University of Anbar
College of Engineering
Dept. of Electrical Engineering

Fundumantal of Electronic II

Second Class

Chapter 6 : Field Effect Transistors

Lec06_p4

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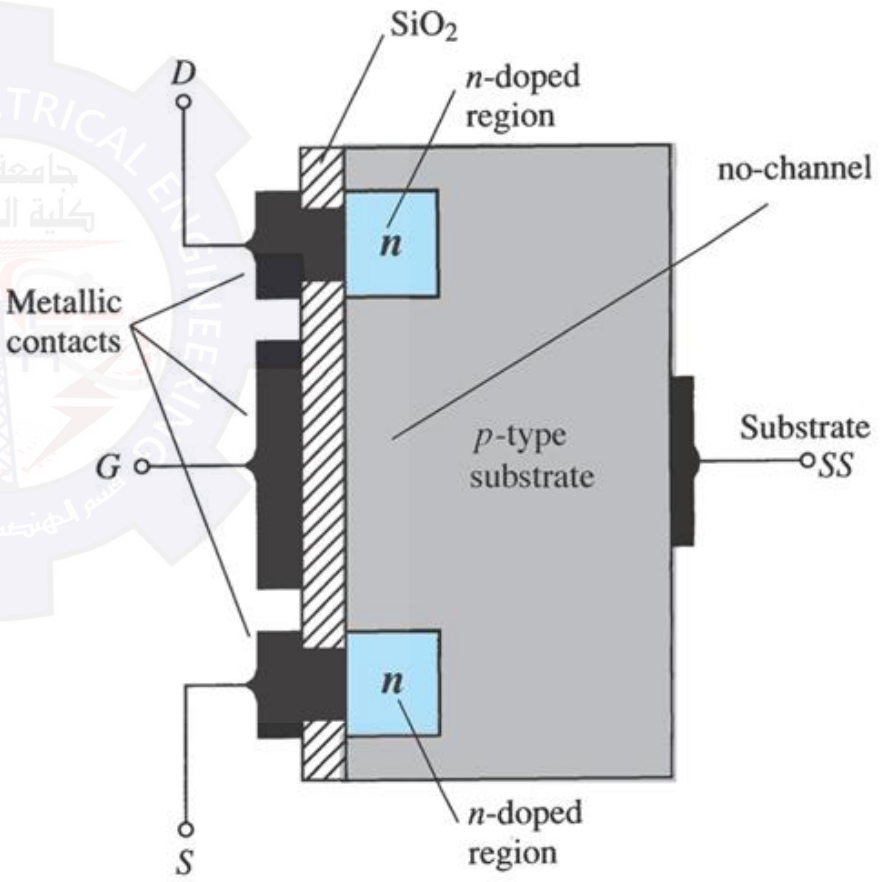
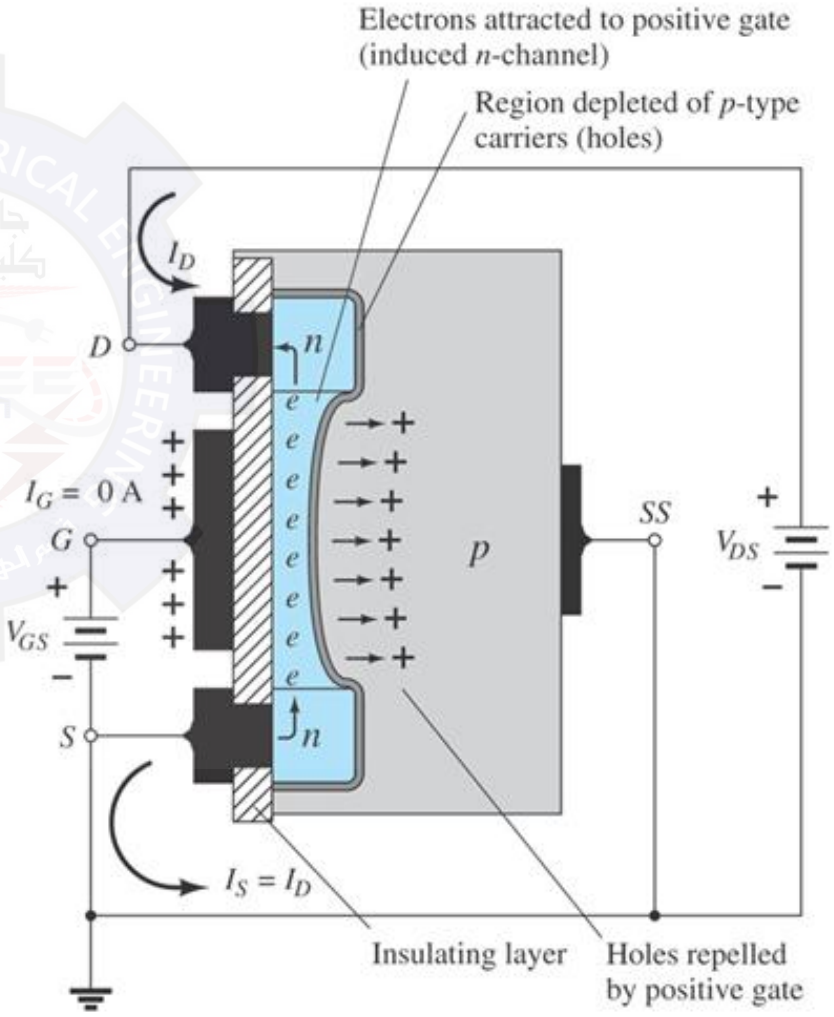
Enhancement-Type MOSFET Construction

