Analog and Digital Systems (UEE505)

Lecture # 6
MOSFETs

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Deptt. Of Electrical & Instrumentation Engineering
Thapar Institute of Engineering & Technology Patiala, India

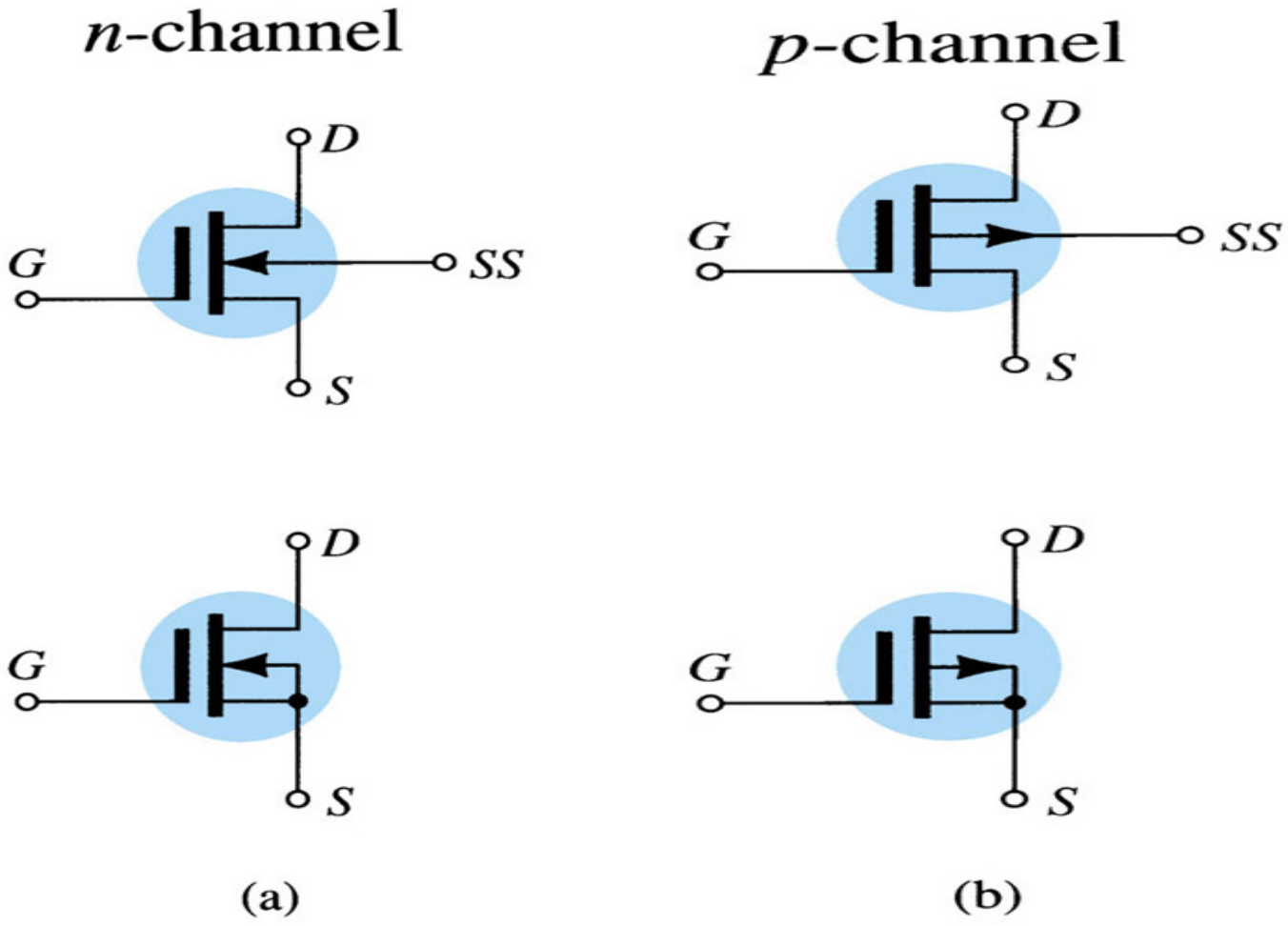
MOSFET Introduction

- MOSFETs have characteristics similar to JFETs and additional characteristics that make them very useful.

