

# Lecture 9 Transistor



New  
Mansoura  
University

جامعة المنصورة الجديدة

## □ Bipolar Junction Transistor (BJT)

- ❖ BJT Structure
- ❖ Basic BJT Operation
- ❖ BJT Characteristics and Parameters
- ❖ The BJT as an Amplifier
- ❖ The BJT as a Switch

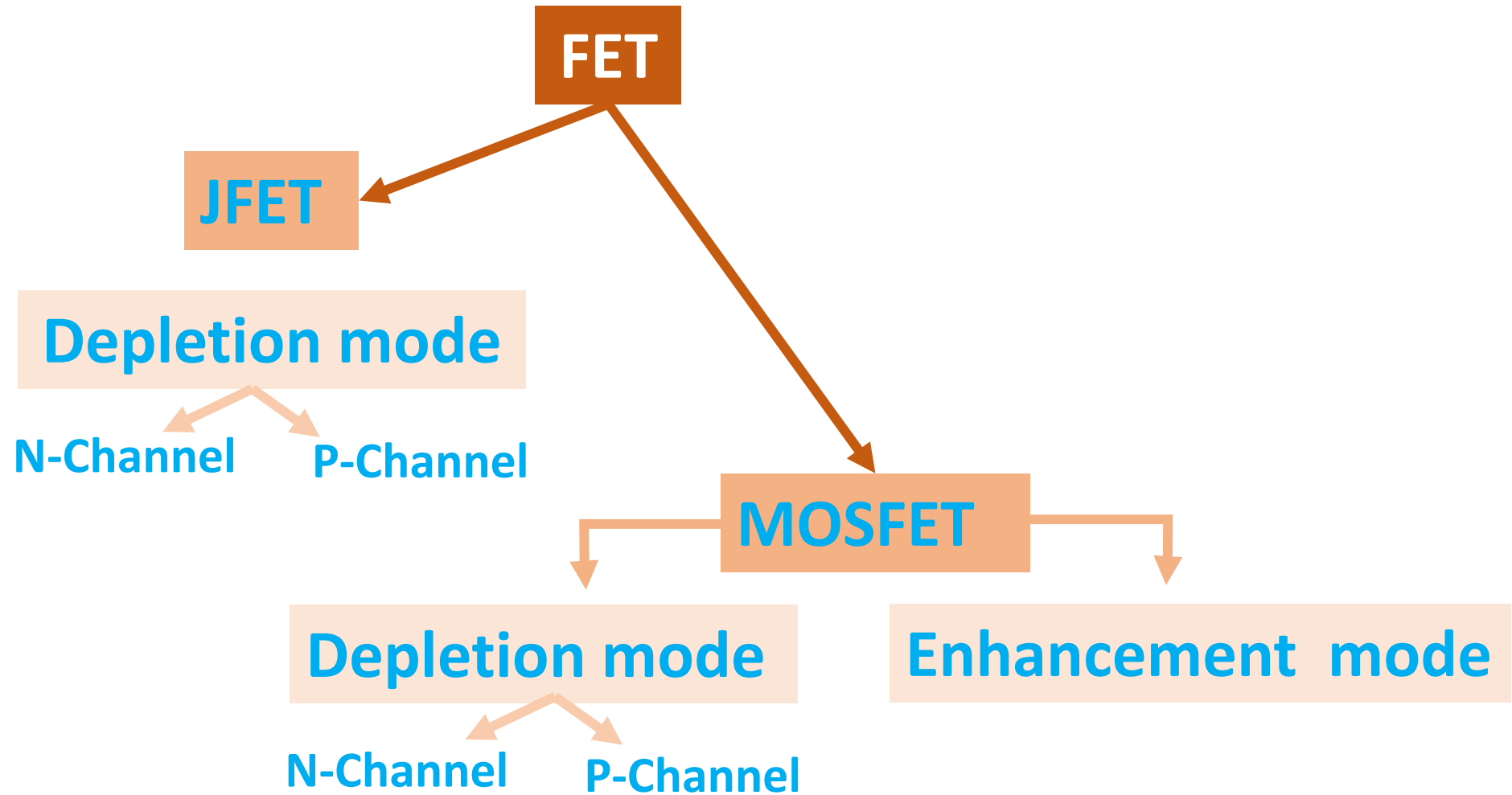
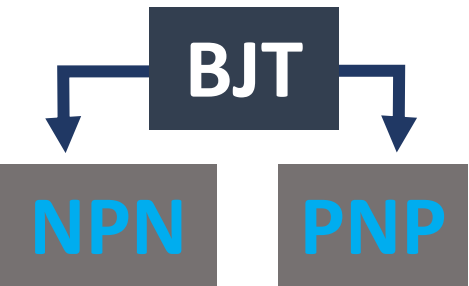
## □ Field Effect Transistors (FET)

- ❖ Difference between BJT & FET
- ❖ Type of FET
  - JFET (Junction Field Effect Transistor)
  - MOSFET (Metal Oxide Semiconductor Field Effect Transistor).

**Course Name: Electric and electronic circuits**

**Course Code: CSE 113**

# Transistors



# Transistors

**BJT** transfer the signal from low resistance to high resistance

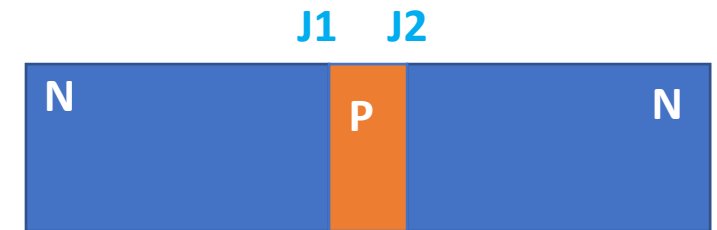
**B** (Bipolar )we have two carrier electron and hole

**J** junction of two diodes (one forward and the other backward biasing)

J1 forward bias - very low resistance

J2 backward - high resistance

**Active mode**



**T** (Transfer + Resistance )

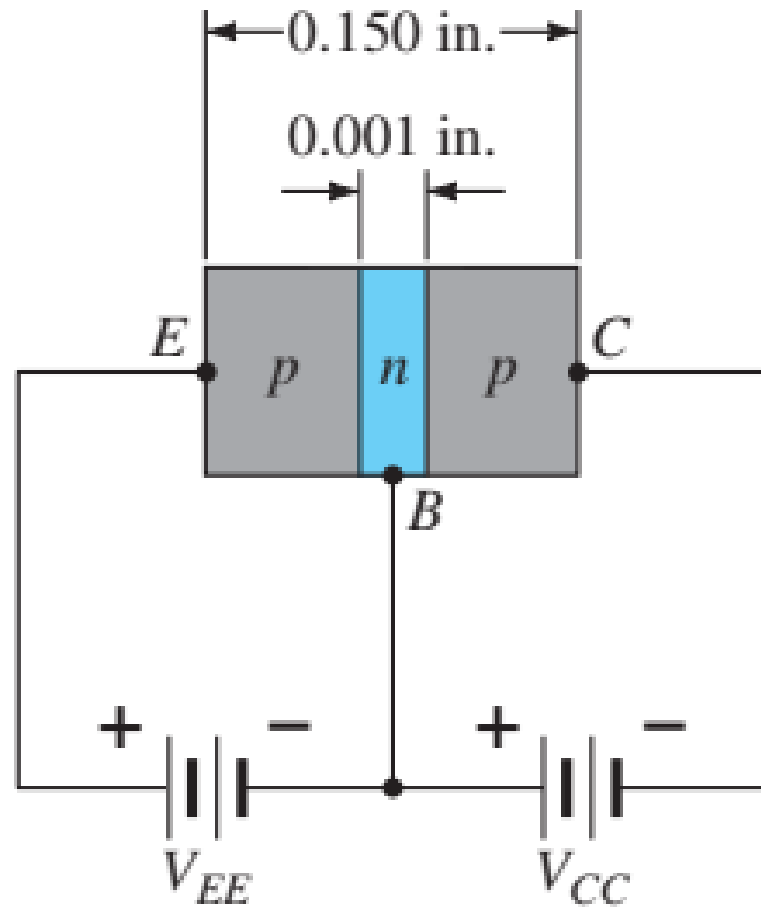
J1	J2	Region of the operation
F.B	R.B	Active (Amplifier)
F.B	F.B	Saturation mode (switch) On
R.B	R.B	Cut off (off)
R.B	F.B	Inverted (rarely used)

F.B (Forward Bias )

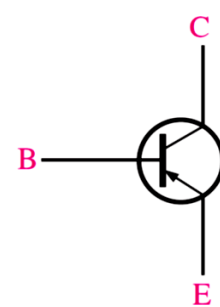
R.B (Reverse Bias)

# Transistors

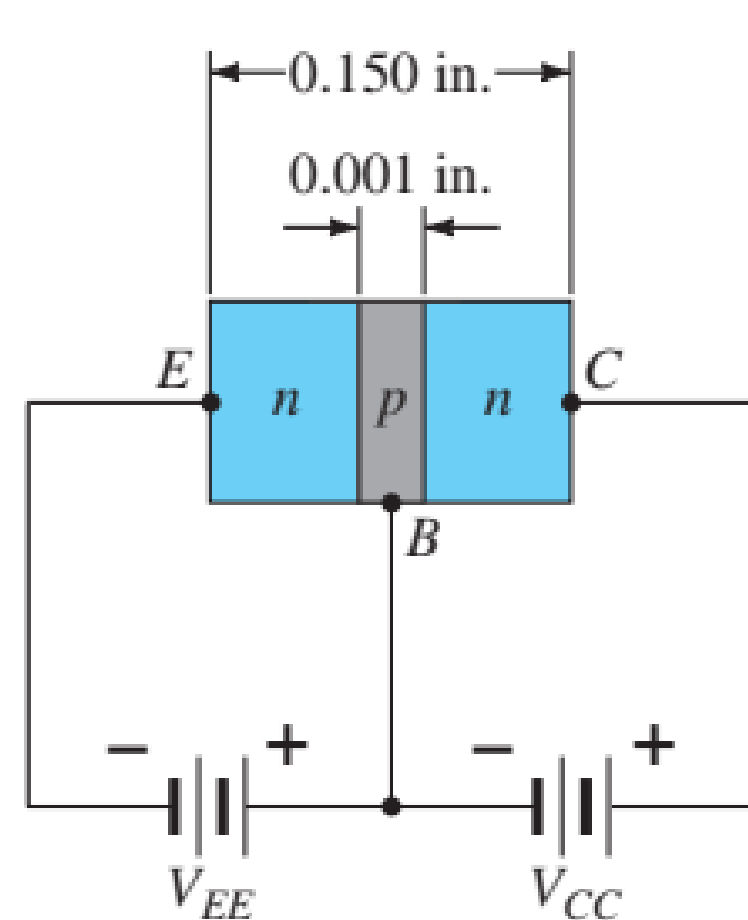
## TRANSISTOR CONSTRUCTION



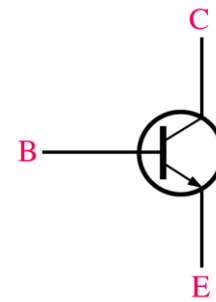
(a)