- The Drain (D) and Source (S) connect to the to *n*-doped regions.
- The Gate (G) connects to the *p*-doped substrate via a thin insulating layer of SiO_2
- **There is no channel**
- The *n*-doped material lies on a *p*-doped substrate that may have an additional terminal connection called the Substrate (SS)



Enhancement-Type MOSFET Construction

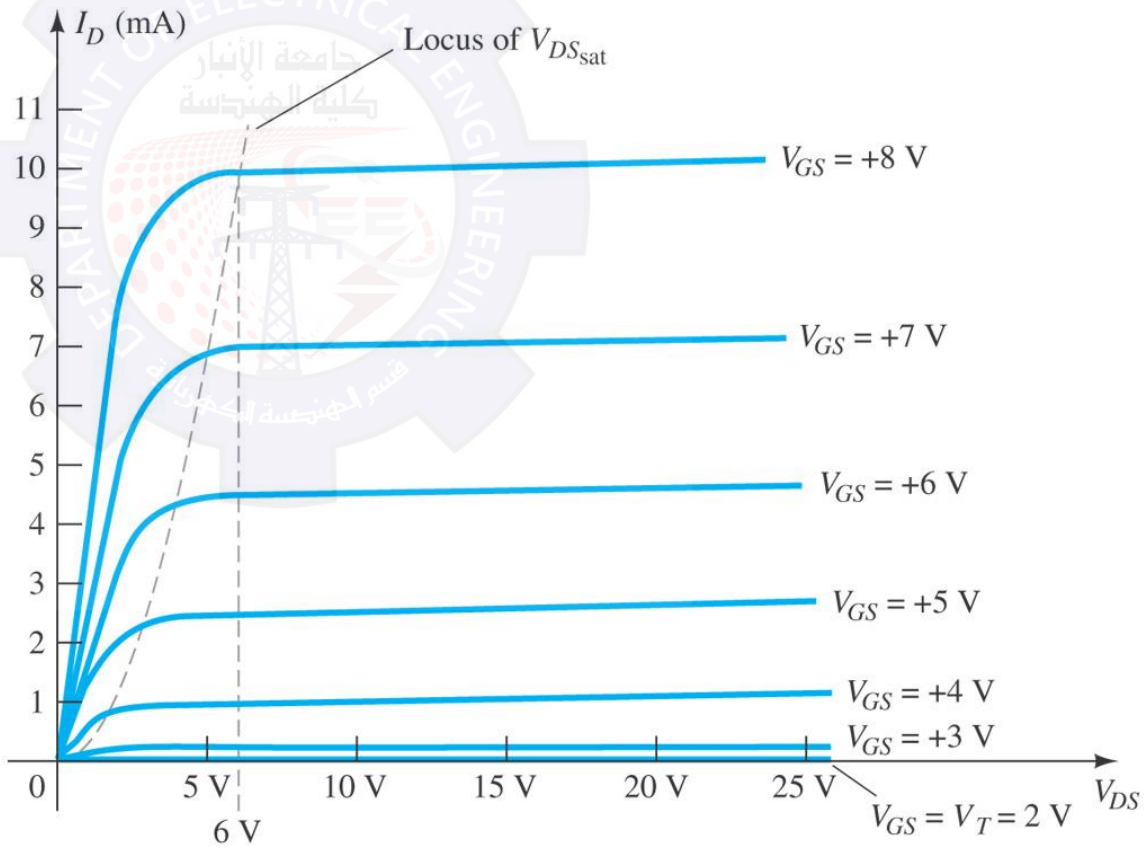
- For V_{GS}=0, I_D=0 (no channel).
- For V_{DS} some positive voltage, and V_{GS}=0, two reverse biased p-n junctions and no significant flow between drain and source.
- For V_{GS}>0 and V_{DS}>0, the positive voltage at gate pressure holes to enter deeper regions of the p-substrate, and the electrons in p-substrate will be attracted to the positive gate.
- The level of V_{GS} that results in the significant increase in drain current is called ***threshold voltage*** (V_T).
- For V_{GS}<V_T, I_D=0 mA.