There are 2 types of MOSFET's:

- Depletion mode MOSFET (D-MOSFET):
  - Operates in Depletion mode the same way as a JFET when $V_{GS} \leq 0$
  - Operates in Enhancement mode like E-MOSFET when $V_{GS} > 0$
- Enhancement Mode MOSFET (E-MOSFET)
  - Operates in Enhancement mode
  - $I_{DSS} = 0$ until $V_{GS} > V_T$ (threshold voltage)

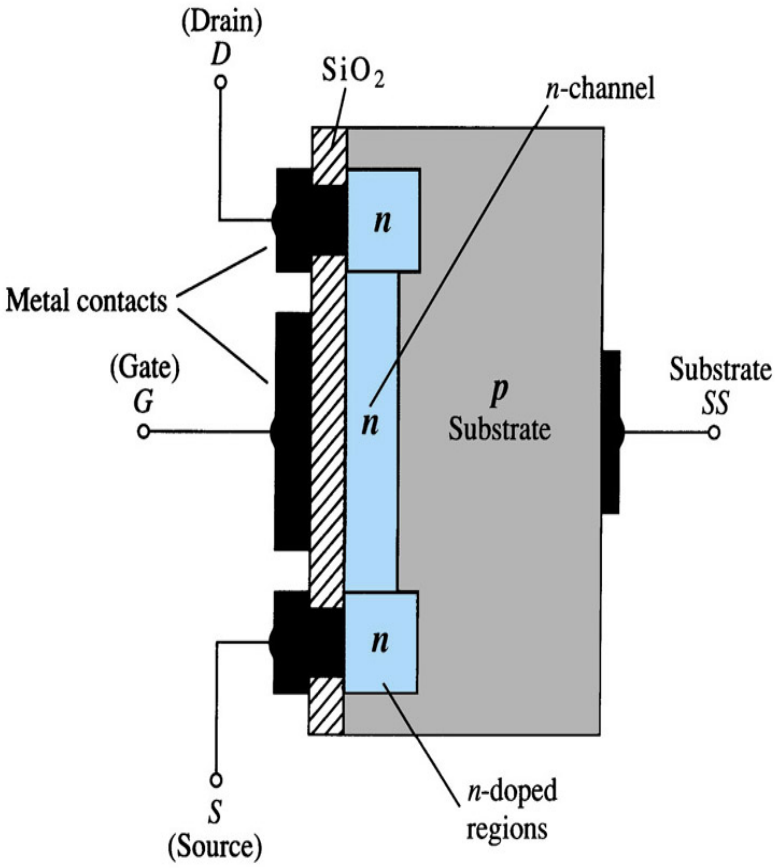
D-MOSFET Symbols



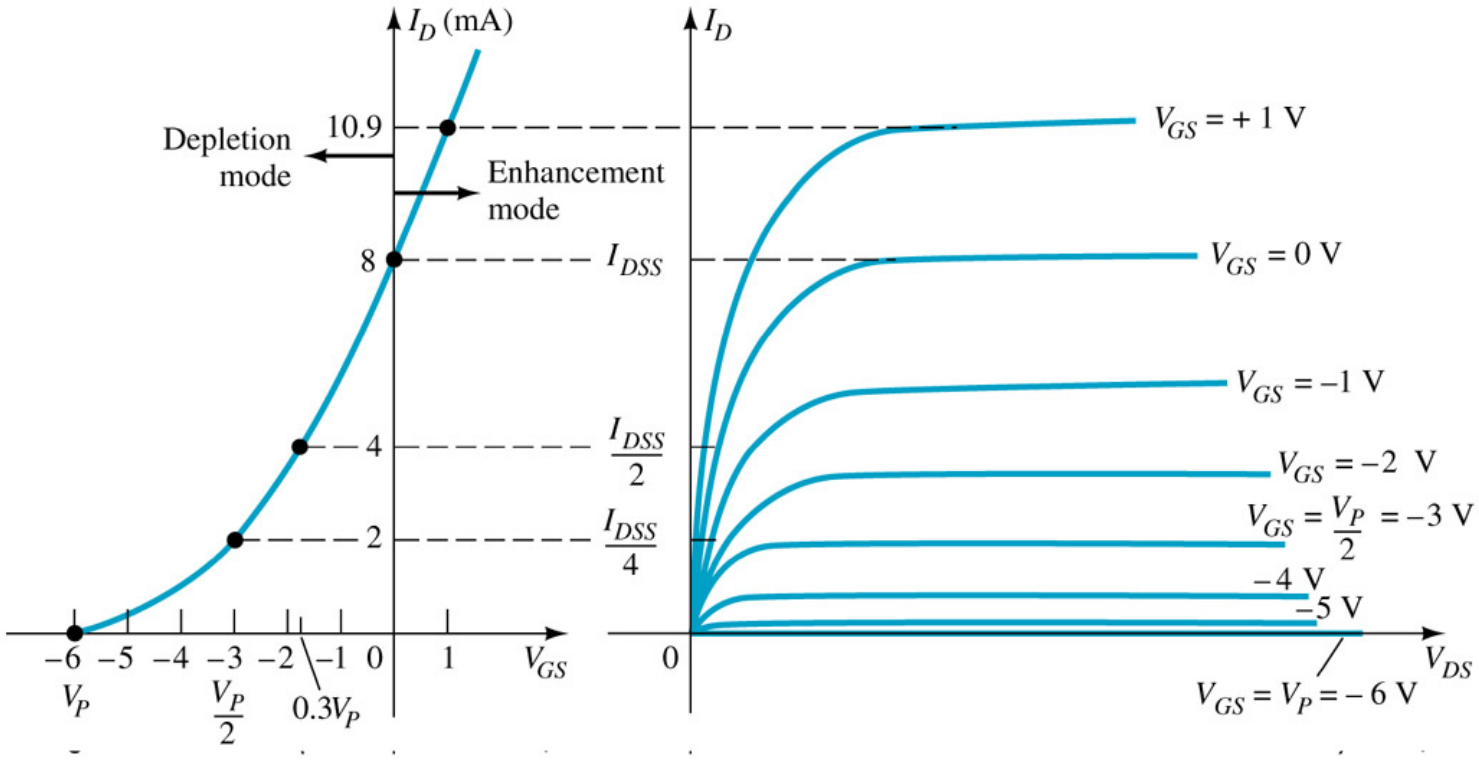
DMOSFET : Construction & Operation

