFET parameter measurements and Benchmark tests for MOSFET models.	N

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction of MOSFET modeling**: Circuit Design with MOSFETs, MOSFET Modeling, Model Parameter Determination, Interconnect Modeling.	4	10
2.	**Basic of Semiconductor and pn Junction Theory** : Energy Band Model, Intrinsic Semiconductor, Extrinsic or Doped Semiconductor, Electrical Conduction, PN Junction at Equilibrium, Diode Current-Voltage Characteristics	8	20
3.	**MOS Transistor Structure and Operation** : MOSFET Structure, MOSFET Characteristics, MOSFET Scaling, Hot-Carrier Effects, VLSI Device Structures, MOSFET Parasitic Elements, effective or Electrical Channel Width	8	20
4.	**MOS Capacitor** : MOS Capacitor with No Applied Voltage, MOS Capacitor at Non-Zero Bias, Capacitance of MOS Structures,	7	15
5.	Threshold Voltage : MOSFET with Uniformly Doped Substrate, Non-uniformly Doped MOSFET, Threshold Voltage Variations with Device Length and Width, Short-Channel Effect, Narrow-Width Effect, Drain Induced Barrier Lowering (DIBL) Effect, Small-Geometry Effect.	7	15
6.	**SPICE Diode and MOSFET Models and Their Parameters** : Diode Model, MOSFET Level 1 DC Model, Level 1 Capacitance Model, MOSFET Level 2 DC Model, Level 2 Capacitance Model, MOSFET BSIM Model	5	10
7.	**Advance MOSFET Models**: Double gate MOSFET, FINFET and Gate All Around MOSFETs.	6	10
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**20**	**20**	**30**	**10**	**10**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. N. D. Arora, MOSFET Models for VLSI Circuit Simulation, Springer-Verlag.
2. S. M. Sze, Physics of Semiconductor Devices, (2e), Wiley Eastern.
3. J. P. Colinge, Fin-FETs and other multi-gate Transistors, Springer.
4. Operation and Modeling of the MOS Transistor, Y. Tsividis.

(b) Open source software and website:

1. Multisim
2. PSPice
3. Spice (Open Source Software)

Suggested Course Practical List :(30 Hours)

1. To obtain ID – VGS characteristic of n-channel and p-channel MOSFET for different values of VDS and VBS.
2. To obtain ID – VDS characteristic of n-channel and p-channel MOSFET for different values of VGS and VBS.
3. To obtain C – V characteristic of p-type substrate MOS capacitor.
4. To obtain VTn as a function of VBS for n-channel MOSFET device and calculate body-bias parameter.
5. To obtain VTn as a function of VDS for n-channel MOSFET device and calculate DIBL parameter.
6. To obtain leakage current as a function of VDS for n-channel MOSFET device and calculate Sub-threshold (SS) parameter.
7. To observe CLM effect from ID – VDS characteristic of n-channel MOSFET device and calculate output resistance.
8. To obtain gm – VGS characteristic of n-channel and p-channel MOSFET for different values of VDS and VBS. Calculate threshold voltage from gm – VGS characteristic.
9. To obtain following parameters for two different technologies and compare them. a) DIBL b) SS c) Output resistance
10. To observe the effect of leakage current, simulate CMOS inverter circuit in Standard CMOS technology and obtain leakage power dissipation
11. To measure ID –VGS and ID - VDS characteristic for n-channel/p-channel MOSFET device. Obtain Following parameters: a) Body-bias parameter b) DIBL c) SS d) Output resistance

List of Laboratory/Learning Resources Required:

i. Function Generator

ii. Oscilloscope

iii. Digital Multi-meter

iv. DC Power Supply (0-30 V)

Suggested Project List:

Open Ended Problems:

1. Write a 'c' program to obtain gm - VGS from ID –VGS characteristic for n-channel/p-channel MOSFET device.

2. Write a 'c' program to obtain gds – VDS from ID - VDS characteristic for n-channel/p-channel MOSFET device.

3. Write a 'c' program to obtain threshold voltage from ID –VGS characteristic for n-channel/p-channel MOSFET device.

4. Write a 'c' program to obtain leakage current information from ID –VGS characteristic for n-channel/pchannel MOSFET device.

5. Write a 'c' program to obtain output resistance from ID –VGS characteristic for n-channel/p-channel MOSFET device.

6. Write a 'c' program to obtain body-bias parameter from ID –VGS characteristic for n-channel/p-channel MOSFET device.

7. Write a 'c' program to obtain DIBL parameter from ID –VGS characteristic for n-channel/p-channel MOSFET device.

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