(b) pnp



(b)

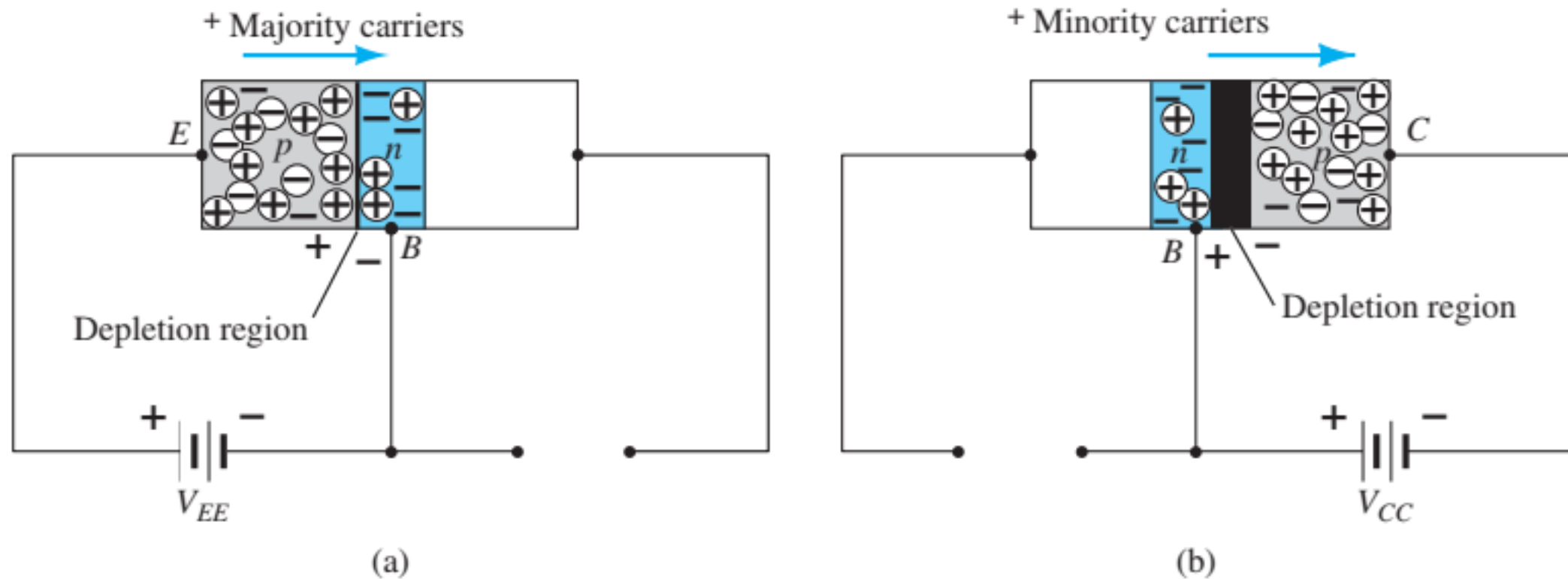


(a) npn

Types of transistors: (a) pnp;  
(b) npn.

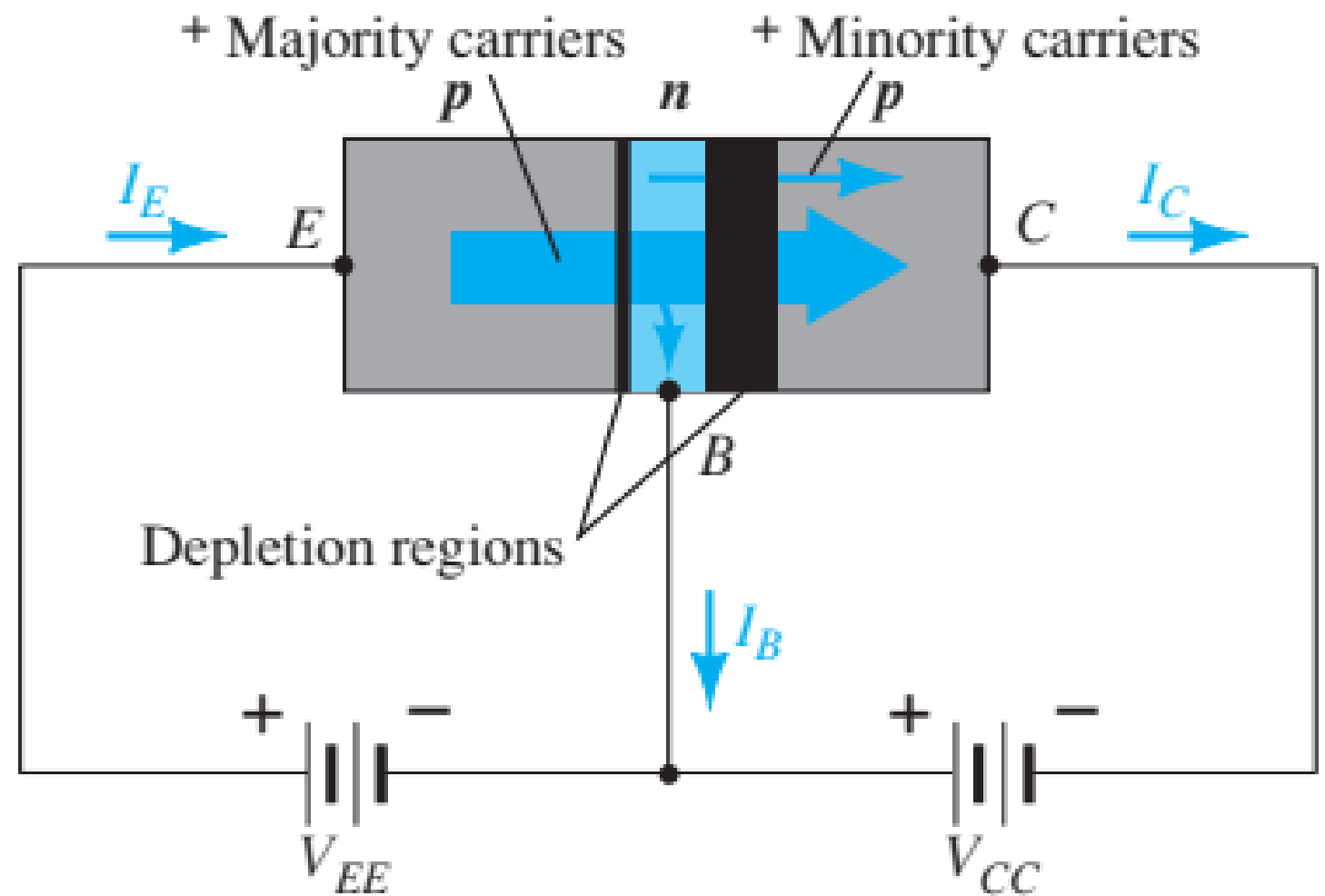
# Basic BJT Operation

*One p–n junction of a transistor is reverse-biased, whereas the other is forward-biased.*



*Biassing a transistor: (a) forward-bias; (b) reverse-bias.*

# Currents in a Transistor



*Majority and minority carrier flow of a pnp transistor.*

## Currents in a Transistor

- ❑ Applying Kirchhoff's current law to the transistor
- ❑ The collector current  $I_C$  comprises two components

$$I_E = I_C + I_B$$

$$I_C = I_{C_{minority}} + I_{C_{O_{minority}}}$$

$$I_C = \alpha I_E + I_{CBO} \rightarrow \text{Neglect}$$

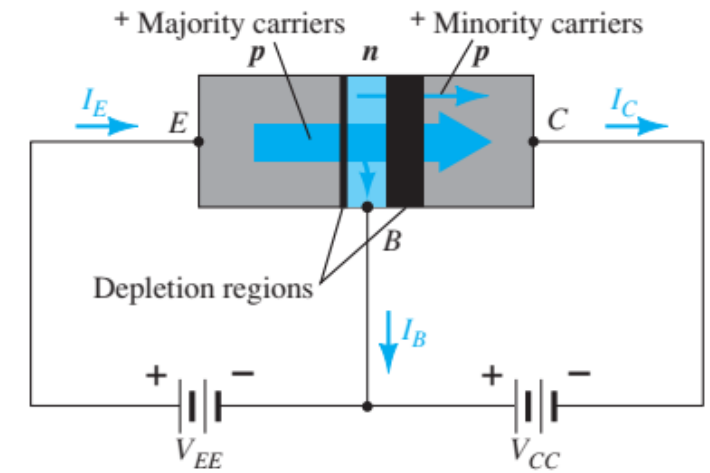
$$I_C = \alpha I_E$$

$$I_B = (1 - \alpha) I_E$$

$$\alpha = \frac{I_C}{I_E}$$

Common – Base Current gain factor  
Or Amplification factor

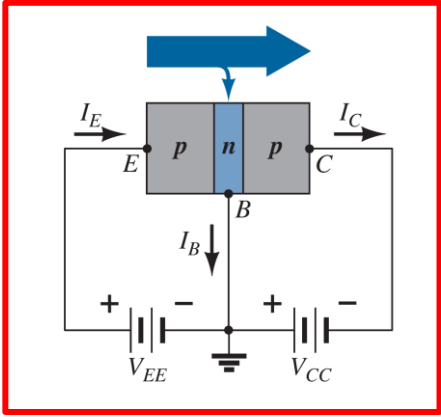
$\alpha$  value between 0.95 to 0.98



- ❑ The minority-current component is called the leakage current  $I_{CO}$  ( $I_C$  current with emitter terminal Open).
- ❑  $I_C$  is measured in milliamperes and  $I_{CO}$  is measured in microamperes or nanoamperes.