- The Drain (D) and Source (S) connect to the to n-doped regions. These doped regions are connected via an n channel. This n-channel is connected to the Gate (G) via a thin insulating layer of SiO2.

- The n-doped material lies on a p-doped substrate that may have an additional terminal connection called Substrate (SS).



DMOSFET : Characteristics



In Depletion Mode :

When $V_{GS} = 0V$, $I_D = I_{DSS}$

When $V_{GS} < 0V$, $I_D < I_{DSS}$

In Enhancement Mode :

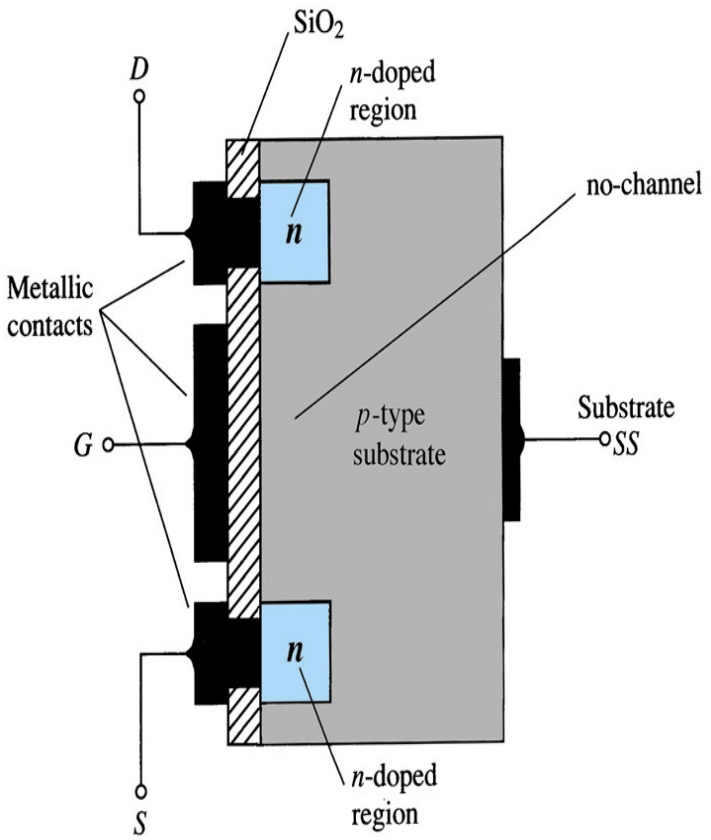
$V_{GS} > 0V$ and $I_D > I_{DSS}$

The formula used to plot the Transfer Curve is:

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

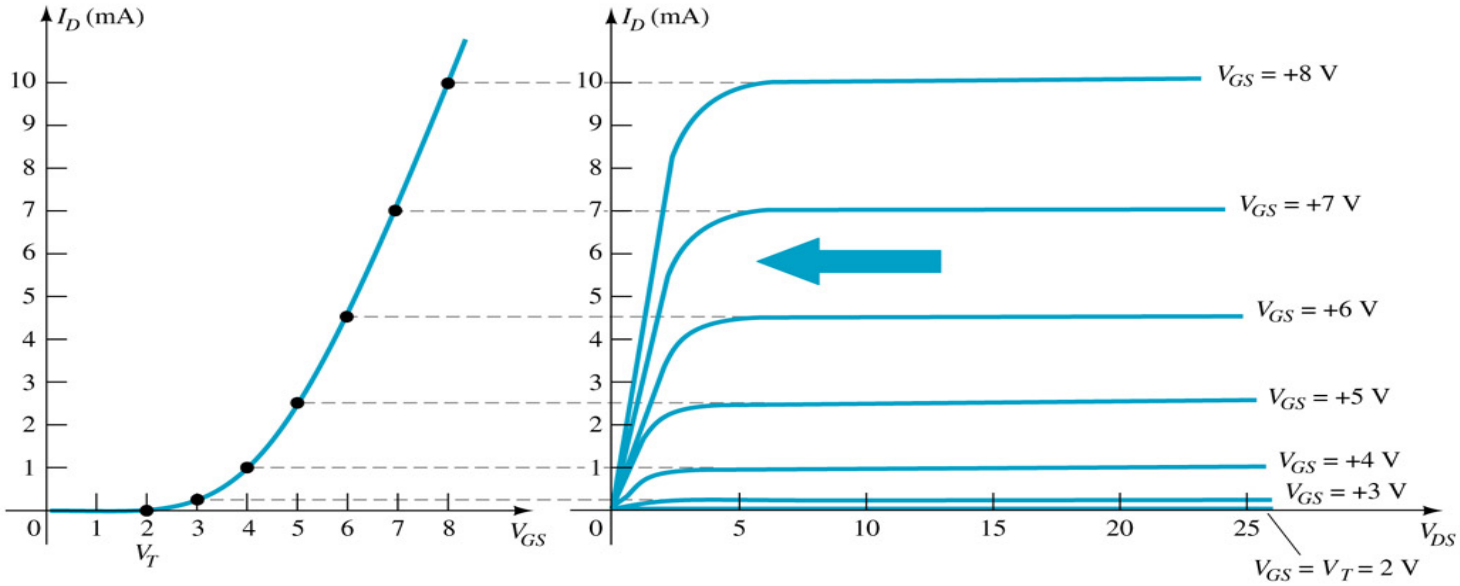
EMOSFET :Construction & Operation

- The Drain (D) and Source (S) connect to the to n-doped regions
- These n-doped regions are not connected via an n-channel without an external voltage
- The Gate (G) connects to the p-doped substrate via a thin insulating layer of SiO_2
- The n-doped material lies on a p-doped substrate that may have an additional terminal connection called SS



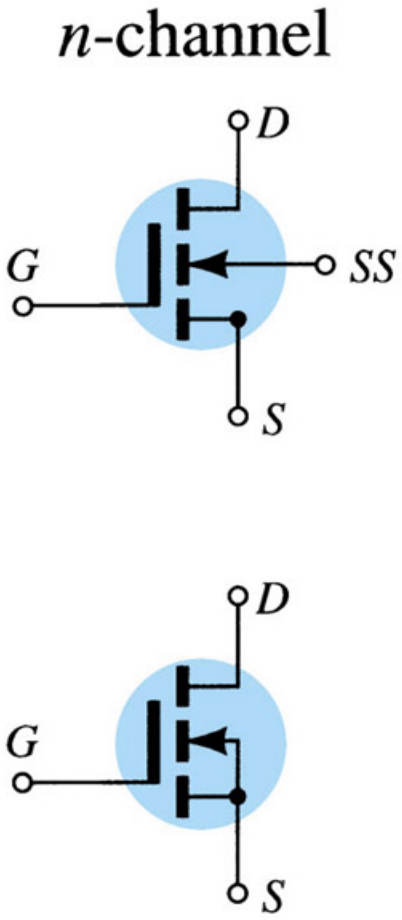
EMOSFET :Characteristics

- The Enhancement mode MOSFET only operates in the enhancement mode.



- **V_{GS} is always positive and $I_{DSS} = 0$ when $V_{GS} < V_T$**
- **As V_{GS} increases above V_T, I_D increases.**
- **If V_{GS} is kept constant and V_{DS} is increased, then I_D saturates (I_{DSS})**
- **To determine ID for given VGS: $I_D = k (V_{GS} - V_T)^2$**
- **where VT = threshold voltage or voltage at which the MOSFET turns on.**
- **k = constant found in the specification sheet. It is a function of the construction of the device.**

E-MOSFET Symbols



(a)

Applications of MOSFET

- Used as Inverter
- Switching Circuits
- Amplifiers
- Linear Voltage Regulator

References

- For more details, refer to:
  - *Boylestad R. L., Electronic Devices and Circuit Theory, Pearson Education*
  - *Neamen, Donald A., Electronic Circuit Analysis and Design, McGraw Hill*
  - *Sedra A. S. and Smith K. C., Microelectronic Circuits, Oxford University Press*