ELECTRONICS DEVICES AND CIRCUITS

SECTION - C

TRANSISTORS

OBJECTIVE

MOSFETs

MOSFETs

MOSFETs have characteristics similar to JFETs and additional characteristics that make then 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)

MOSFET Handling

**MOSFETs** are very static sensitive.
Because of the very thin SiO_2 layer between the external terminals and the layers of the device, any small electrical discharge can stablish an unwanted conduction.
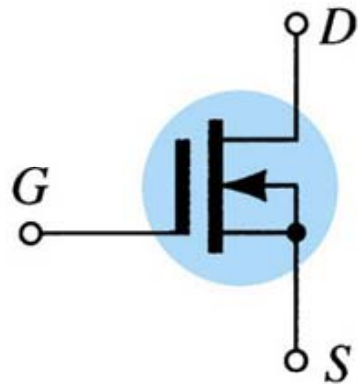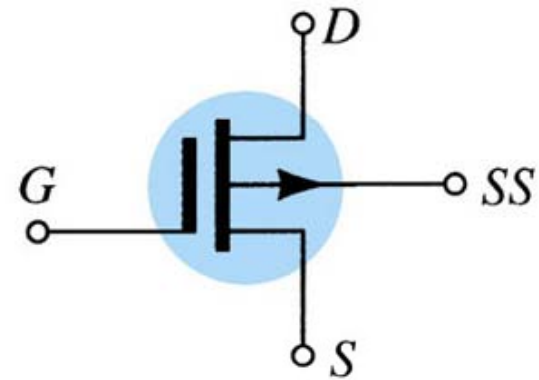
Protection:
- Always transport in a static sensitive bag
- Always wear a static strap when handling MOSFETS
- Apply voltage limiting devices between the Gate and Source, such as back-to-back Zeners to limit any transient voltage
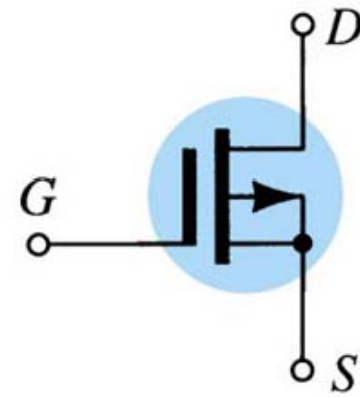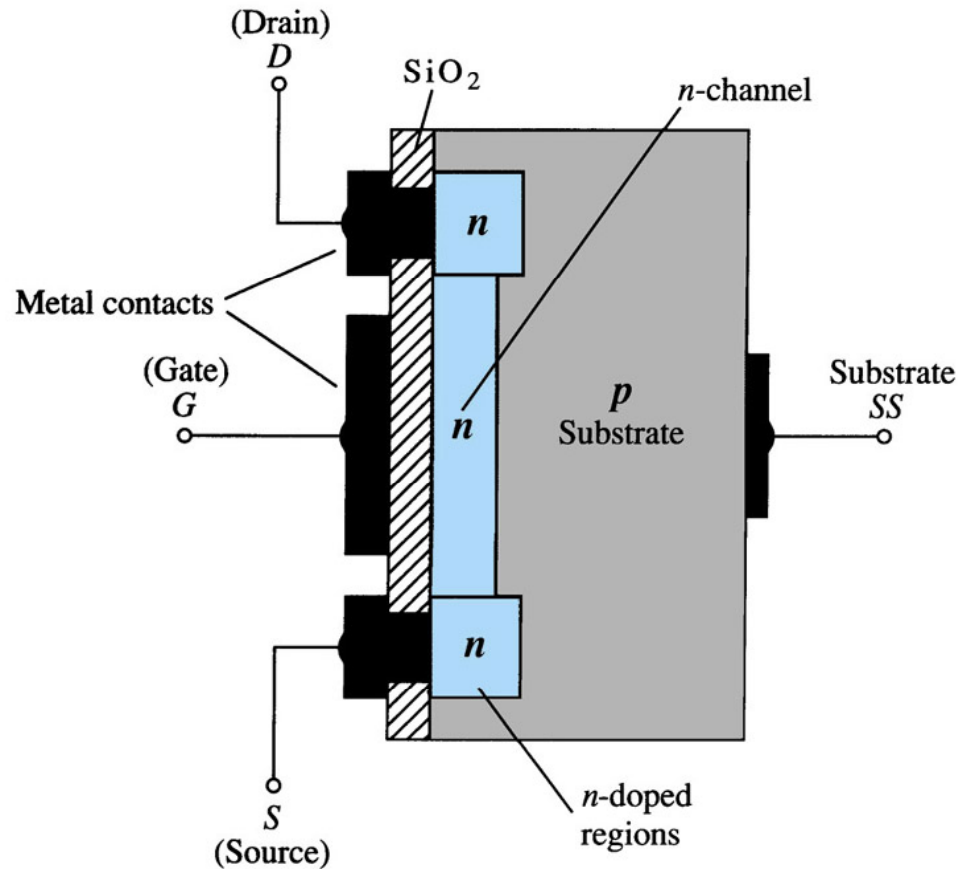
D-MOSFET Symbols

