

EE-202 Electronics-I-
Chapter 11:
Field-Effect Transistors
MOSFET-CMOS

MOSFETs

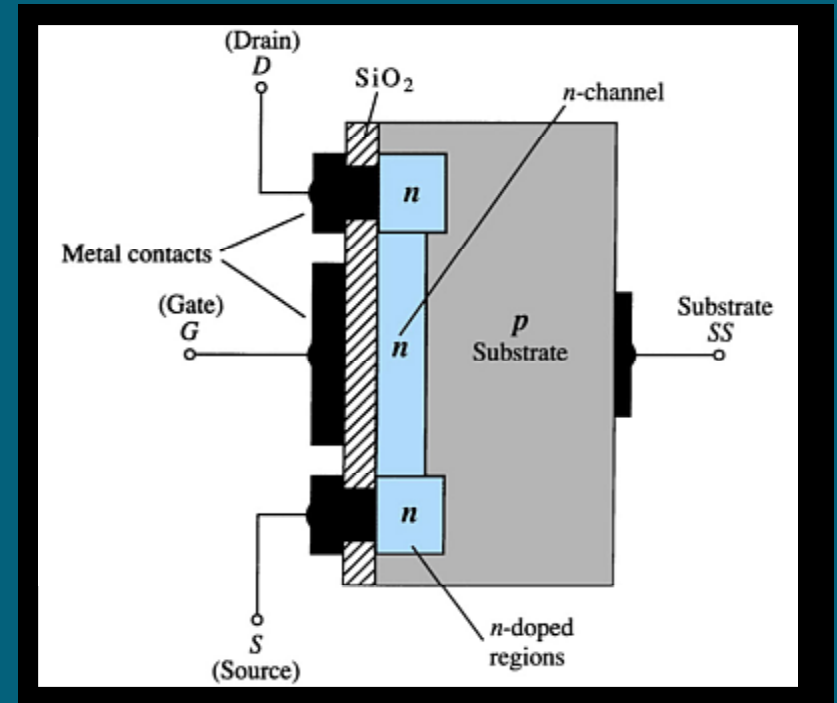
There are two types of MOSFETs:

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

Depletion-Type MOSFET

Three terminals are **drain (D)**, **source (S)** and the **gate (G)**.

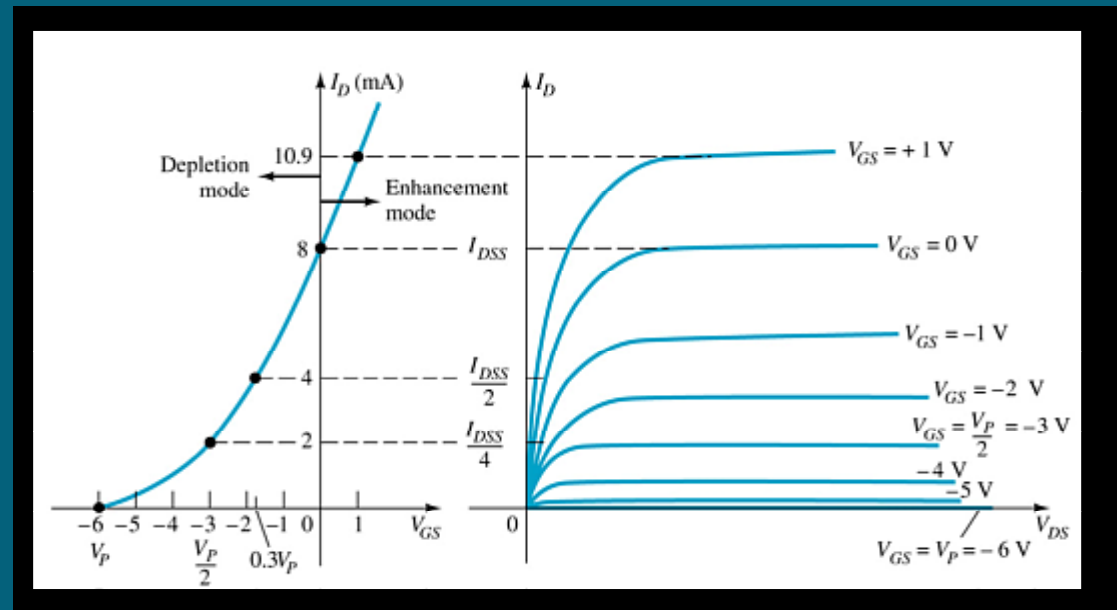
An additional terminal named **substrate (SS)**.



