University of Anbar
College of Engineering
Dept. of Electrical Engineering

Fundumantal of Electronic II

Second Class

Chapter 6 : Field Effect Transistors

Lec06_p3

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MOSFETs

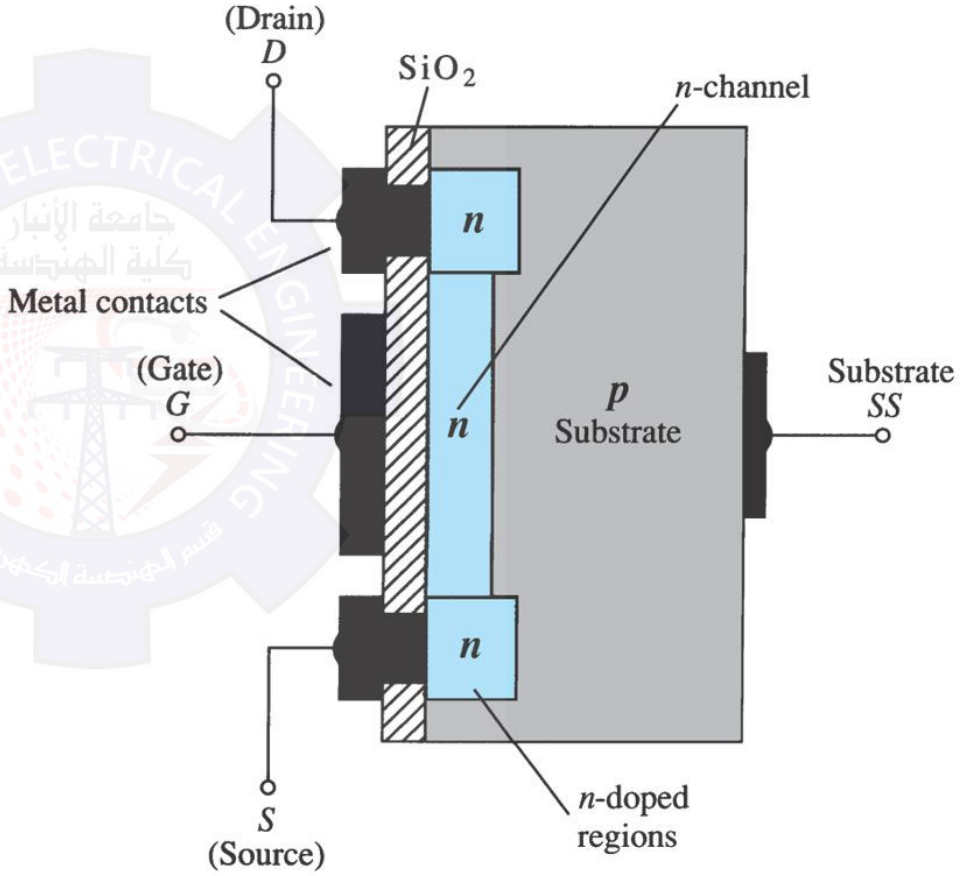
MOSFETs have characteristics similar to JFETs and additional characteristics that make then very useful.

There are two types of MOSFETs:

- **Depletion-Type**
- **Enhancement-Type**

Depletion-Type MOSFET Construction

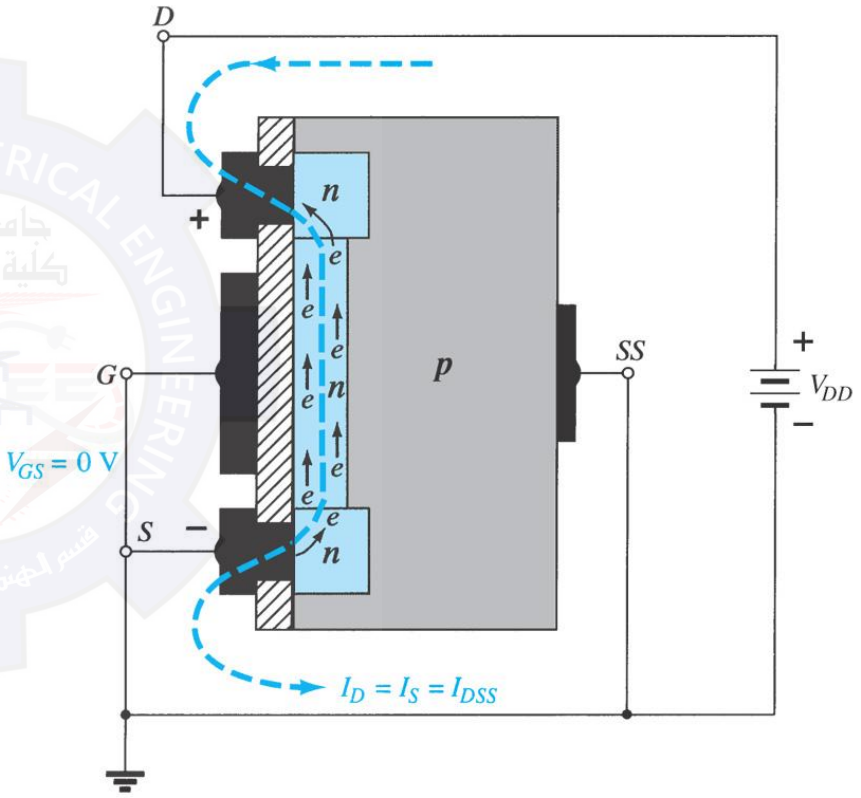
- The Drain (D) and Source (S) connect to the to *n*-doped regions.
- These *n*-doped regions are connected via an *n*-channel.
- This *n*-channel is connected to the Gate (G) via a thin insulating layer of SiO_2.
- The *n*-doped material lies on a *p*-doped substrate that may have an additional terminal connection called Substrate (SS).



n-Channel depletion-type MOSFET.

Depletion-Type MOSFET :Basic Operation and Characteristics

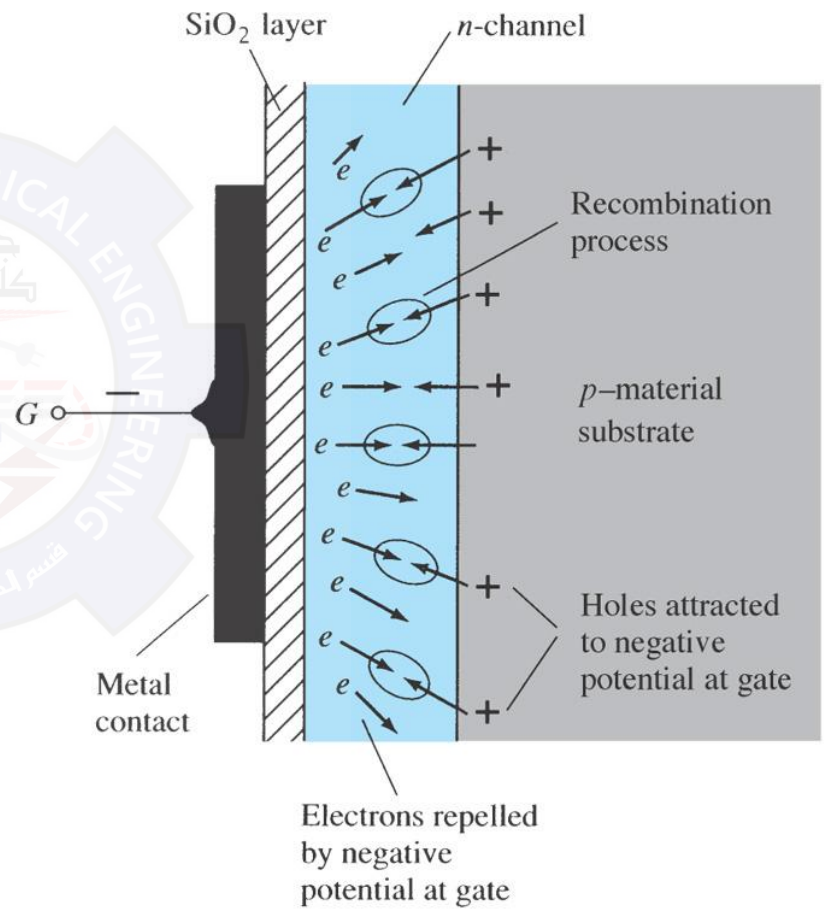
- V_{GS}=0 and V_{DS} is applied across the drain to source terminals.
- This results to attraction of free electrons of the n-channel to the drain, and hence current flows.