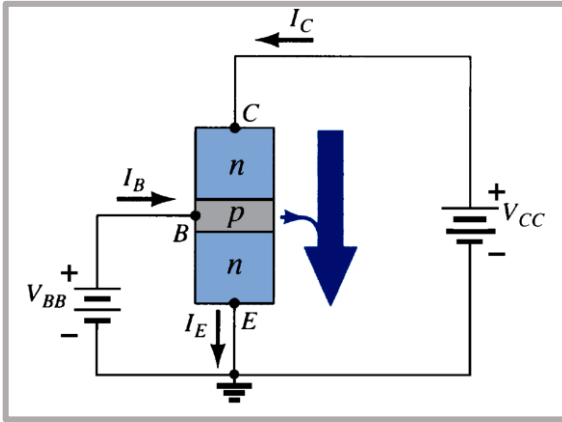
# TRANSISTOR CONFIGURATION

## -COMMON-BASE CONFIGURATION

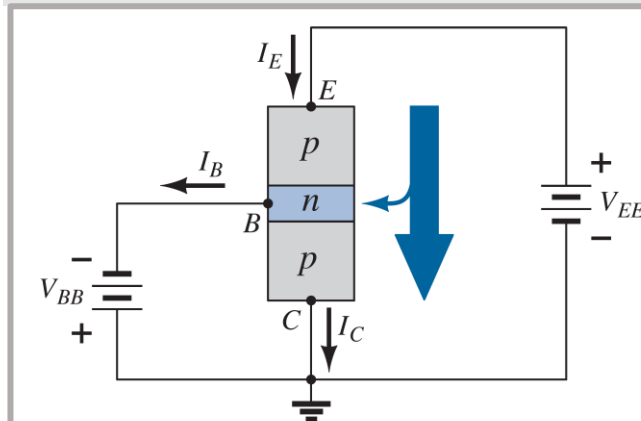


Assignment

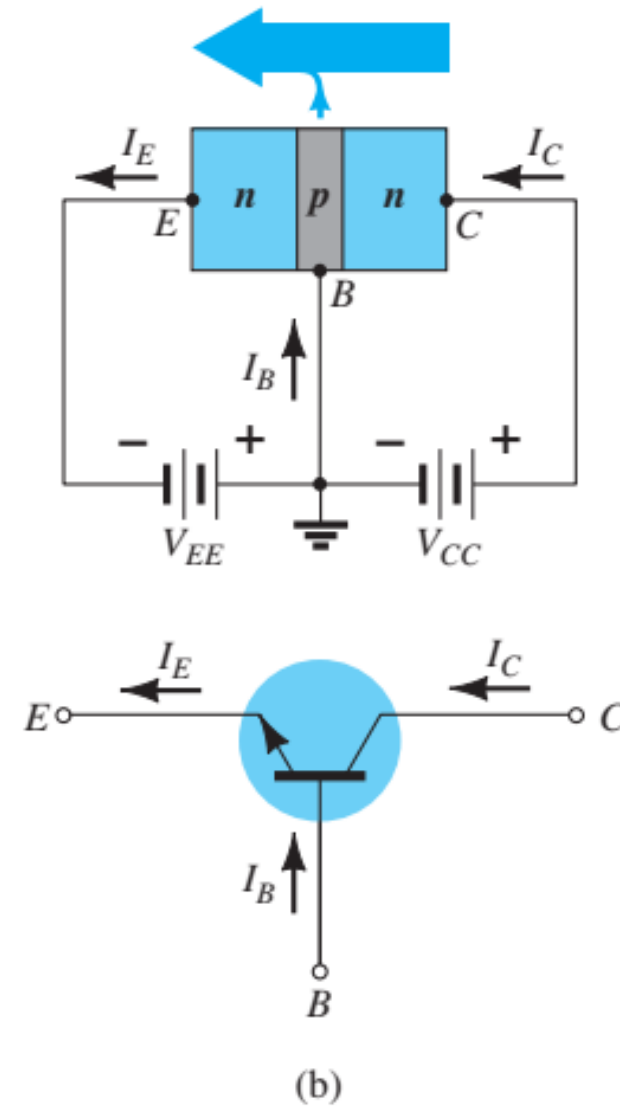
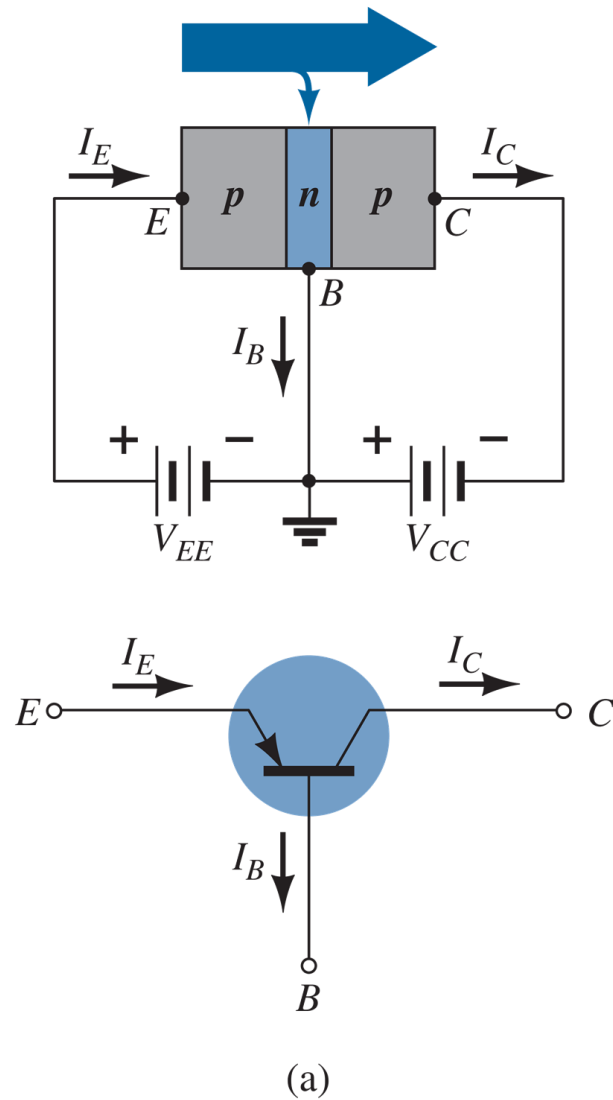
## -COMMON-EMITTER CONFIGURATION



## -COMMON-COLLECTOR CONFIGURATION



# COMMON-BASE CONFIGURATION



*The arrow in the graphic symbol defines the direction of emitter current (conventional flow) through the device.*

## COMMON-BASE CONFIGURATION

Active mode

Cut off region

Saturation region

Breakdown region

# COMMON-BASE CONFIGURATION

## Active mode

J1 Forward Bias

EB Diode

J2 Reverse Bias

BC Diode

$$I_E = I_C + I_B$$

$$I_C = I_{C_{\text{majority}}} + I_{C_{\text{minority}}}$$

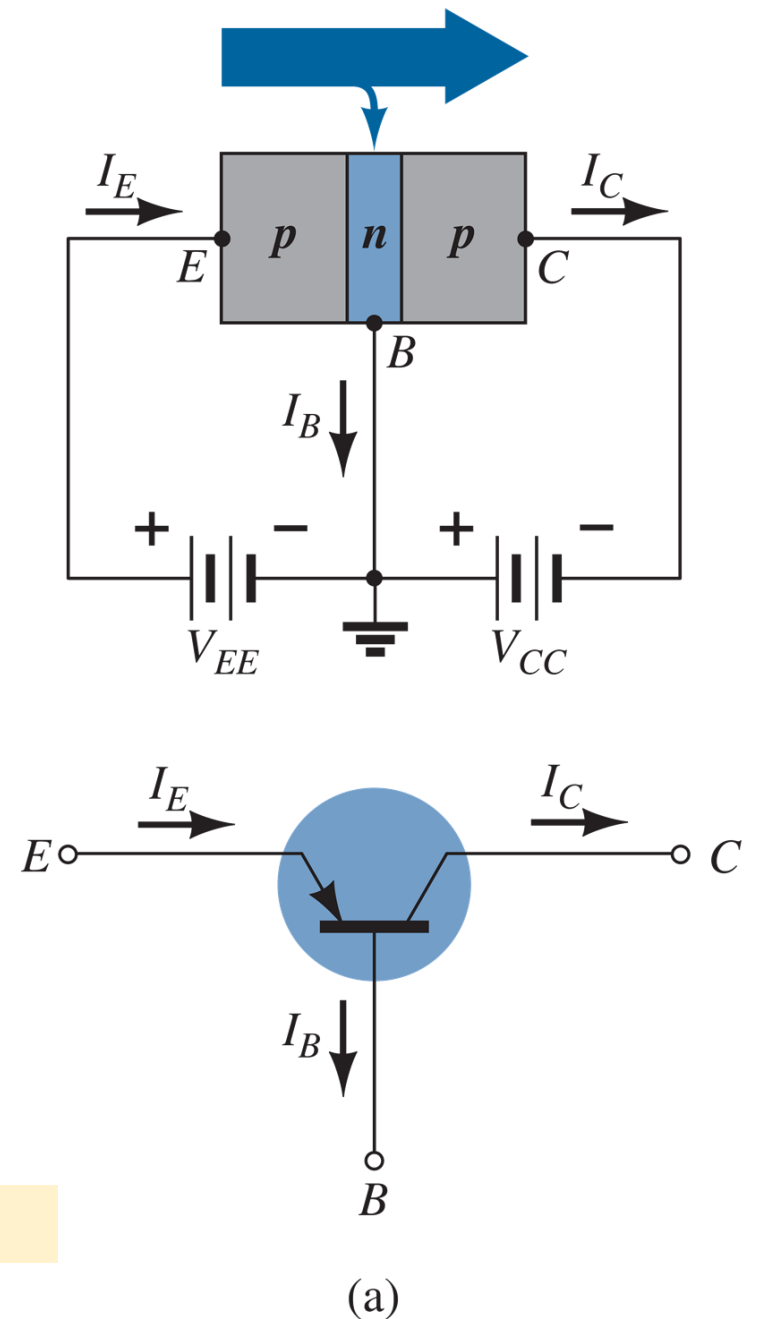
$$I_C = \alpha I_E + I_{CBO}$$

Neglect

$$I_C = \alpha I_E \longrightarrow \alpha = \frac{I_C}{I_E}$$

Common – Base Current gain factor Or Amplification factor  
 $\alpha$  value between 0.95 to 0.98