Basic MOSFET Operation

A depletion-type MOSFET can operate in two modes:

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



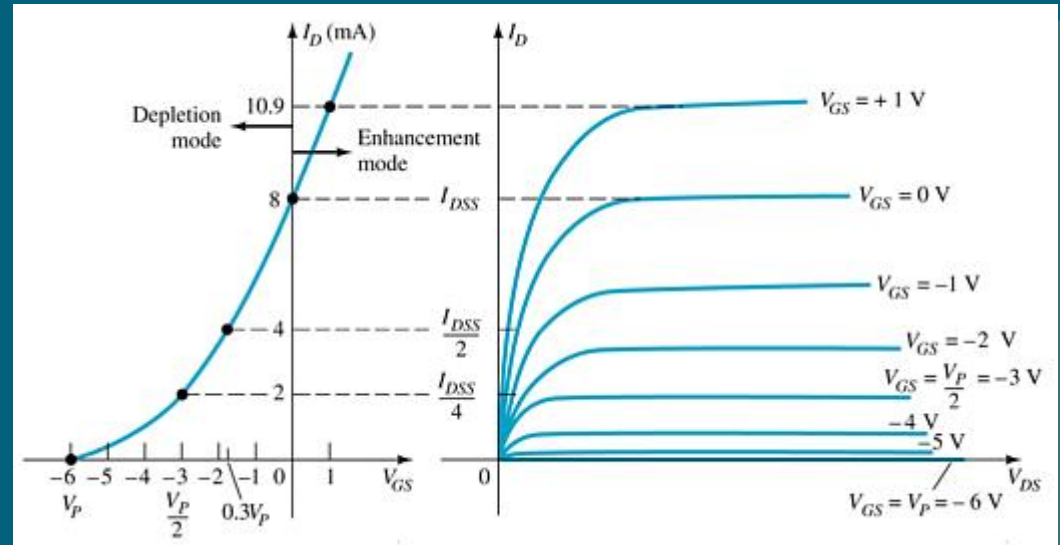
Depletion-Type MOSFET in Depletion Mode

Depletion Mode

The characteristics are similar to a JFET.