Basic Operation of the E-Type MOSFET

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

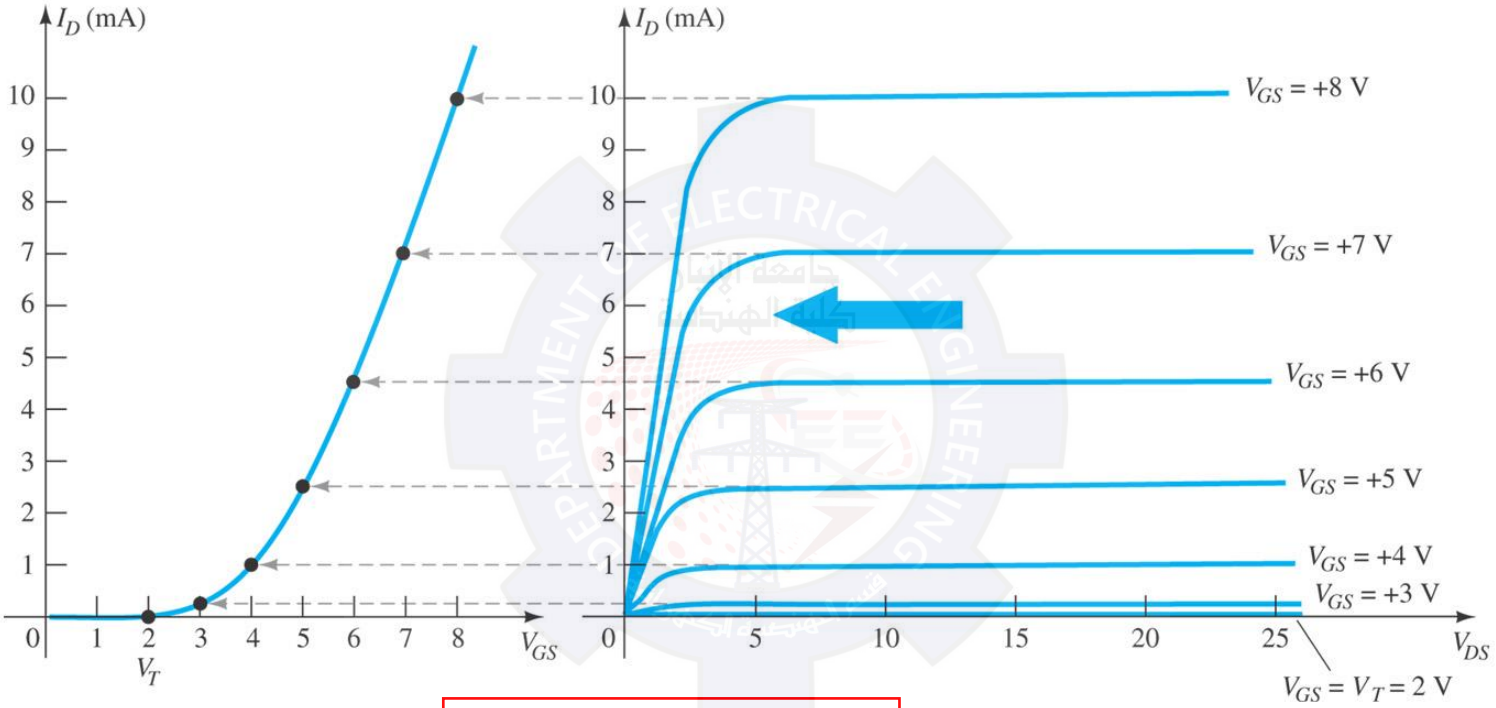
- **V_{GS} is always positive.**
- **As V_{GS} increases, I_D increases**
- **As V_{GS} is kept constant and V_{DS} is increased, then I_D saturates (I_{DSS}) and the saturation level, V_{DSsat} is reached**