$$I_B = (1 - \alpha) I_E$$



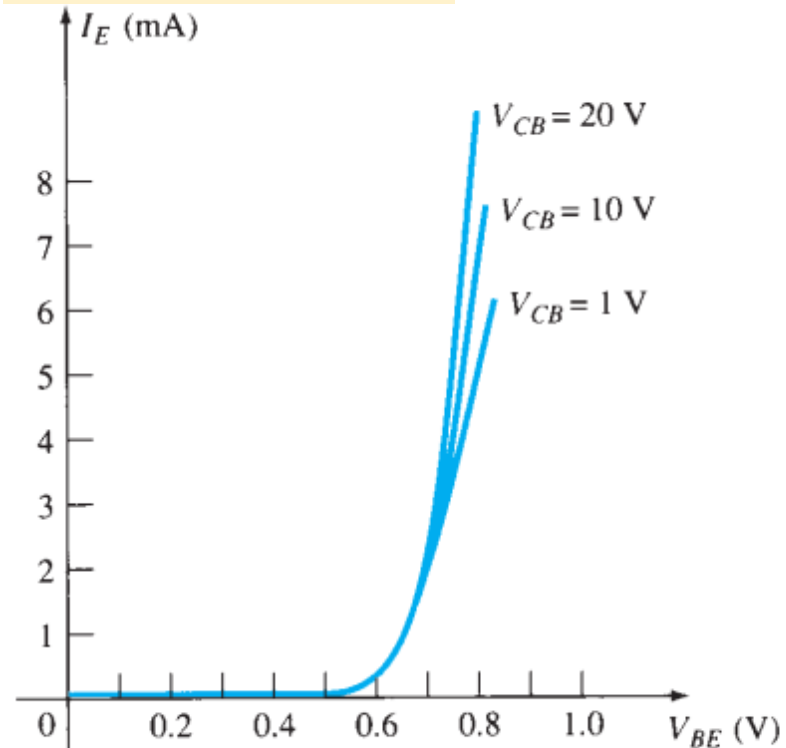
# COMMON-BASE CONFIGURATION

## Active mode

Transistor is two port device

Input characteristic

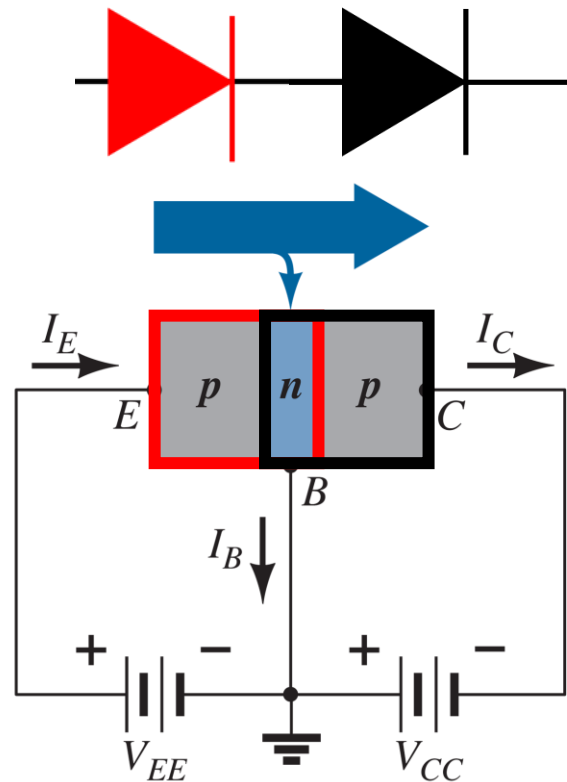
$I_E$  versus  $V_{BE}$



Input or driving point characteristics for a common-base silicon transistor amplifier.

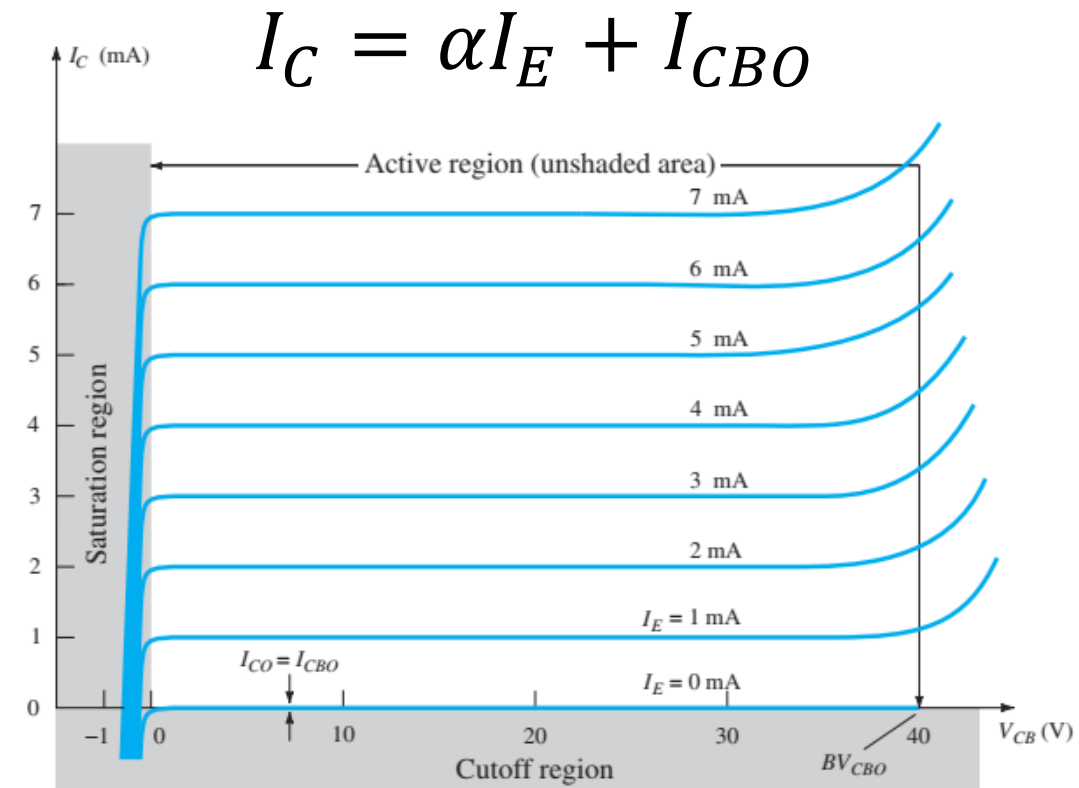
Forward Bias

Reverse Bias



Output characteristic

$I_C$  versus  $V_{CB}$



Output or collector characteristics for a common-base transistor amplifier.

# COMMON-BASE CONFIGURATION

Cut off region

J1 Reverse Bias

J2 Reverse Bias

In this region Transistor work as switch **off**

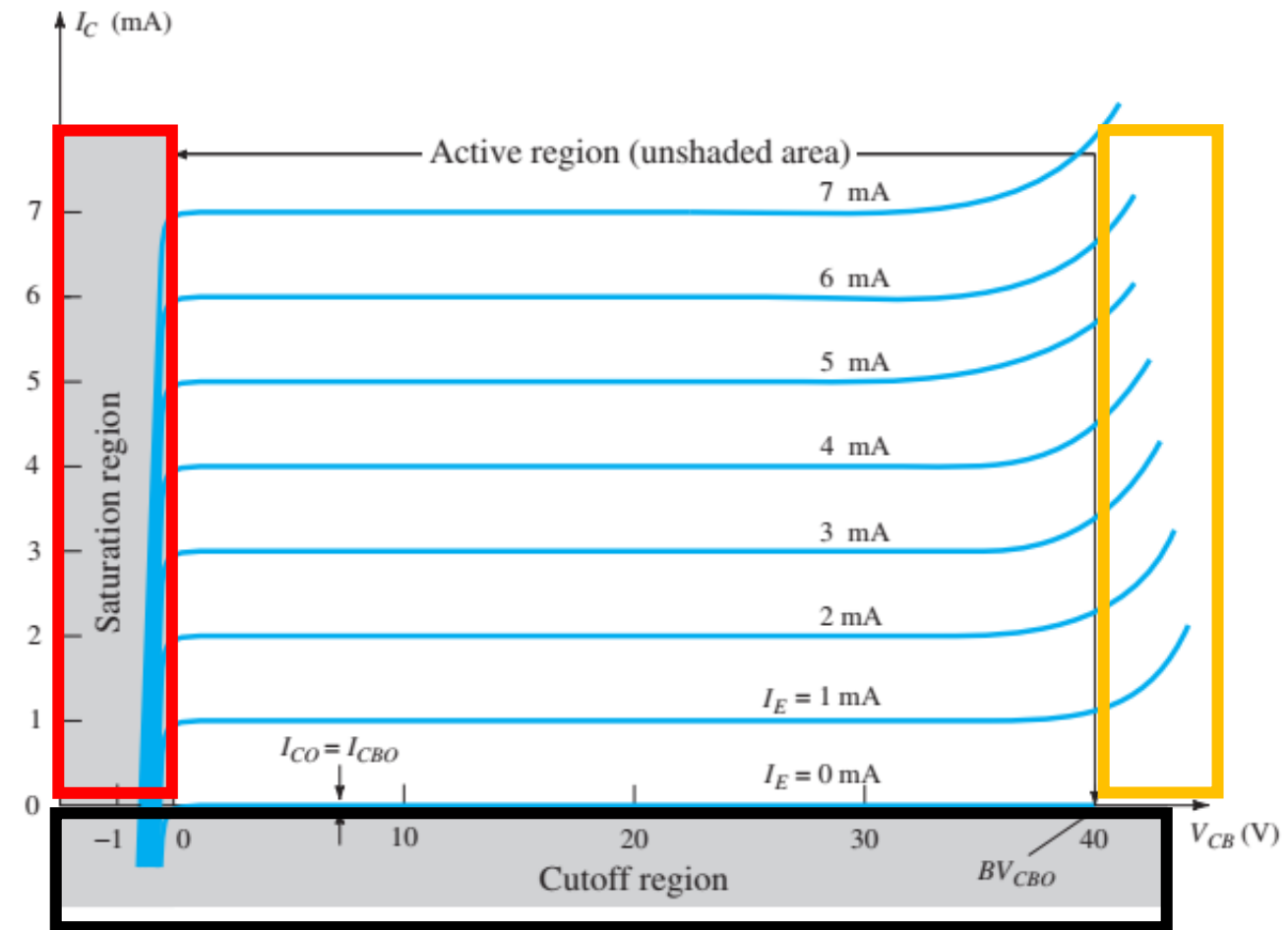
Saturation region

J1 Forward Bias

J2 Forward Bias

In this region Transistor work as switch **on**

Breakdown region



**FIG. 3.8**

Output or collector characteristics for a common-base transistor amplifier.