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

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

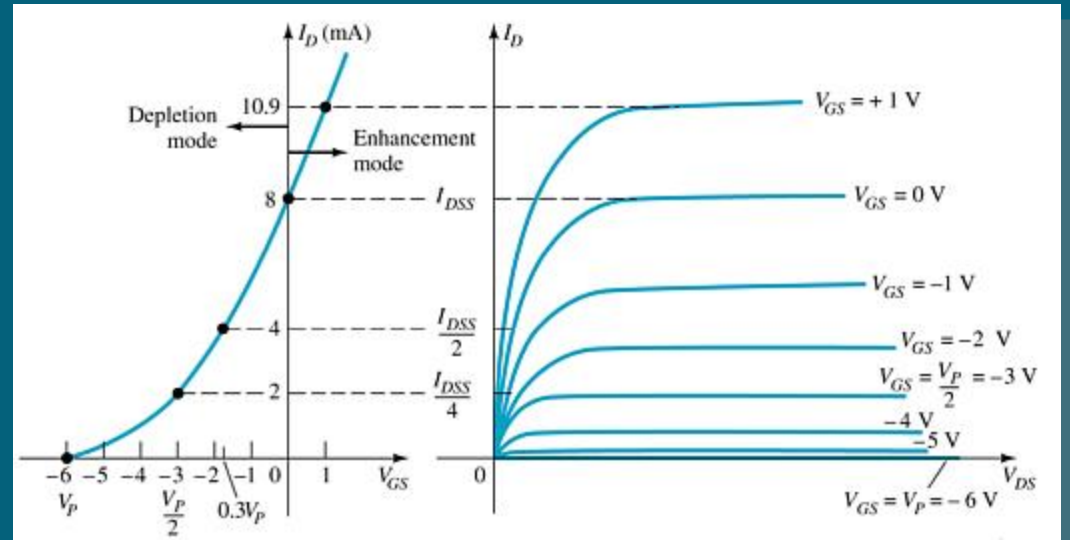


Depletion-Type MOSFET in Enhancement Mode

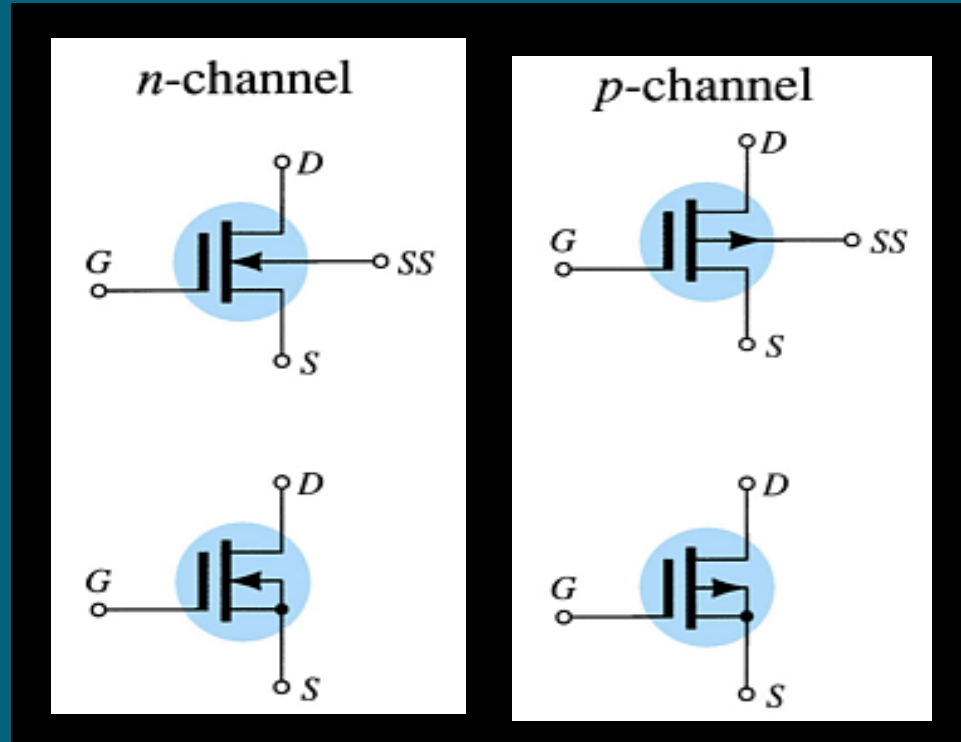
Enhancement Mode

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

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

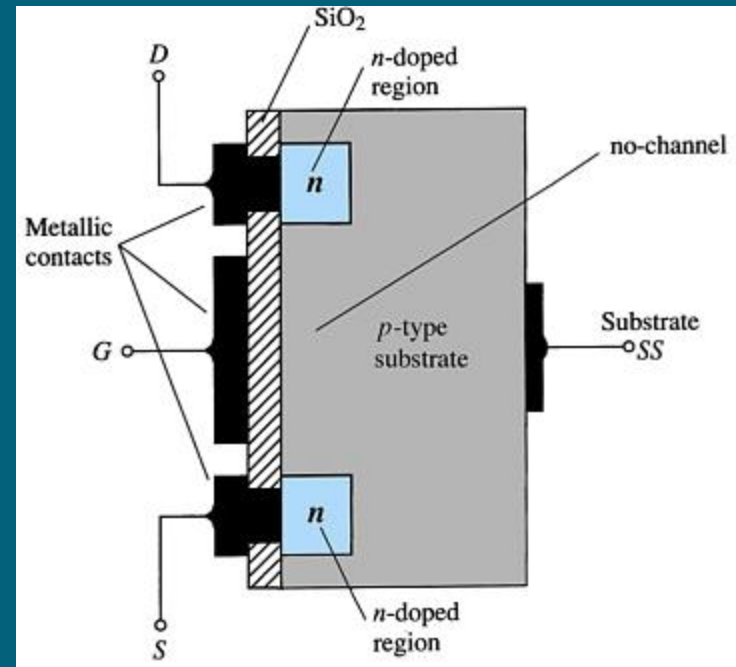


p-Channel Depletion-Type MOSFET



Enhancement-Type MOSFET Construction

- Three terminals;