n-channel
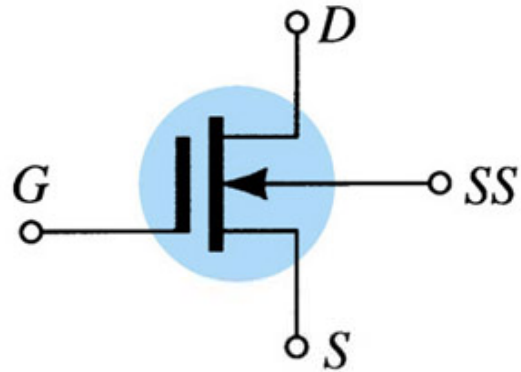
p-channel

(a)

(b)

Depletion Mode MOSFET Construction

The Drain (D) and Source (S) leads 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 SS

Basic Operation

A D-MOSFET may be biased to operate in two modes:
the **Depletion** mode or the **Enhancement** mode
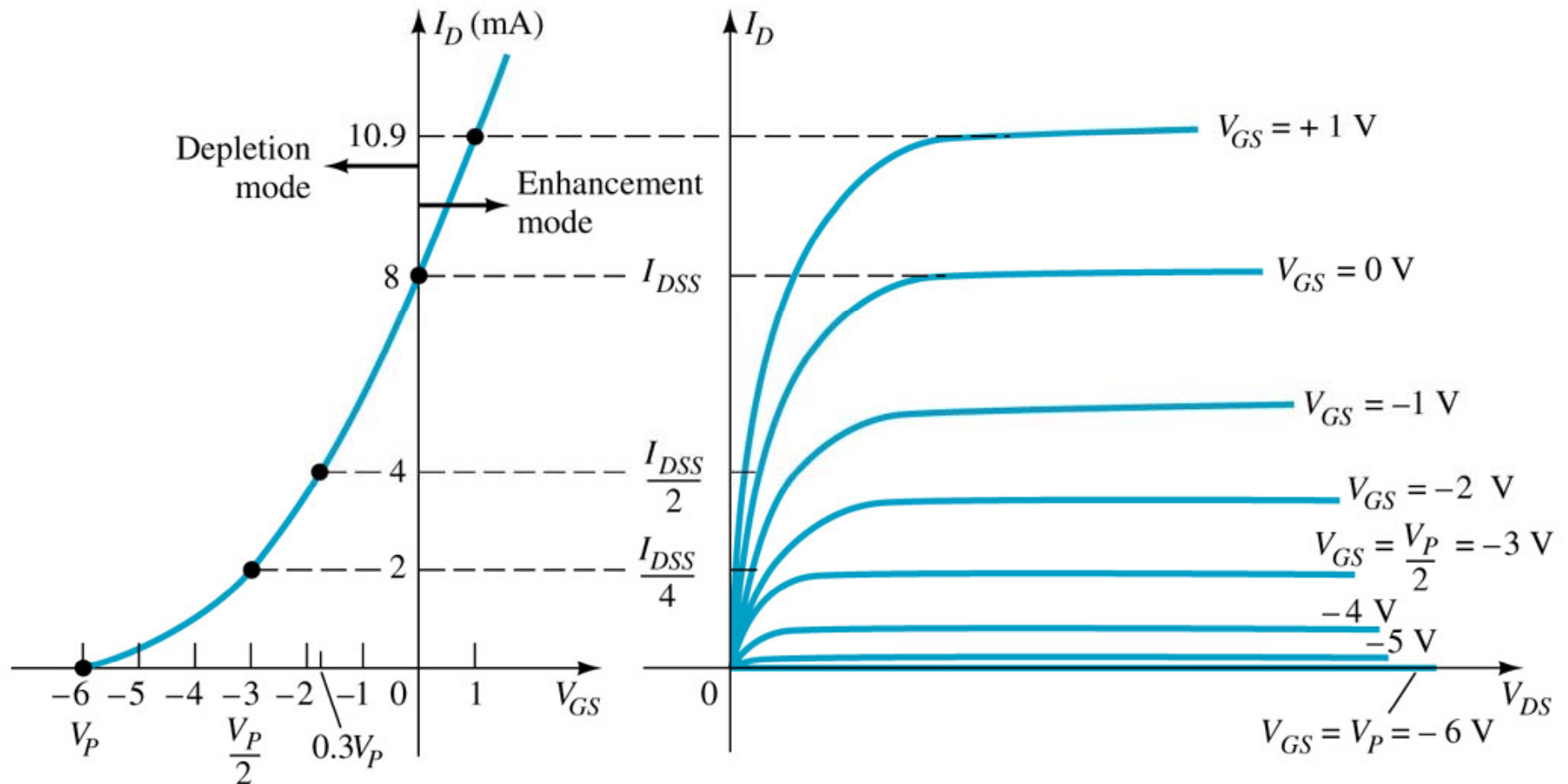
D-MOSFET Depletion Mode Operation
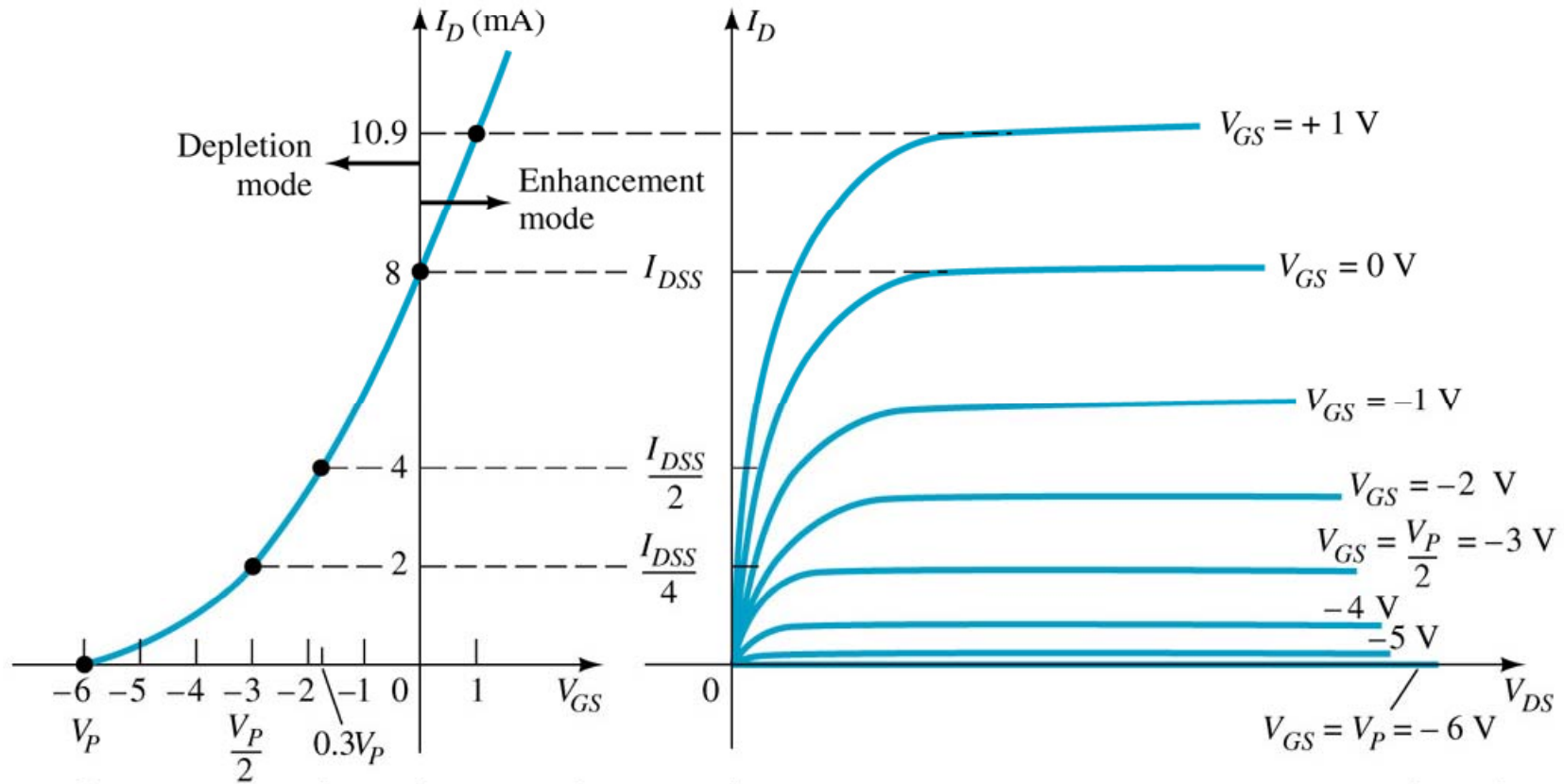
The transfer characteristics are similar to the JFET