Transistors

# COMMON-BASE CONFIGURATION

J1	J2	Region of the operation
F.B	R.B	Active (Amplifier)
F.B	F.B	Saturation mode (switch) On
R.B	R.B	Cut off (off)
R.B	F.B	Inverted (rarely used)

F.B (Forward Bias )

R.B (Reverse Bias)

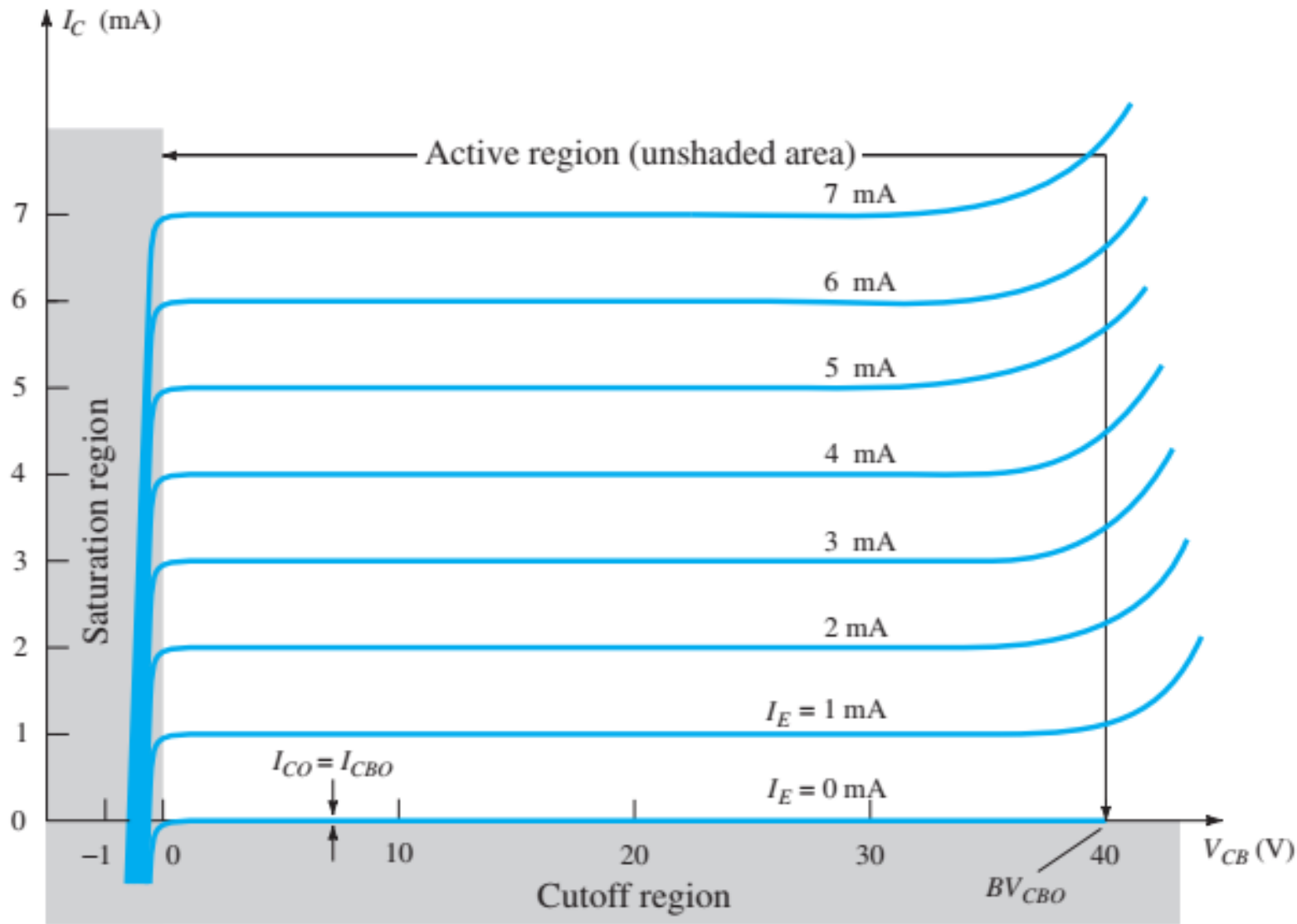
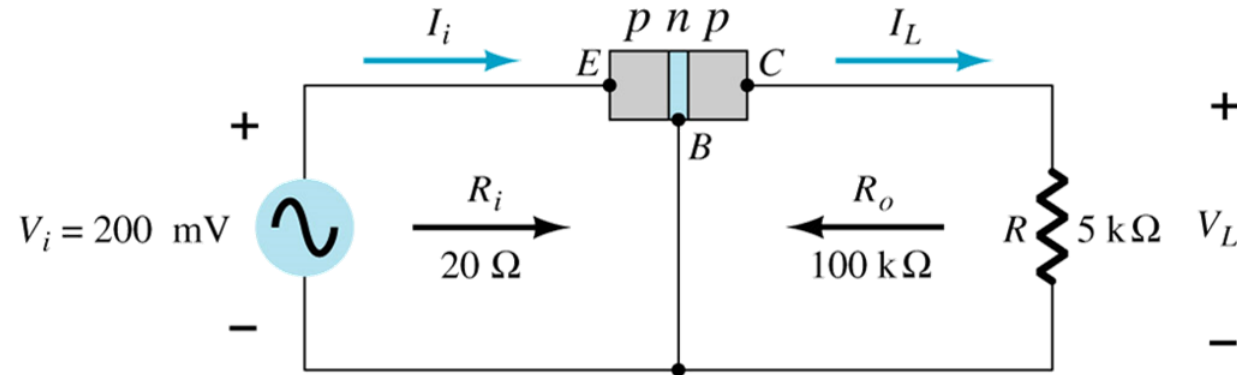


FIG. 3.8

Output or collector characteristics for a common-base transistor amplifier.

# EXAMPLE TUTORIAL

Omit DC biasing to demonstrate AC response. Assume  $R_i$  and  $R_o$  from input & output.



Currents and Voltages:

$$I_E = I_i = \frac{V_i}{R_i} = \frac{200\text{mV}}{20\Omega} = 10\text{mA}$$

$$I_C \cong I_E$$

$$I_L \cong I_i = 10\text{mA}$$

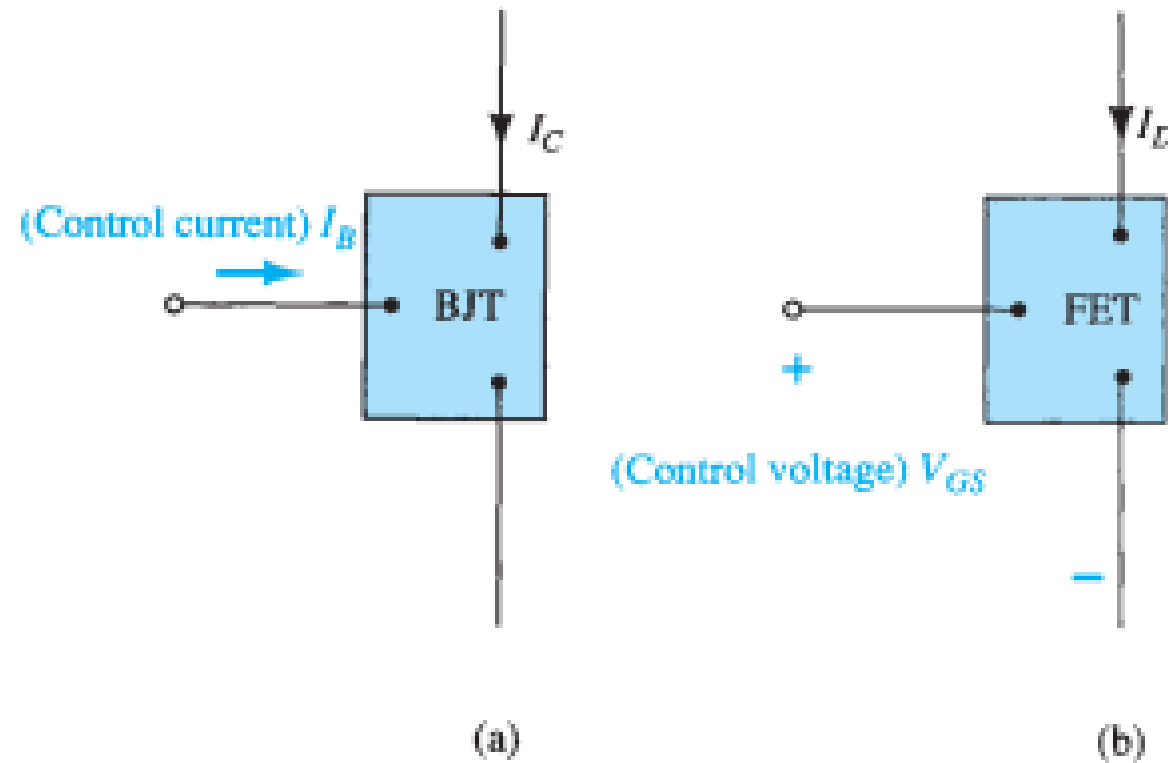
$$V_L = I_L R = (10\text{mA})(5\text{k}\Omega) = 50\text{V}$$

Voltage Gain:

$$A_v = \frac{V_L}{V_i} = \frac{50\text{V}}{200\text{mV}} = 250$$

# JFET

*The BJT transistor is a current-controlled device,  
whereas the JFET transistor is a voltage-controlled device*



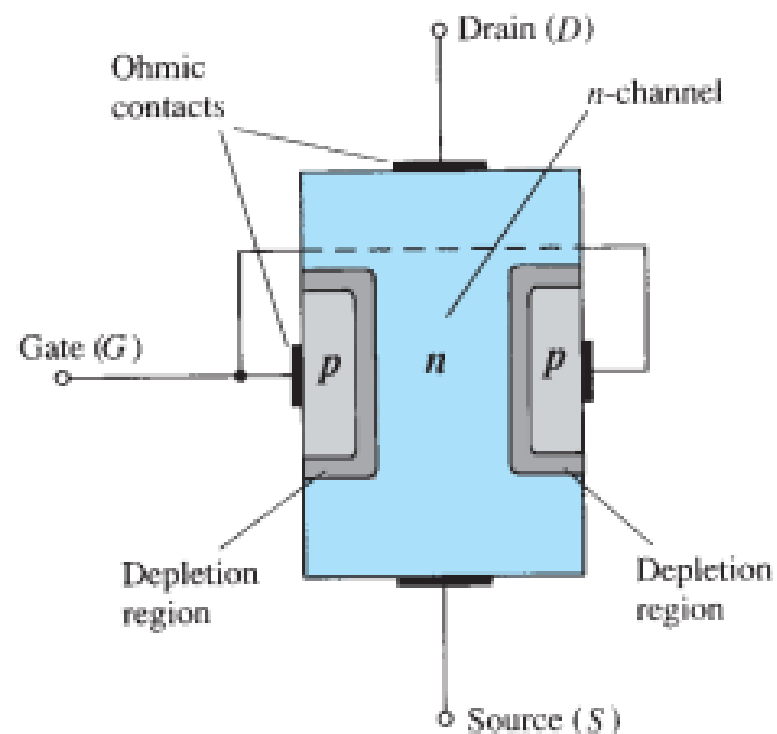
**FIG. 6.1**

*(a) Current-controlled and (b) voltage-controlled amplifiers.*

## JFET

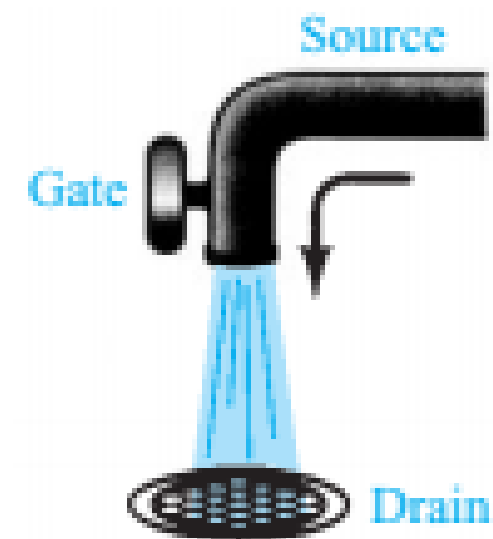
*One of the most important characteristics of the FET is its high input impedance.*