V_{DSsat} can be calculated by:

$$V_{Dsat} = V_{GS} - V_T$$

E-Type MOSFET Transfer Curve



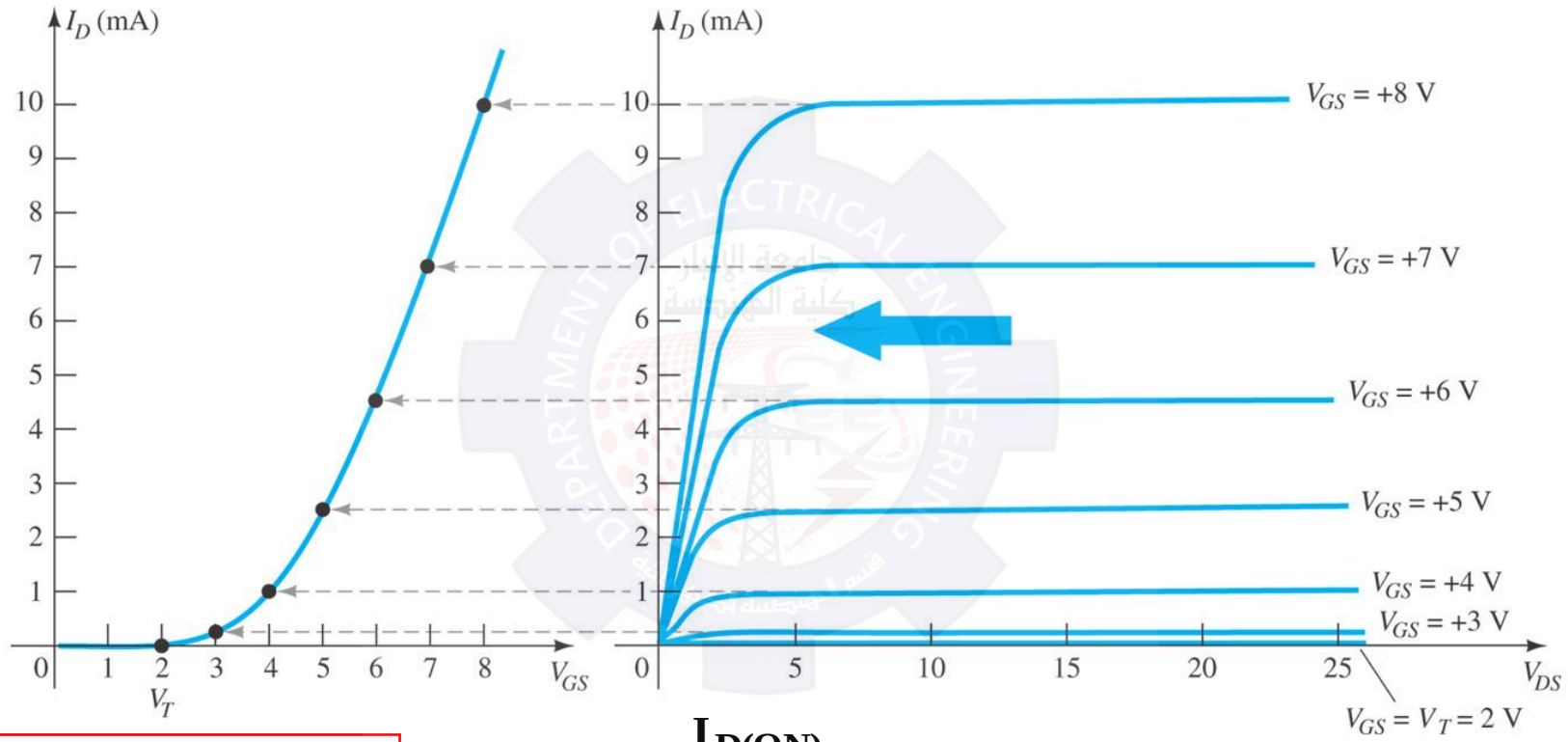
To determine I_D given V_{GS}: $\mathbf{I_D = k(V_{GS} - V_T)^2}$