- The **drain (D)** and **source (S)** is connected via *n*-type regions.
- The **gate (G)** connects to the *p*-type substrate via an insulating layer - SiO_2
- There is no channel between them
- An additional terminal connection called the **substrate (SS)**



Basic Operation of the Enhancement-Type MOSFET and Transfer Curve

- V_{GS} always positive
- As V_{GS} is left constant and V_{DS} is increased, then I_D saturates (I_{DSS}) and also, V_{DSsat} occurs

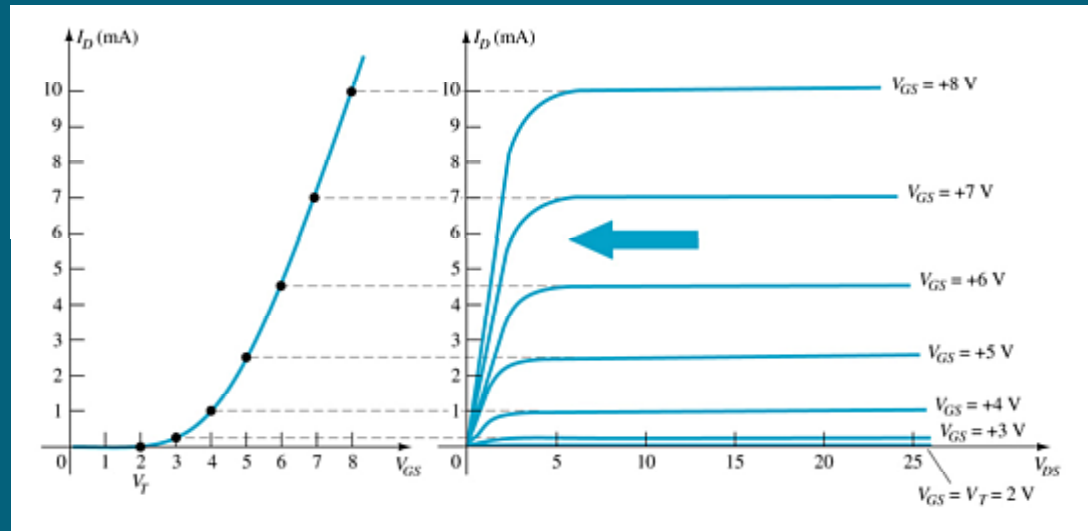
To determine I_D given V_{GS} :