### CONSTRUCTION AND CHARACTERISTICS OF JFETs



**FIG. 6.3**

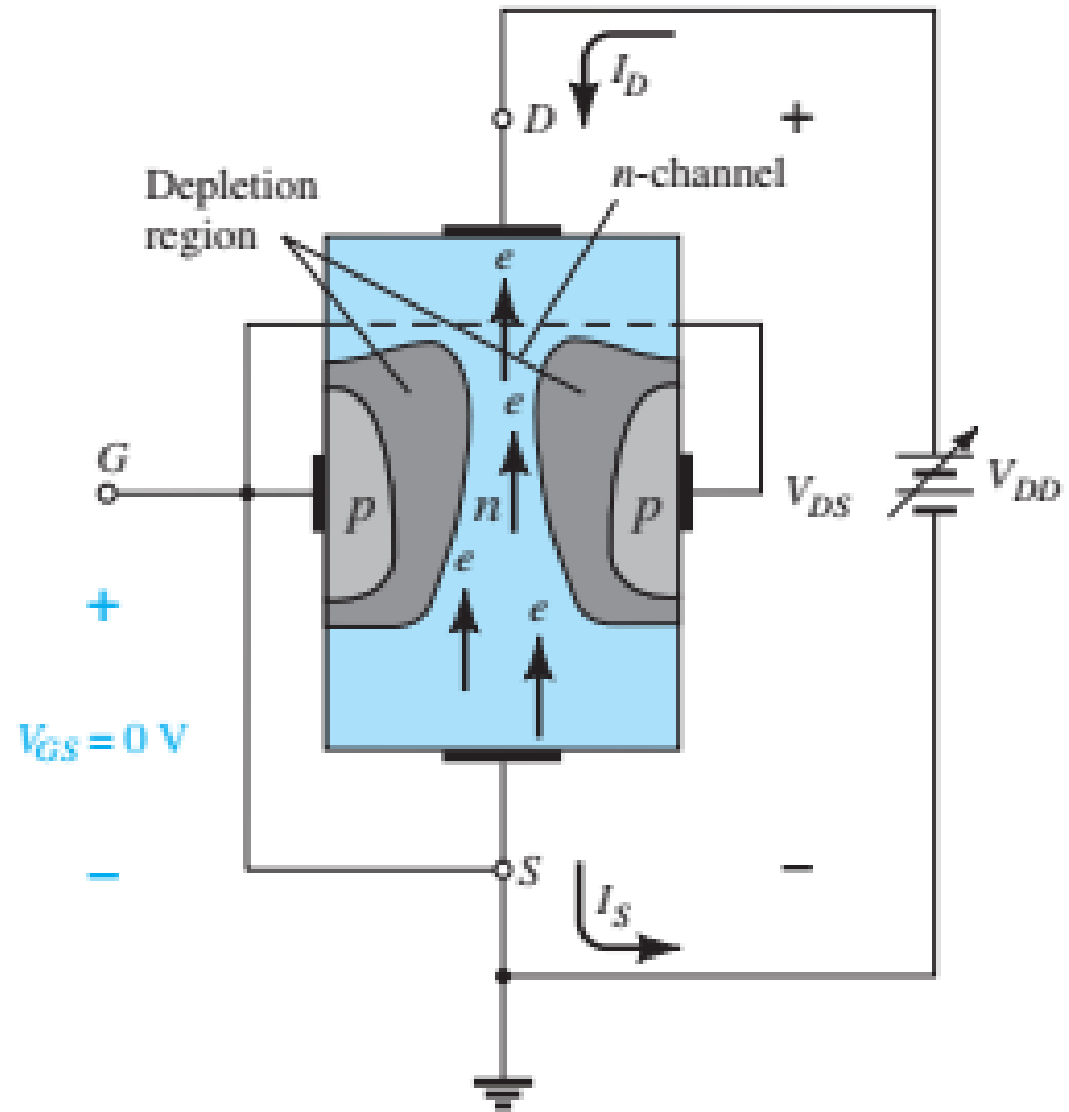
*Junction field-effect transistor (JFET).*



**FIG. 6.4**

*Water analogy for the JFET control mechanism.*

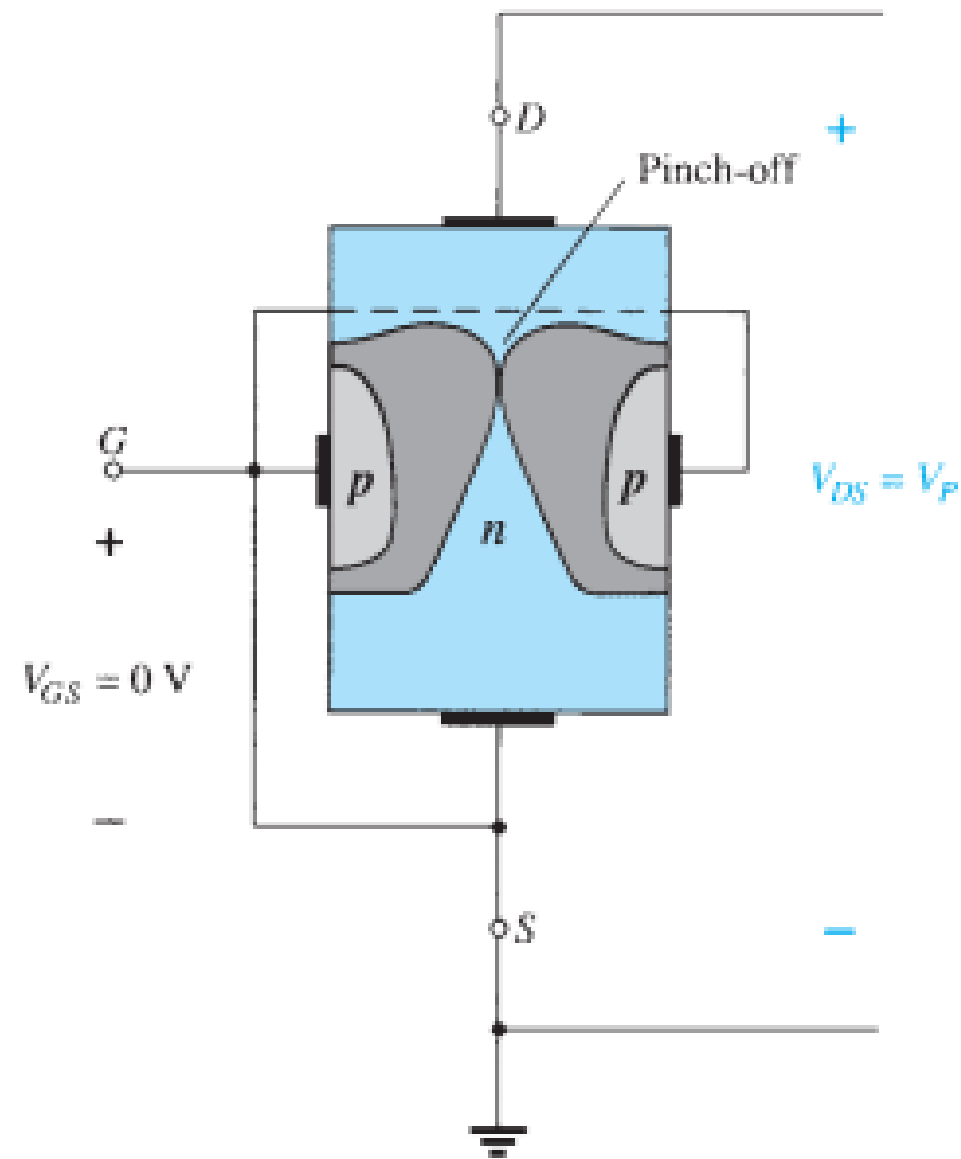
$V_{GS} = 0\text{ V}$ ,  $V_{DS}$  Some Positive Value



