



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering Syllabus

Subject Code : 3716301

Subject Name : MOSFET Modeling for VLSI Circuits

WEF Academic Year :	2023 - 24
Semester :	1
Category of the Course :	Core I

Type of course : MOSFET Device Modeling, Advanced Semiconductor Devices

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 state-of-art MOSFET based circuits for applications demanding low-power, low-voltage, and high speed application.

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			ESE(E)	PA	ESE (V)	PA(I)		
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.	% 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



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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.	3	10
Total		42	100

Reference 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. Tsididis.

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

1. To understand basics of Semiconductor physics.
2. To understand MOS capacitor modeling and effects of frequency on C-V characteristic.
3. To study and analyze MOSFET modeling techniques.
4. To analyze Short-channel effects and its modeling.
5. To study and analyze MOSFET parameter measurements and Benchmark tests for MOSFET models.

Suggested List of Experiments :

1. To obtain $I_D - V_{GS}$ characteristic of n-channel and p-channel MOSFET for different values of V_{DS} and V_{BS} .
2. To obtain $I_D - V_{DS}$ characteristic of n-channel and p-channel MOSFET for different values of V_{GS} and V_{BS} .
3. To obtain C - V characteristic of p-type substrate MOS capacitor.
4. To obtain V_{Th} as a function of V_{BS} for n-channel MOSFET device and calculate body-bias parameter.
5. To obtain V_{Th} as a function of V_{DS} for n-channel MOSFET device and calculate DIBL parameter.
6. To obtain leakage current as a function of V_{DS} for n-channel MOSFET device and calculate Sub-threshold (SS) parameter.
7. To observe CLM effect from $I_D - V_{DS}$ characteristic of n-channel MOSFET device and calculate output resistance.
8. To obtain $g_m - V_{GS}$ characteristic of n-channel and p-channel MOSFET for different values of V_{DS} and V_{BS} . Calculate threshold voltage from $g_m - V_{GS}$ 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 $I_D - V_{GS}$ and $I_D - V_{DS}$ characteristic for n-channel/p-channel MOSFET device. Obtain Following parameters:
 - a) Body-bias parameter
 - b) DIBL



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- c) SS
- d) Output resistance

Open Ended Problems :

1. Write a 'c' program to obtain $g_m - V_{GS}$ from $I_D - V_{GS}$ characteristic for n-channel/p-channel MOSFET device.
2. Write a 'c' program to obtain $g_{ds} - V_{DS}$ from $I_D - V_{DS}$ characteristic for n-channel/p-channel MOSFET device.
3. Write a 'c' program to obtain threshold voltage from $I_D - V_{GS}$ characteristic for n-channel/p-channel MOSFET device.
4. Write a 'c' program to obtain leakage current information from $I_D - V_{GS}$ characteristic for n-channel/p-channel MOSFET device.
5. Write a 'c' program to obtain output resistance from $I_D - V_{GS}$ characteristic for n-channel/p-channel MOSFET device.
6. Write a 'c' program to obtain body-bias parameter from $I_D - V_{GS}$ characteristic for n-channel/p-channel MOSFET device.
7. Write a 'c' program to obtain DIBL parameter from $I_D - V_{GS}$ characteristic for n-channel/p-channel MOSFET device.

Major Equipment :

- i. Function Generator
- ii. Oscilloscope
- iii. Digital Multi-meter
- iv. DC Power Supply (0-30 V)

List of Open Source Software/ Learning website :

Multisim
PSPice
NGspice (Open Source Software)

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