$$I_D = k(V_{GS} - V_T)^2$$

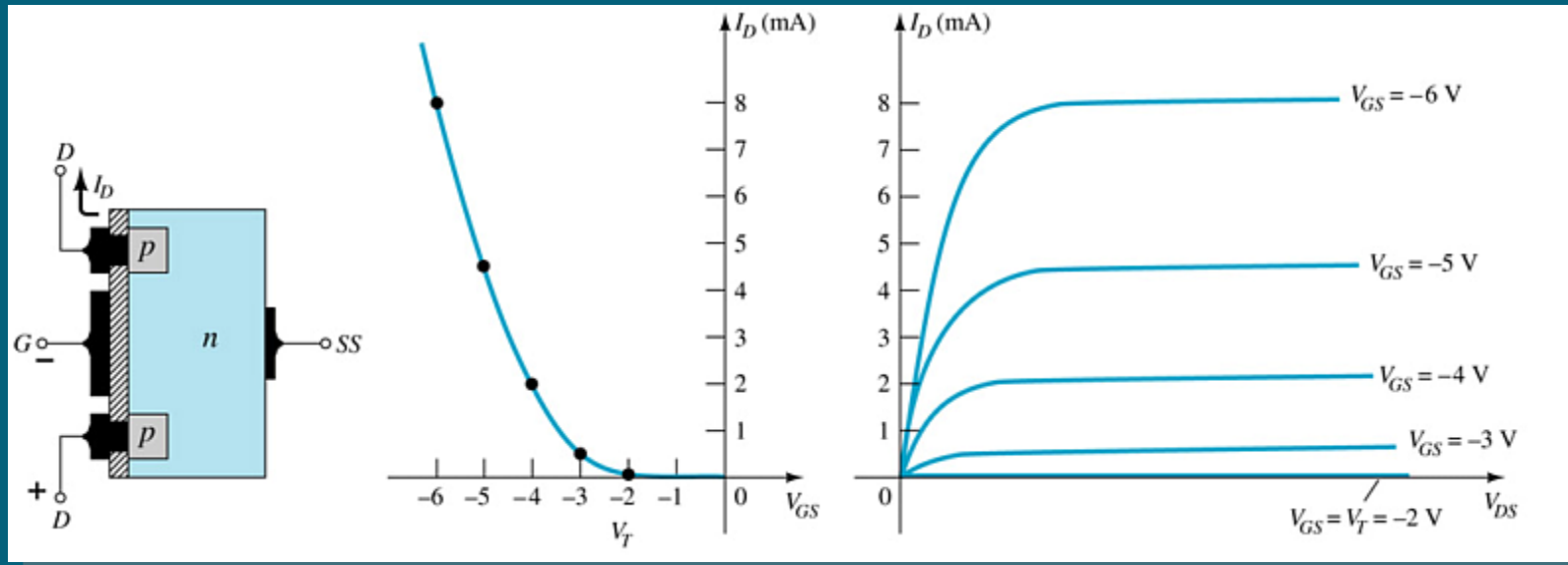
Where:

V_T = threshold voltage

k = constant given in data sheet

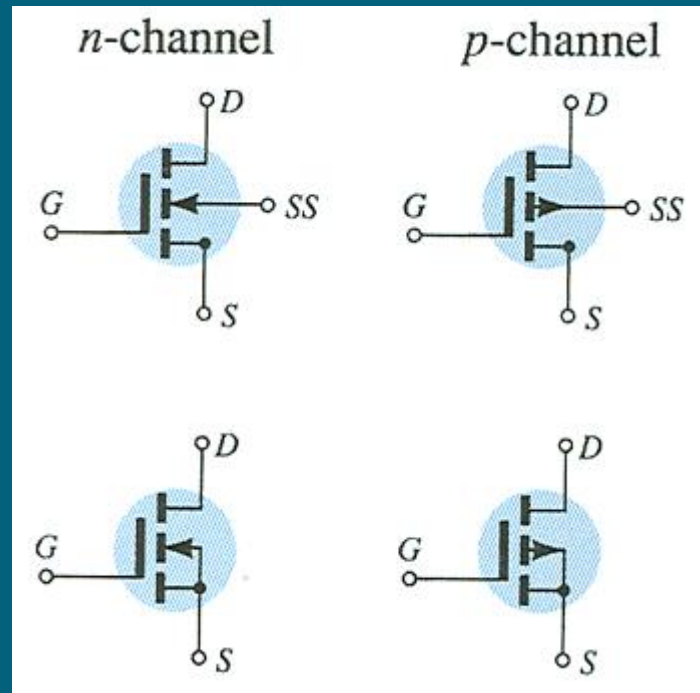


p-Channel Enhancement-Type MOSFETs



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

MOSFET Symbols



CMOS Devices

CMOS (complementary MOSFET) uses a *p*-channel and *n*-channel MOSFET on the same substrate.

Advantages

- Useful in logic circuit designs
- Higher input impedance
- Faster switching speeds
- Lower operating power levels