**FIG. 6.5**

*JFET at  $V_{GS} = 0\text{ V}$  and  $V_{DS} > 0\text{ V}$ .*

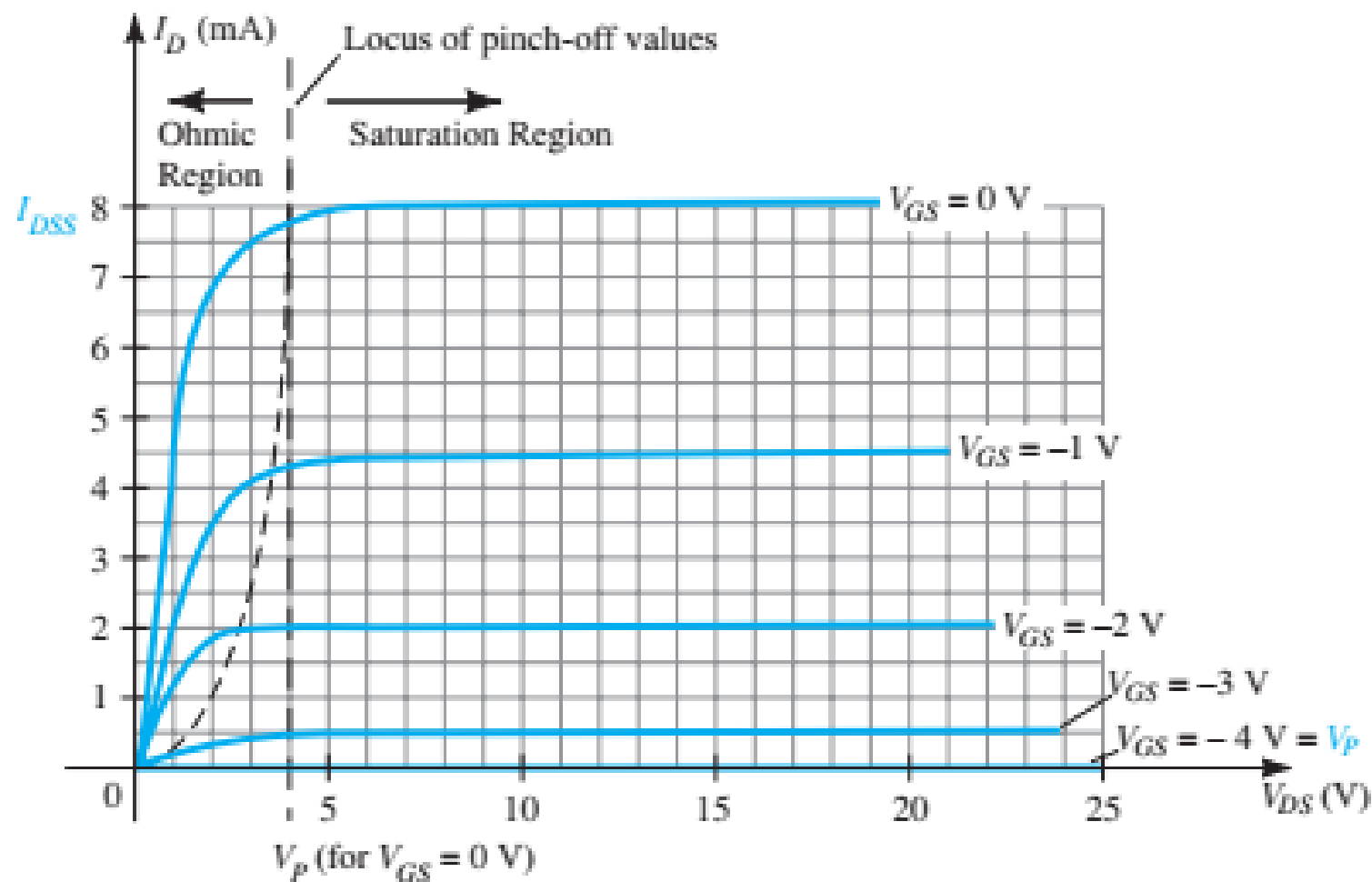
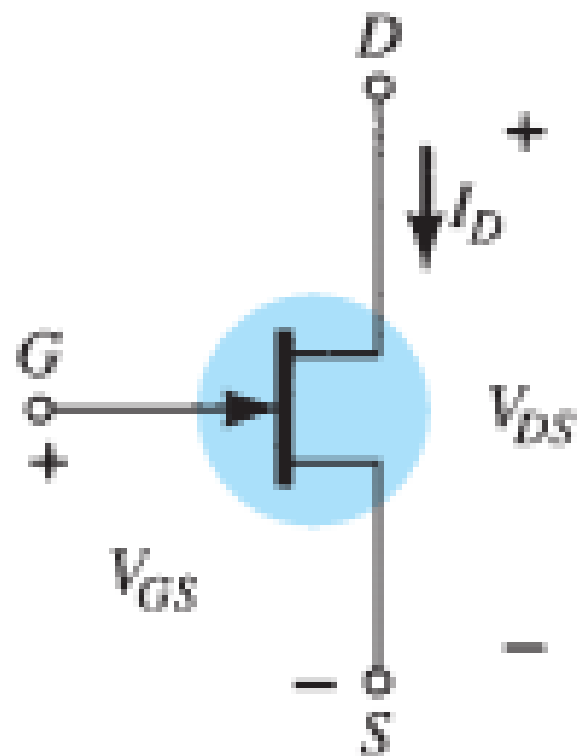
# Pinch-off



**FIG. 6.8**

*Pinch-off ( $V_{GS} = 0\text{ V}$ ,  $V_{DS} = V_P$ ).*

# n-Channel JFET characteristics

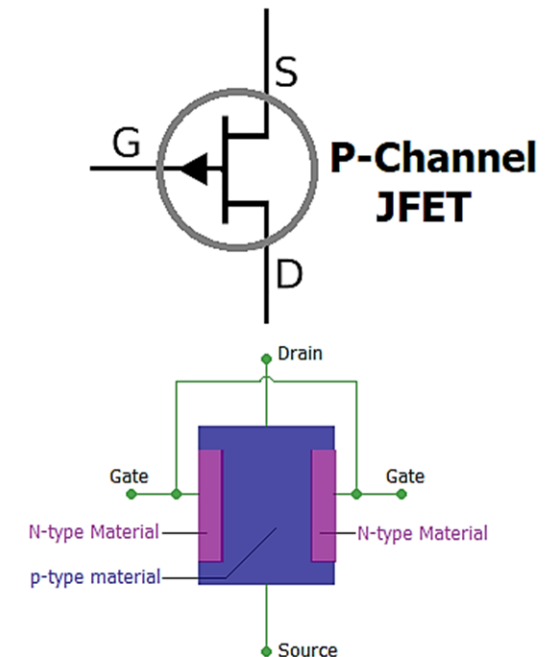
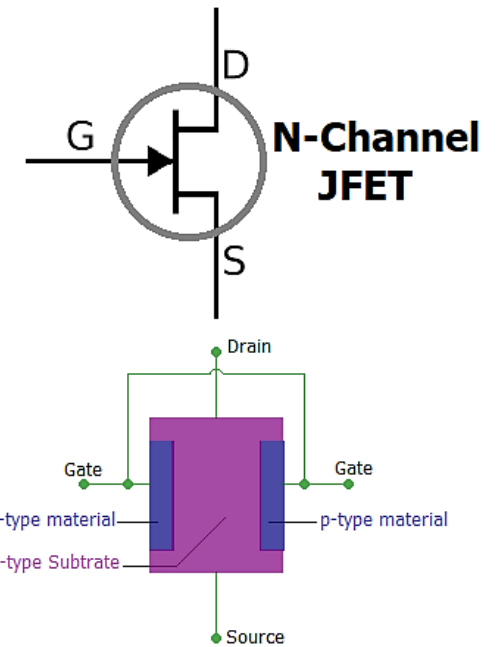


**FIG. 6.11**

*n*-Channel JFET characteristics with  $I_{DSS} = 8$  mA and  $V_P = -4$  V.

## Symbols

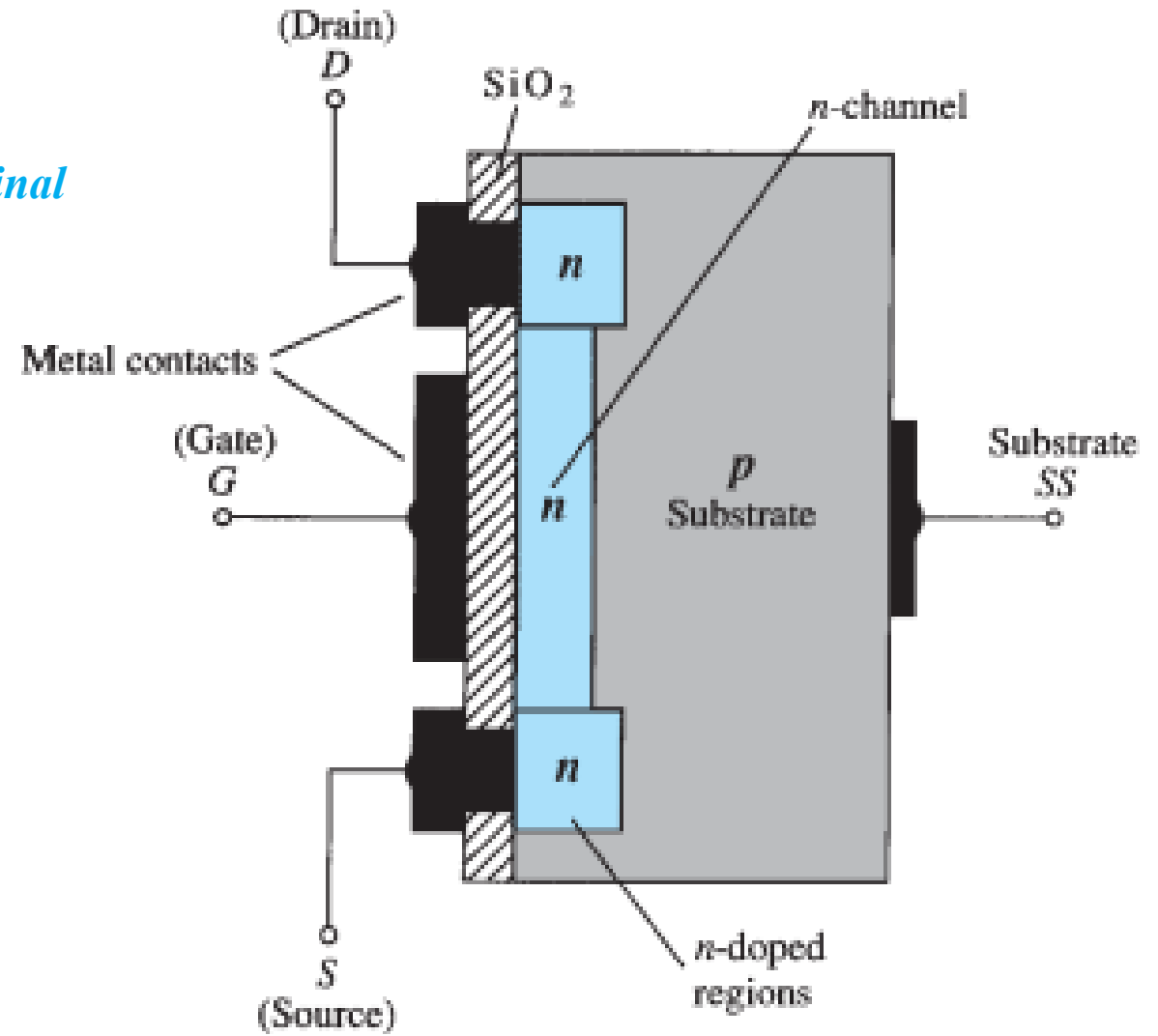
- ❑ JFET is the simplest type of field-effect transistor in which the current can either pass from source to drain or drain to source.
- ❑ JFET uses the voltage applied to the gate terminal to control the current flowing through the channel between the drain and source terminals which results in output current being proportional to the input voltage.
- ❑ The gate terminal is reverse-biased.
- ❑ It's a three-terminal unipolar semiconductor device used in electronic switches, resistors, and amplifiers.
- ❑ It's generally classified into two basic configurations:
  - ❖ N-Channel JFET – The current flowing through the channel between the drain and source is negative in the form of electrons. It has lower resistance than P-Channel types.
  - ❖ P-Channel JFET – The current flowing through the channel is positive in the form of Holes. It has higher resistance than its N-Channel counterparts.