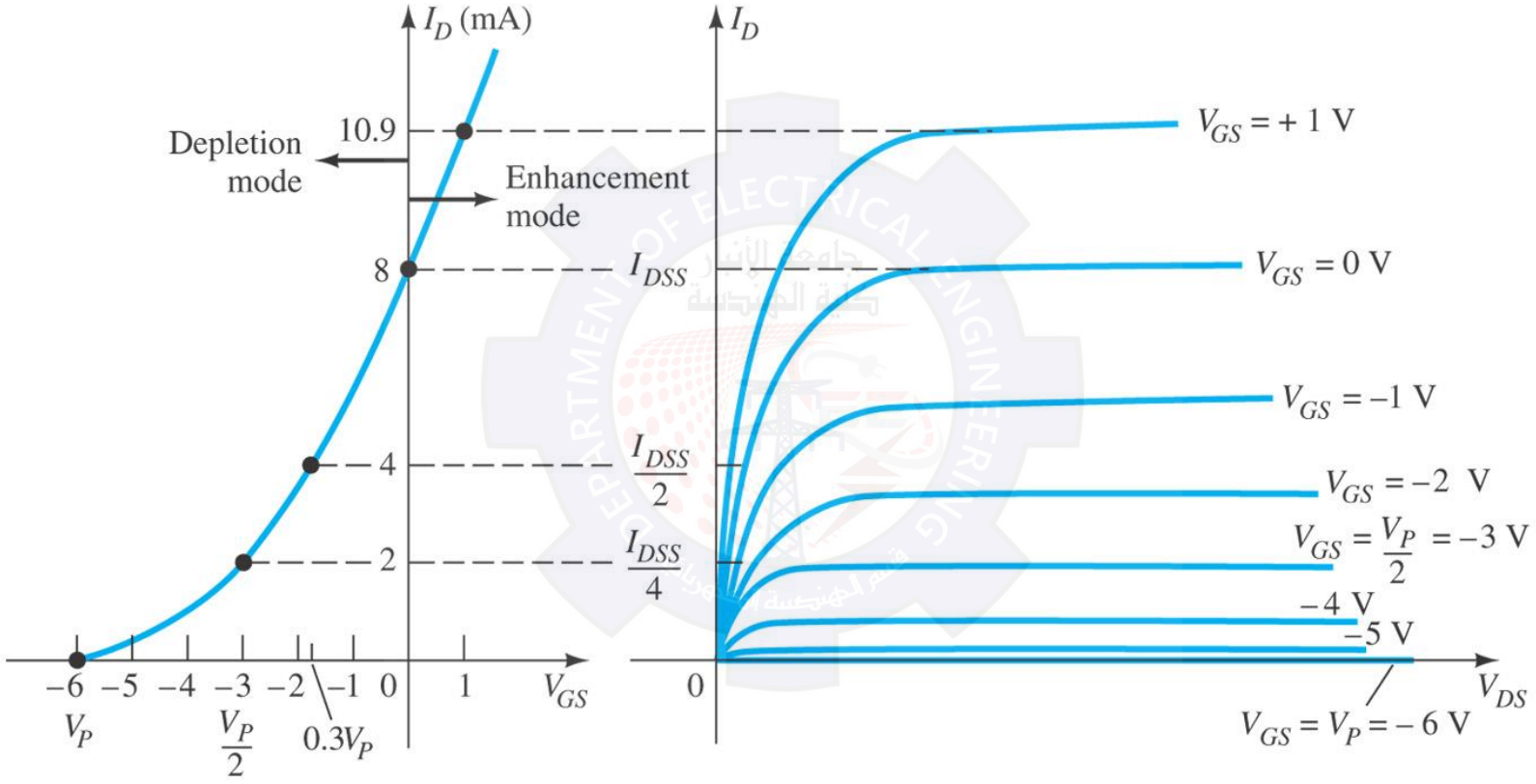
n-Channel depletion-type MOSFET with V_{GS} = 0 V and applied voltage V_{DD}.