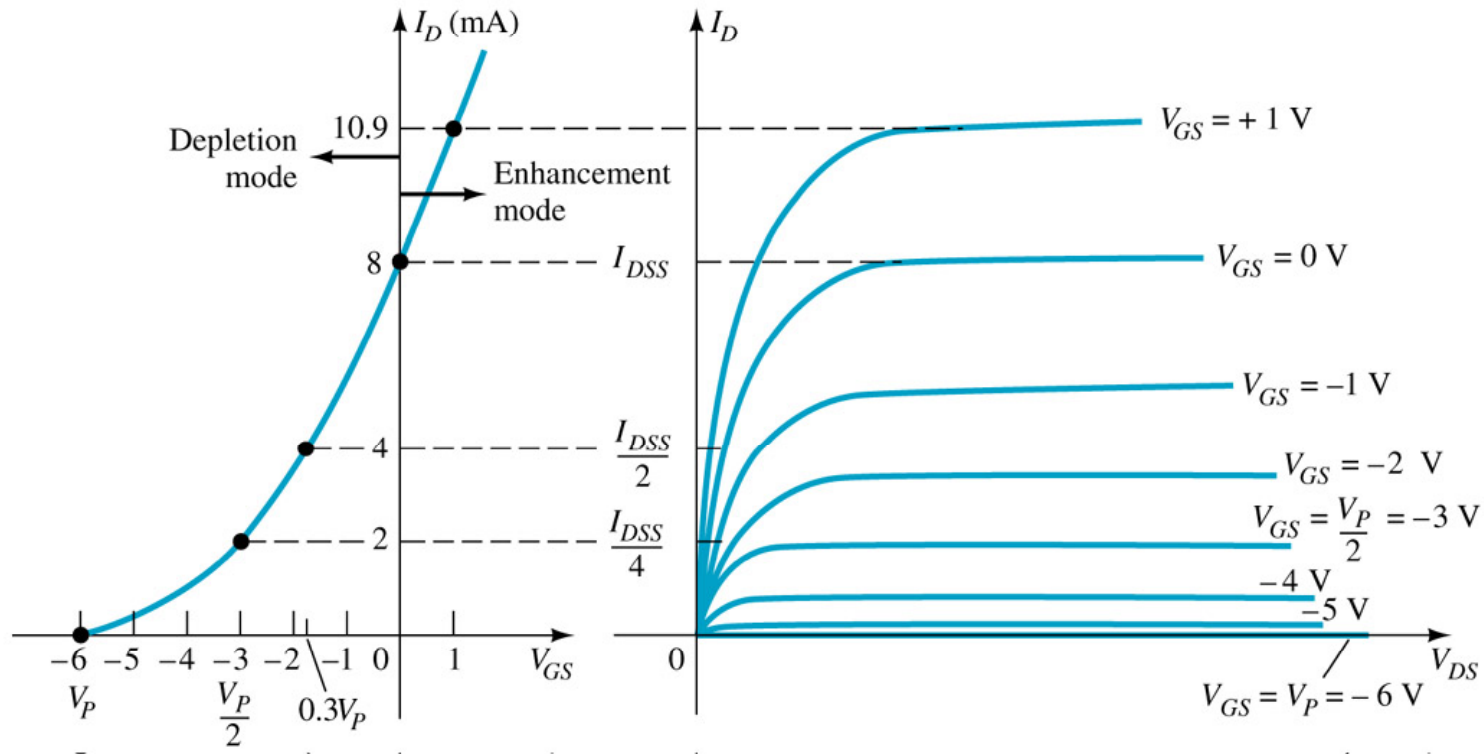In Depletion Mode operation:

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

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

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

The formula used to plot the Transfer Curve, is:

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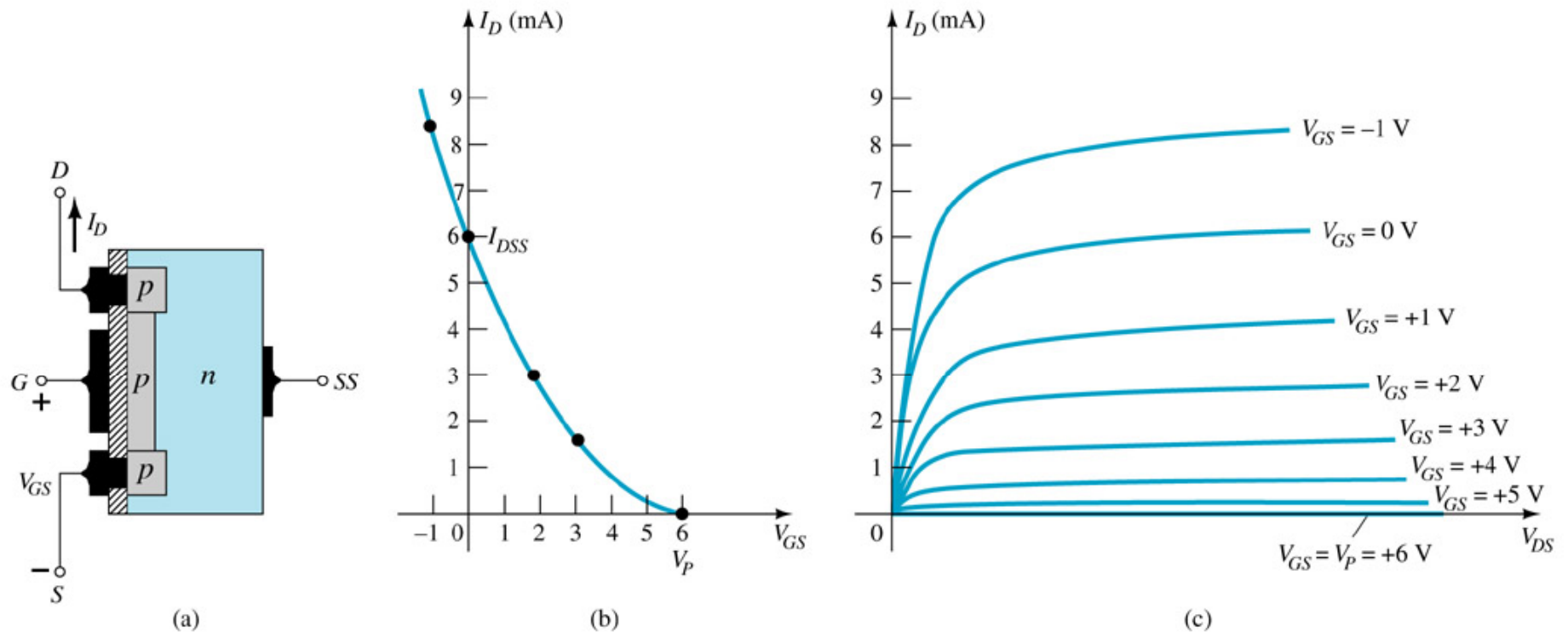
D-MOSFET Enhancement Mode Operation

Enhancement Mode operation

In this mode, the transistor operates with $V_{GS} > 0V$, and I_D increases above I_{DSS}

Shockley's equation, the formula used to plot the Transfer Curve, still applies but V_{GS} is positive:

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

p-Channel Depletion Mode MOSFET

The p-channel Depletion mode MOSFET is similar to the n-channel except that the voltage polarities and current directions are reversed