FOVLSI
Fundamentals of VLSI Design

Course Code : 18EC6DCFOV **Credits :** 03

COURSE OBJECTIVES:

- To understand the basic concepts of MOSFET and study of MOSFET based circuits.
- To understand the basic fabrication process and lambda-based design rules.
- To acquire the knowledge of Additional CMOS logic structures.
- To design combinational circuits used in data path subsystems.
- To apply MOSFET properties for memory cell design.
- To understand the concept of MOSFET based single stage amplifiers.
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Module 1

- **Basic MOS Technology:** Introduction to MOS transistors, nMOS fabrication, CMOS fabrication, Bi-CMOS technology. (Text book-1)
- **MOS Transistor Theory:** Introduction, MOS Device Design Equations, nMOS inverter, Alternate form of Pull up, (Text book-1), DC Characteristics of CMOS Inverter, Inverter switching characteristics, Power dissipation (Text book-2).

Text Book 1

- Douglas A. Pucknell, Kamran E., "Basic VLSI Design", 3rd Edition, *PHI Publication*, India.

Text Book 2

- John P.Uyemura, "Introduction to VLSI Circuits and Systems", Wiley India Edition, 3rd print, 2007.

What is an IC

- An **integrated circuit** or **monolithic integrated circuit** (also referred to as an **IC**, a **chip**, or a **microchip**) is a set of electronic circuits on one small flat piece (or "chip") of semiconductor material that is normally silicon.

Advantages of IC's

1. Very small size
2. Low cost
3. Reduce power consuption
4. Highly reliable
5. Higher operating speed
6. Reduced external wiring connections
7. Easy to use

IC Density of Integration

Density of Integration / Complexity	Gates per IC
SSI: Small-Scale Integration • Logic Gates (AND, OR, NAND, NOR)	<10
MSI: Medium-Scale Integration • Flip Flops • Adders / Counters • Multiplexers & De-multiplexers	10 – 100
LSI: Large-Scale Integration •Small Memory Chips •Programmable Logic Device	100 – 10,000
VLSI: Very Large-Scale Integration •Large Memory Chips •Complex Programmable Logic Device	10,000 – 100,000
ULSI: Ultra Large-Scale Integration •8 & 16 Bit Microprocessors	100,000 – 1,000,000
GSI: Giga-Scale Integration •Pentium IV Processor	>1,000,000

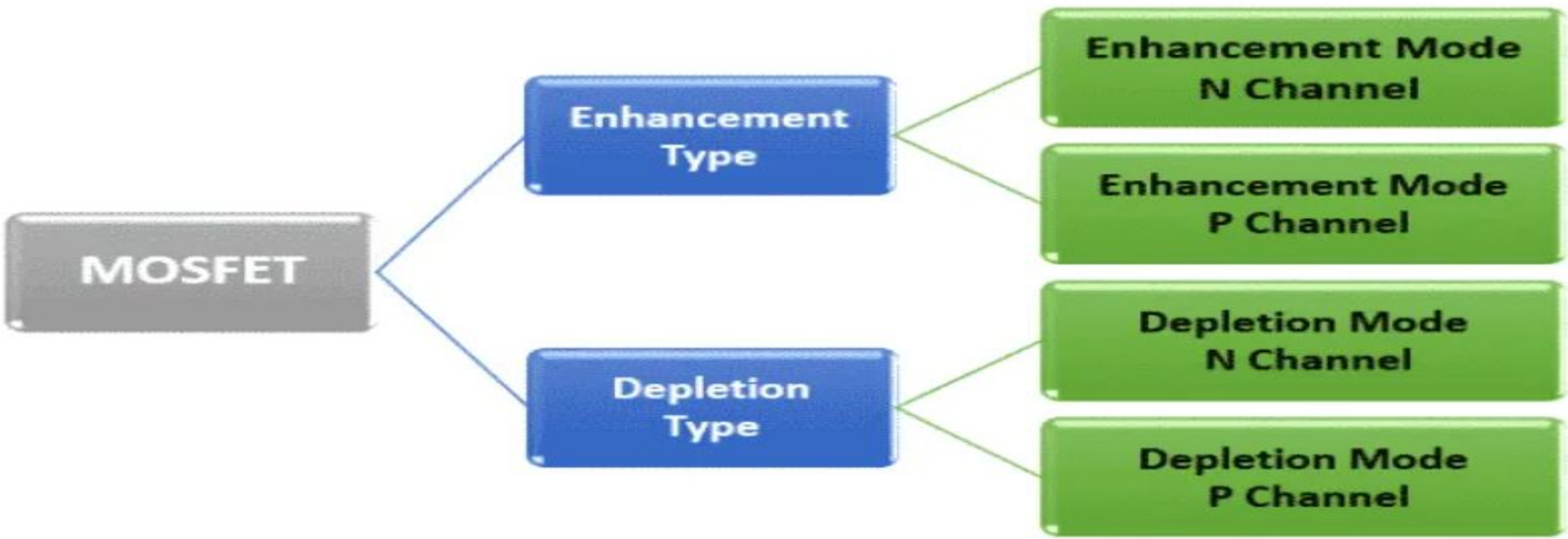
MOSFET

- **M**etal **O**xide **S**ilicon **F**ield **E**ffect **T**ransistor is abbreviated as MOSFET. It is merely a unipolar transistor and used as an electronic switch and to amplify electronic signals.
- The device has three terminals consisting of a source, gate and drain. Apart from these terminals there is a substrate generally called the body which is always connected to the source terminal for practical applications.