Depletion-Type MOSFET :Basic Operation and Characteristics

- V_{GS} is set at a negative voltage such as -1 V.
- The negative potential at the gate pressures electrons toward the p-type substrate and attract holes from the p-type substrate.
- This will reduce the number of free electrons in the *n*-channel available for conduction.
- The more negative the V_{GS}, the resulting level of drain current I_D is reduced.
- When V_{GS} is reduced to V_P (Pinch-off voltage), then I_D=0 mA.



Depletion-Type MOSFET :Basic Operation and Characteristics

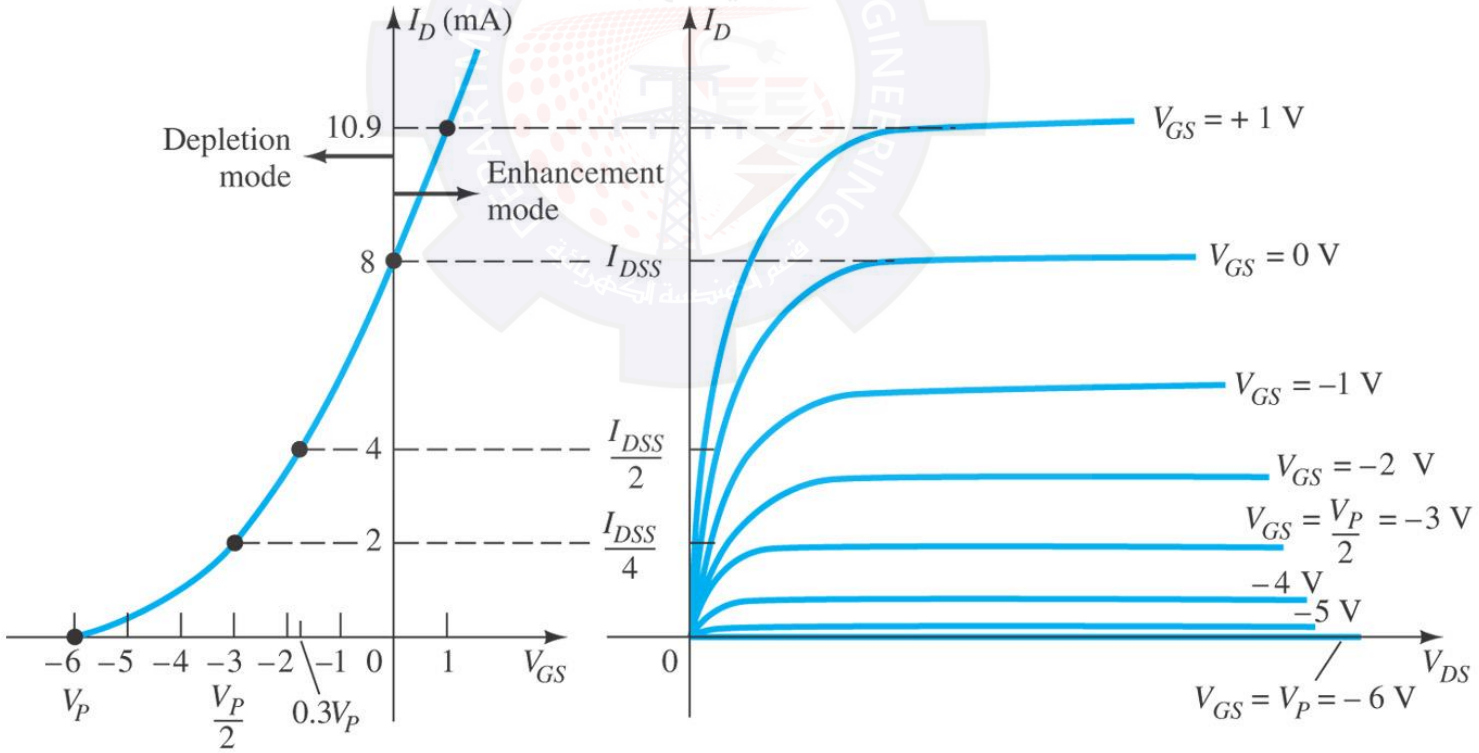


- When V_{GS} is reduced to V_P (Pinch-off) [i.e. V_p=-6V], then I_D=0 mA.
- For **positive** values of V_{GS}, the positive gate will draw additional electrons (free carriers) from the p-type substrate and hence I_D increases.