# MOSFET

## Basic Construction

*There is no direct electrical connection between the gate terminal and the channel of a MOSFET.*

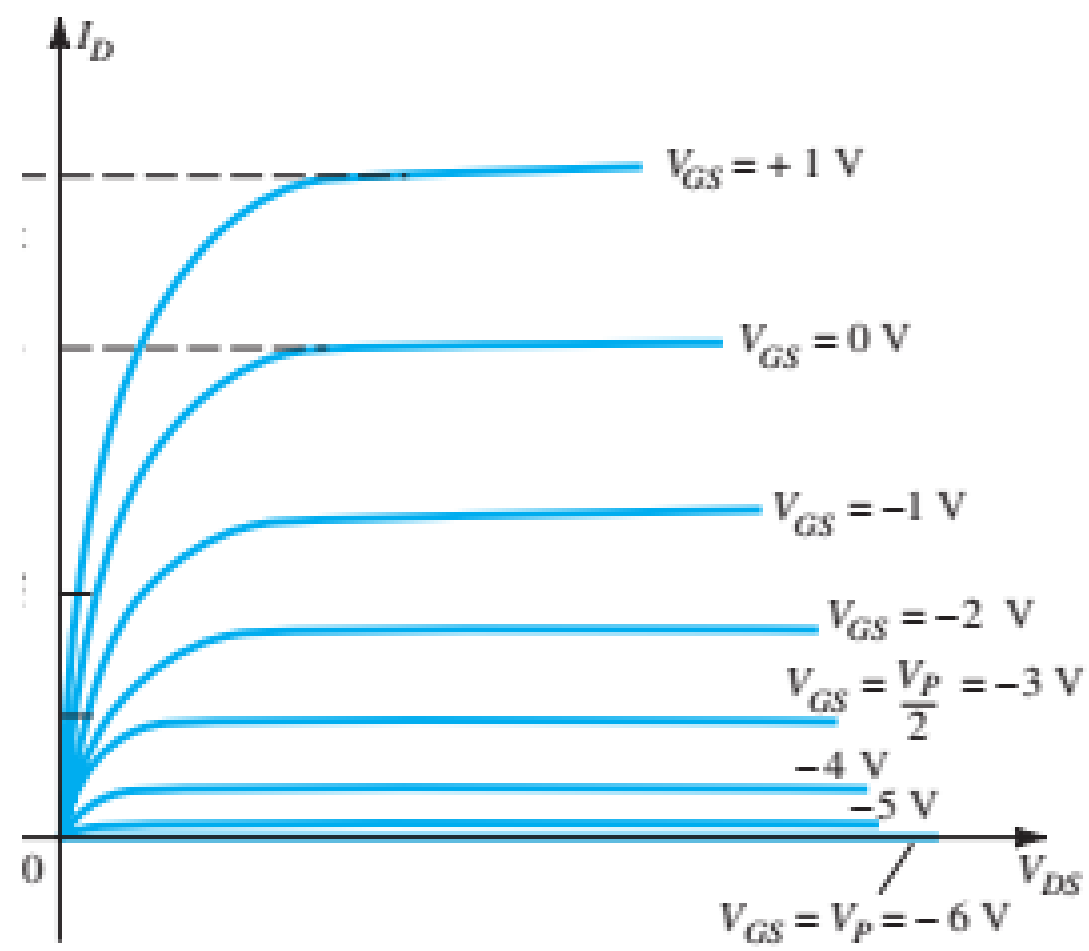


**FIG. 6.24**

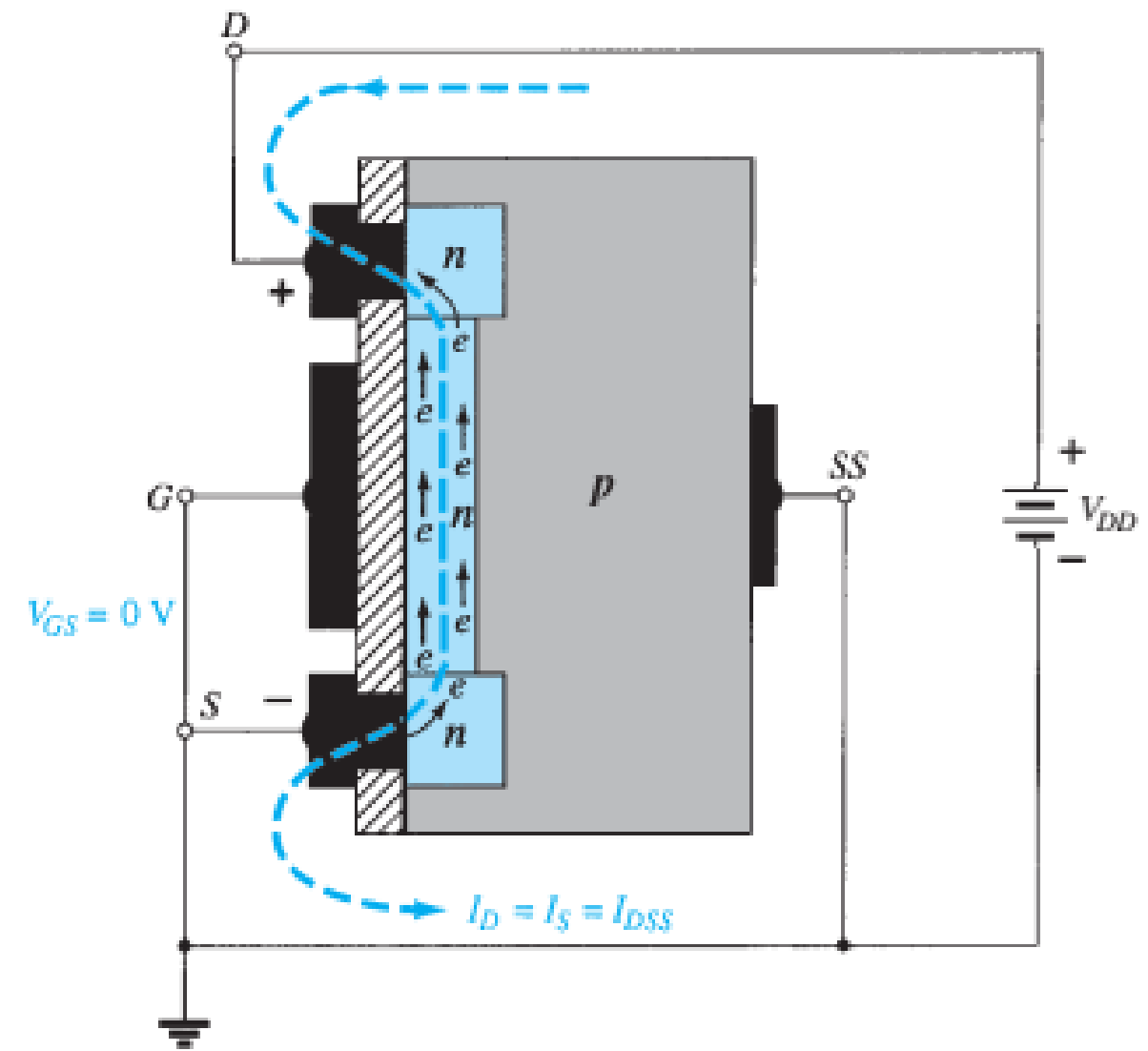
*n-Channel depletion-type MOSFET.*

# MOSFET

## Basic Operation and Characteristics

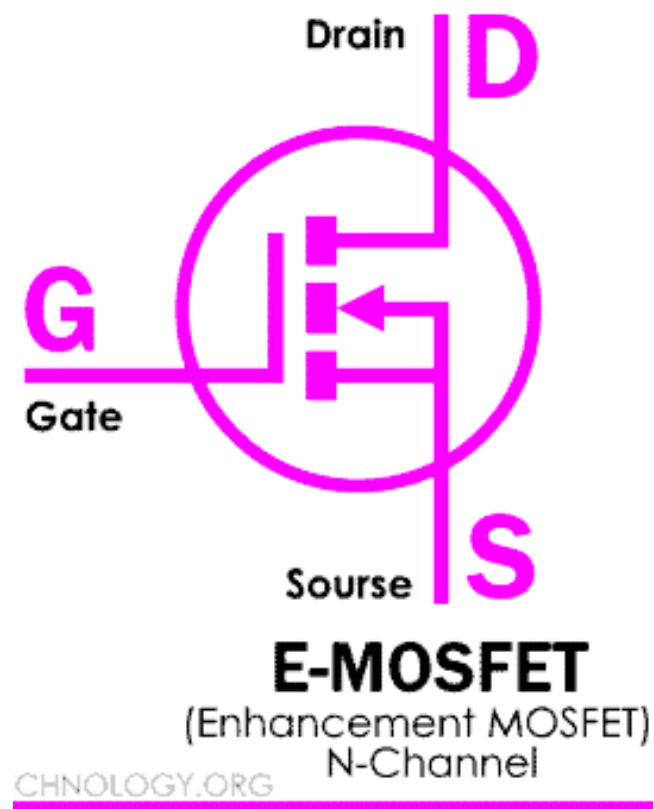
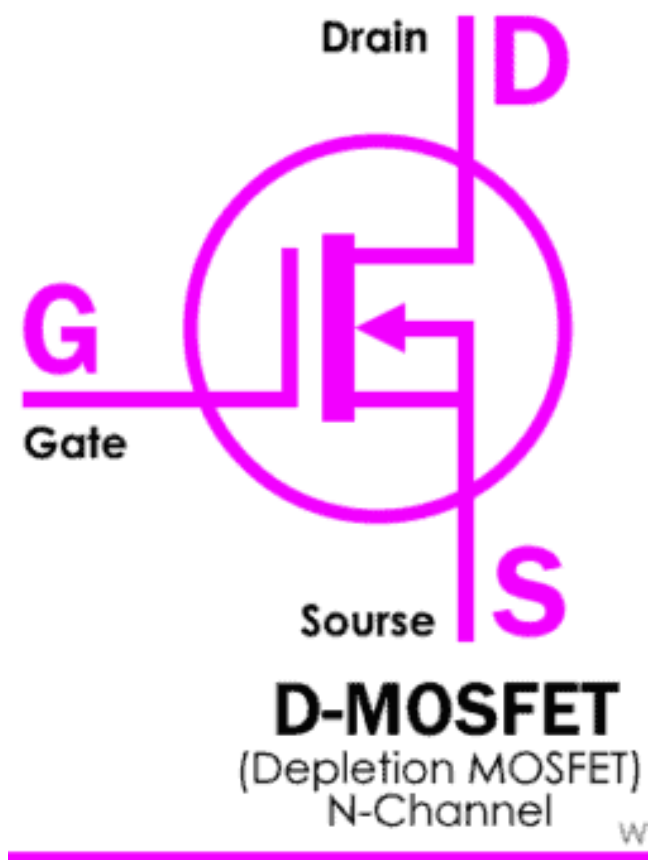


Drain characteristic curve ( $I_D$  versus  $V_{DS}$ )



*n*-Channel depletion-type MOSFET with  $V_{GS} = 0\text{ V}$  and applied voltage  $V_{DD}$

## Symbols



**THANK  
YOU!**