Types of MOSFET

On the basis of Operational Mode, MOSFETs can be classified into two types.

- Enhancement Type MOSFETs
- Depletion Type MOSFETs



Enhancement Type MOSFET

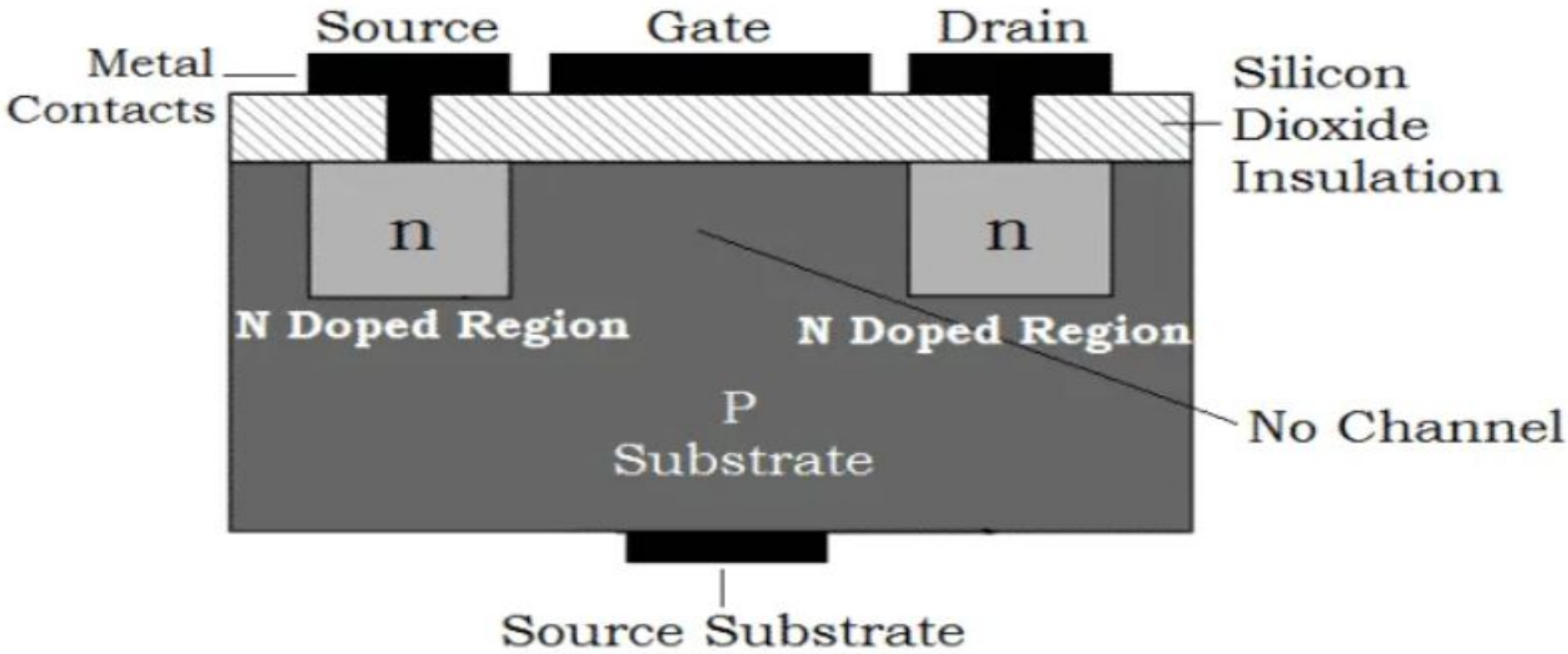
In this mode, there is no conduction at zero voltage which implies it is closed or "OFF" by default as there is no existing channel. When the gate voltage is increased more than the source voltage, the charge carriers (holes) shifts away leaving behind the electrons and thus a wider channel is established.

Types of Enhancement MOSFETs

The Enhancement MOSFETs can be classified into two types depending upon the type of doped substrate (n-type or p-type) used.

- N Channel Enhancement Type MOSFETs
- P Channel Enhancement Type MOSFETs

N Channel Enhancement Mode MOSFET



- A lightly doped P-type substrate forms the body of the device and the source and drain are heavily doped with N-type impurities.
- N-channel have electrons as majority carriers.
- The applied gate voltage is positive to turn “ON” the device.
- It has lower inherent capacitance and smaller junction areas due to the high mobility of electrons which makes it to operate at high switching speeds.
- It contains positively charged contaminants which makes the N-channel MOSFETs to turn on prematurely.
- Drain resistance is low compared to P-type.

Advantages of MOSFET

- MOSFETs provide greater efficiency while operating at lower voltages.
- Absence of gate current results in high input impedance producing high switching speed.
- They operate at lower power and draws no current.

Disadvantages of MOSFET

- The thin oxide layer make the MOSFETs vulnerable to permanent damage when evoked by electrostatic charges.
- Overload voltages makes it unstable.