Where: V_T = threshold voltage or voltage at which the MOSFET turns on

k, a constant, can be determined by using values at a specific point and the formula:

$$\mathbf{k = \frac{I_{D(ON)}}{(V_{GS(ON)} - V_T)^2}}$$

E-Type MOSFET Transfer Curve

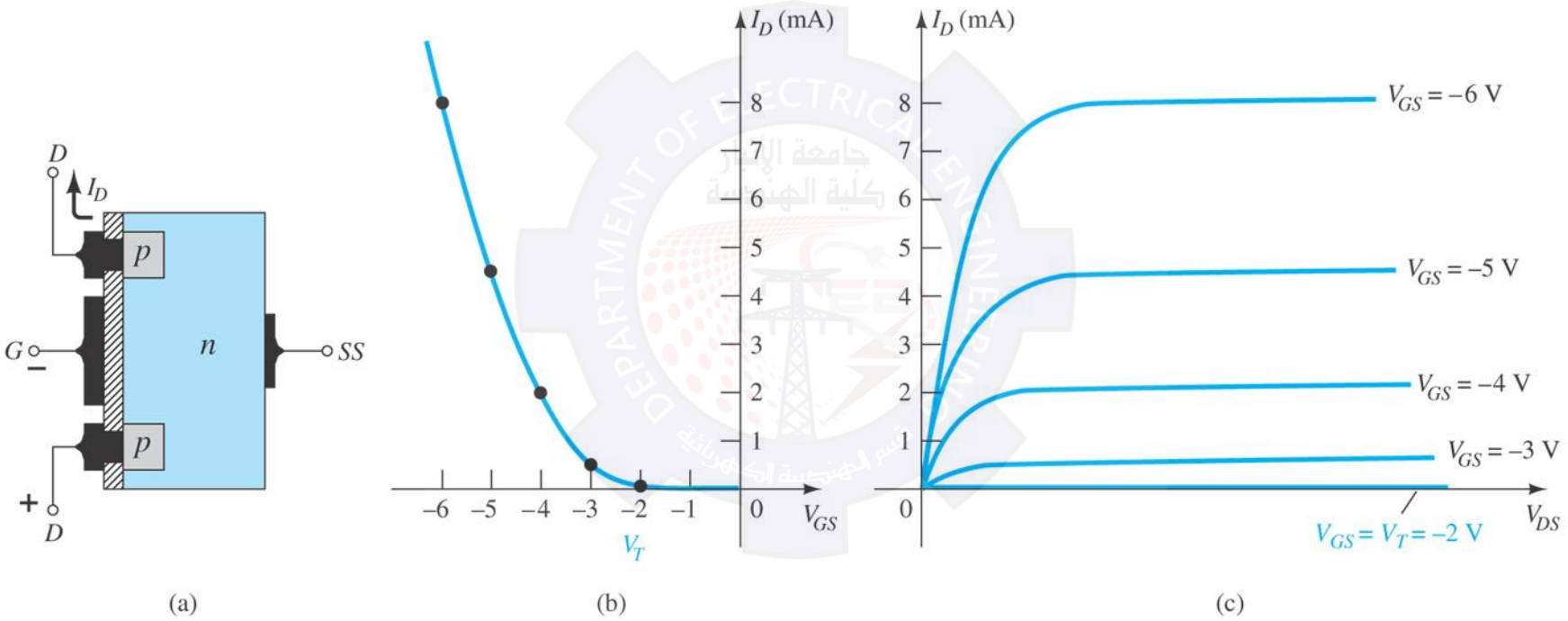


$$\mathbf{I_D = k(V_{GS} - V_T)^2} \qquad \mathbf{k = \frac{I_{D(ON)}}{(V_{GS(ON)} - V_T)^2}}$$

Substituting $I_D(on)$ =10 mA when $V_{GS}(on)$=8V from the characteristics:

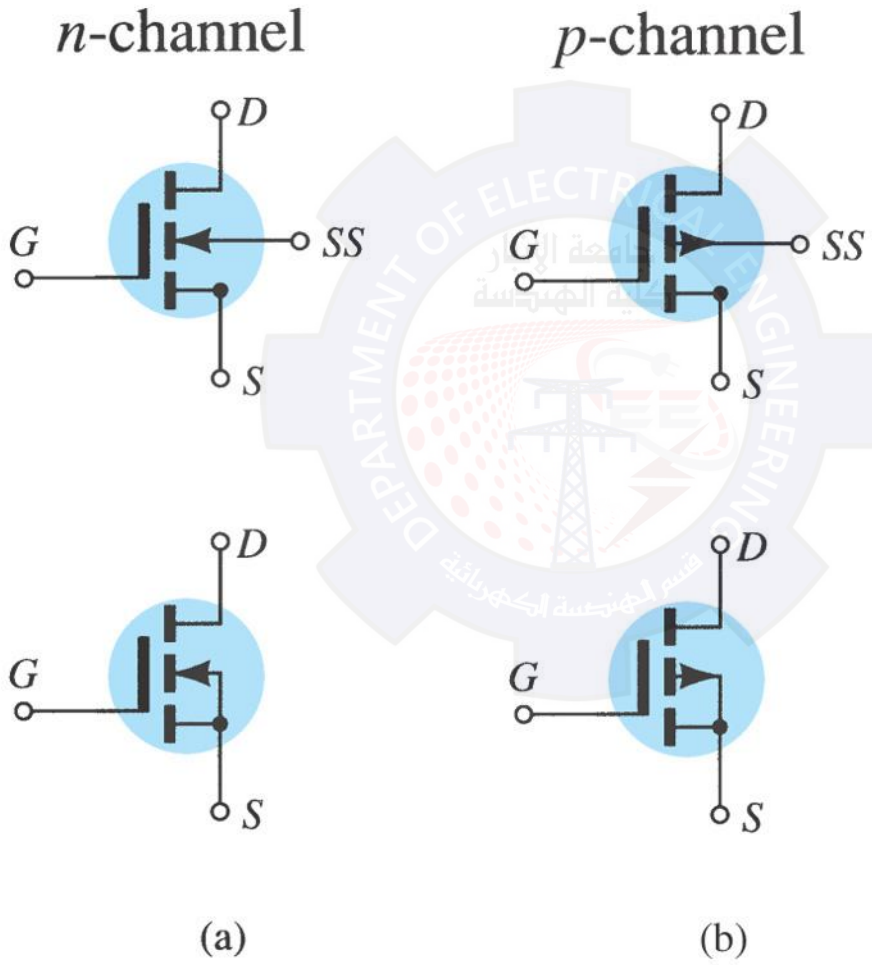
$$k = \frac{10\text{ mA}}{(8-2)^2} = 0.278\times10^{-3}\ \text{A/V}^2 \Rightarrow I_D = 0.278\times10^{-3}(V_{GS} - 2V)^2$$

p-Channel E-Type MOSFETs



The *p*-channel enhancement-type MOSFET is similar to the *n*-channel, except that the voltage polarities and current directions are reversed.

MOSFET Symbols



Symbols for (a) *n*-channel enhancement-type MOSFETs and (b) *p*-channel enhancement-type MOSFETs.