Basic MOSFET Operation

A depletion-type MOSFET can operate in two modes:

- **Depletion mode**
- **Enhancement mode**



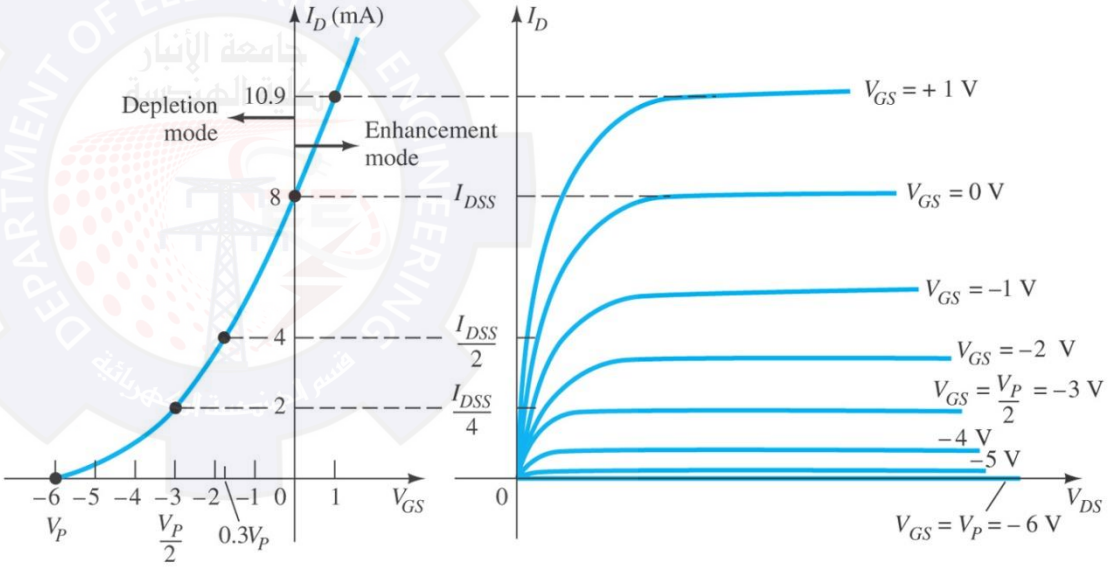
D-Type MOSFET in Depletion Mode

Depletion Mode

The characteristics are similar to a JFET.

- When $V_{GS} = 0$ V, $I_D = I_{DSS}$
- When $V_{GS} < 0$ V, $I_D < I_{DSS}$
- The formula used to plot the transfer curve still applies:

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

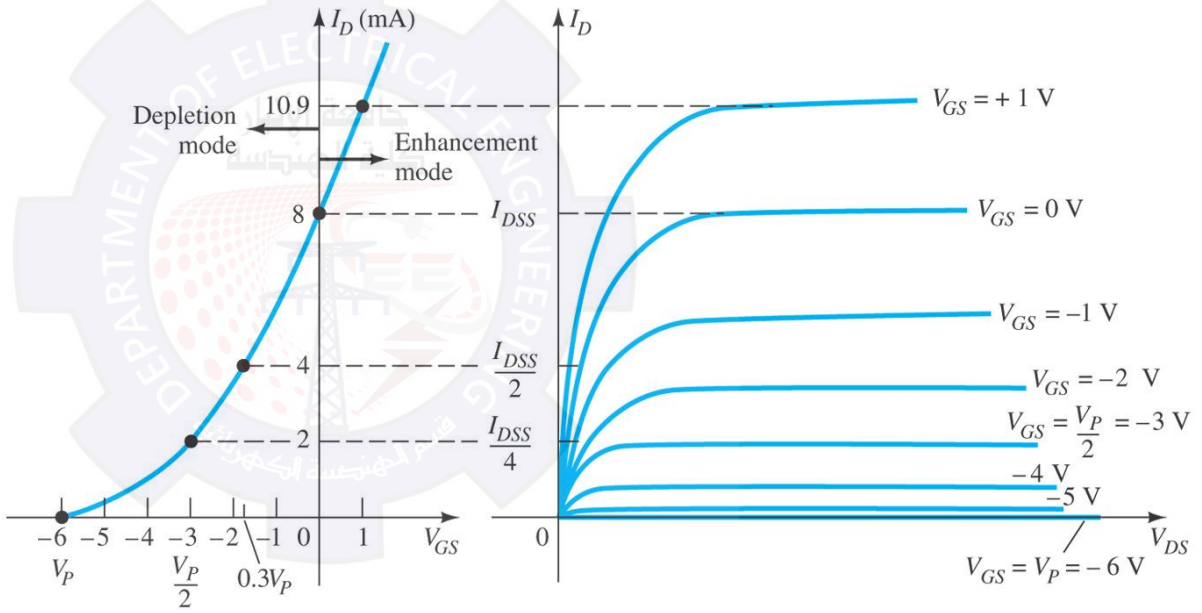


D-Type MOSFET in Enhancement Mode

Enhancement Mode

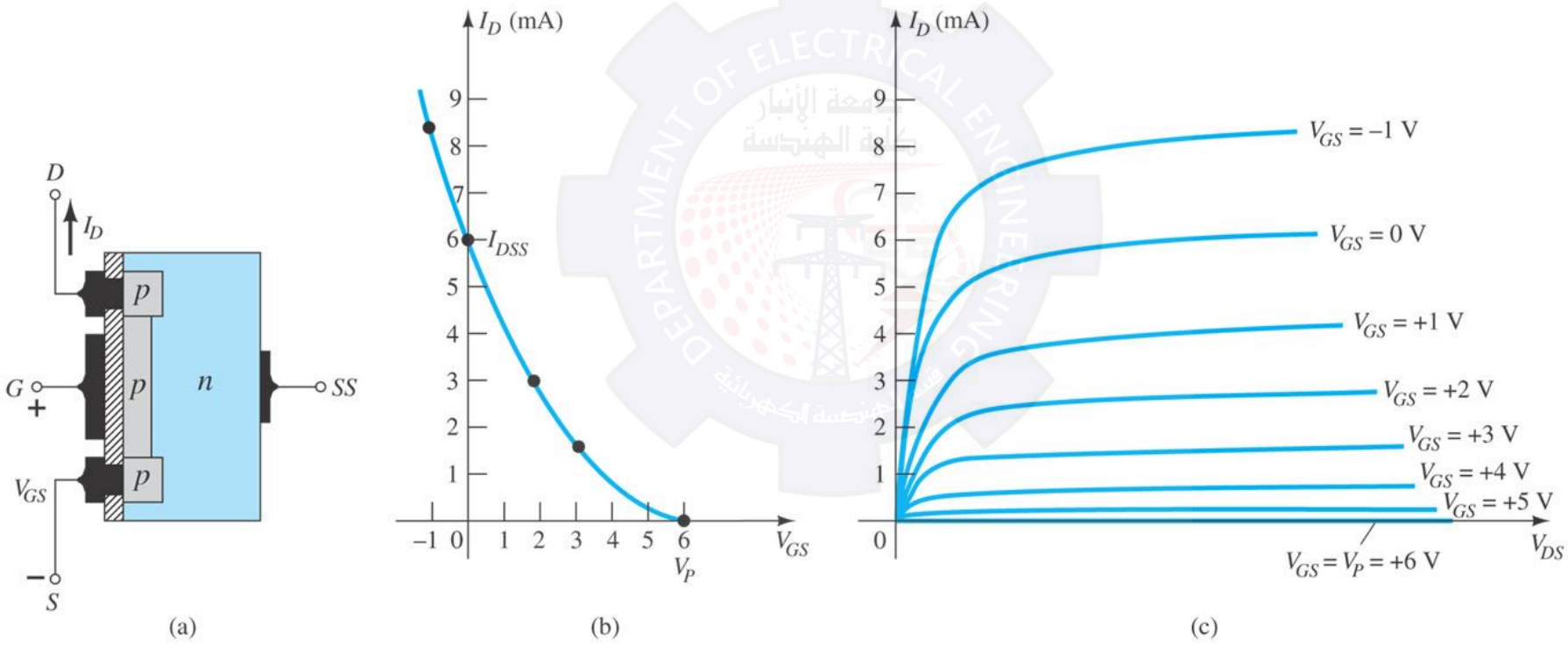
- $V_{GS} > 0$ V
- I_D increases above I_{DSS}
- The formula used to plot the transfer curve still applies:

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

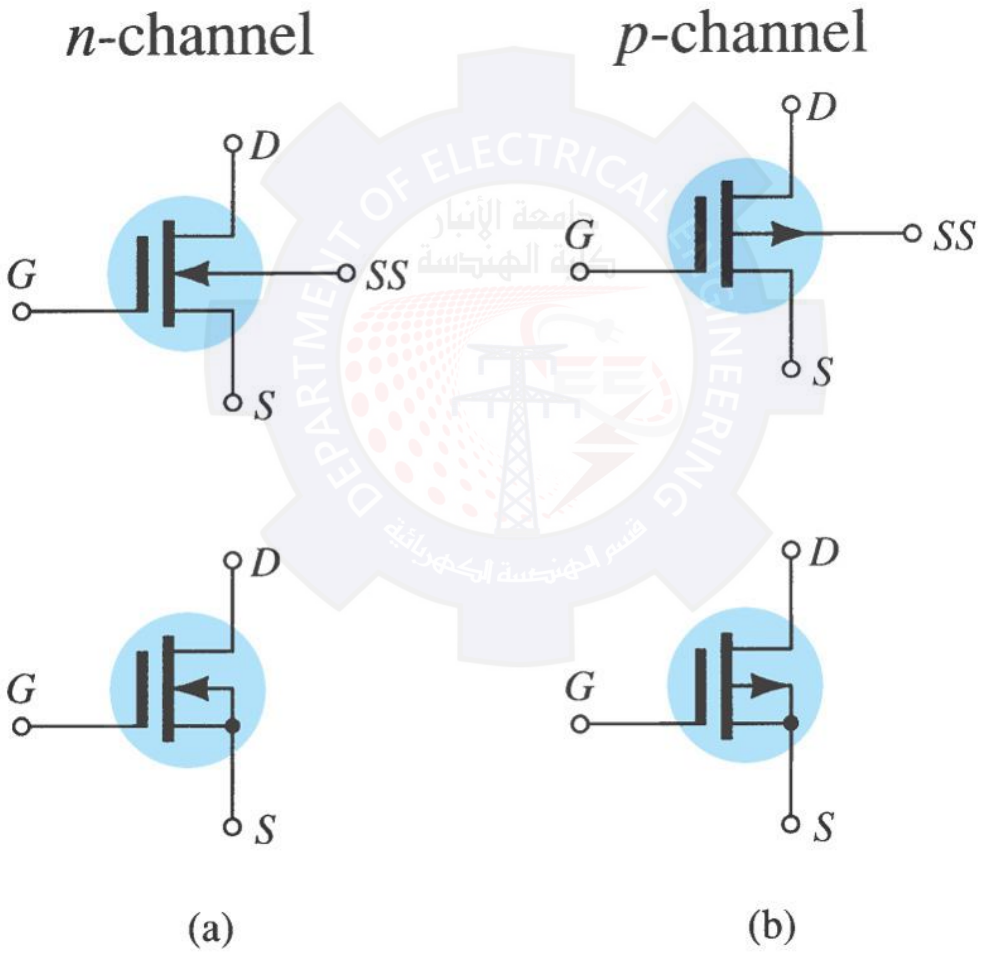


Note that V_{GS} is now a positive polarity

p-Channel D-Type MOSFET



D-Type MOSFET Symbols



(a) *n*-channel depletion-type MOSFETs ,(b) *p*-channel depletion-type MOSFETs