

ECE 312

# Electronic Circuits (1)

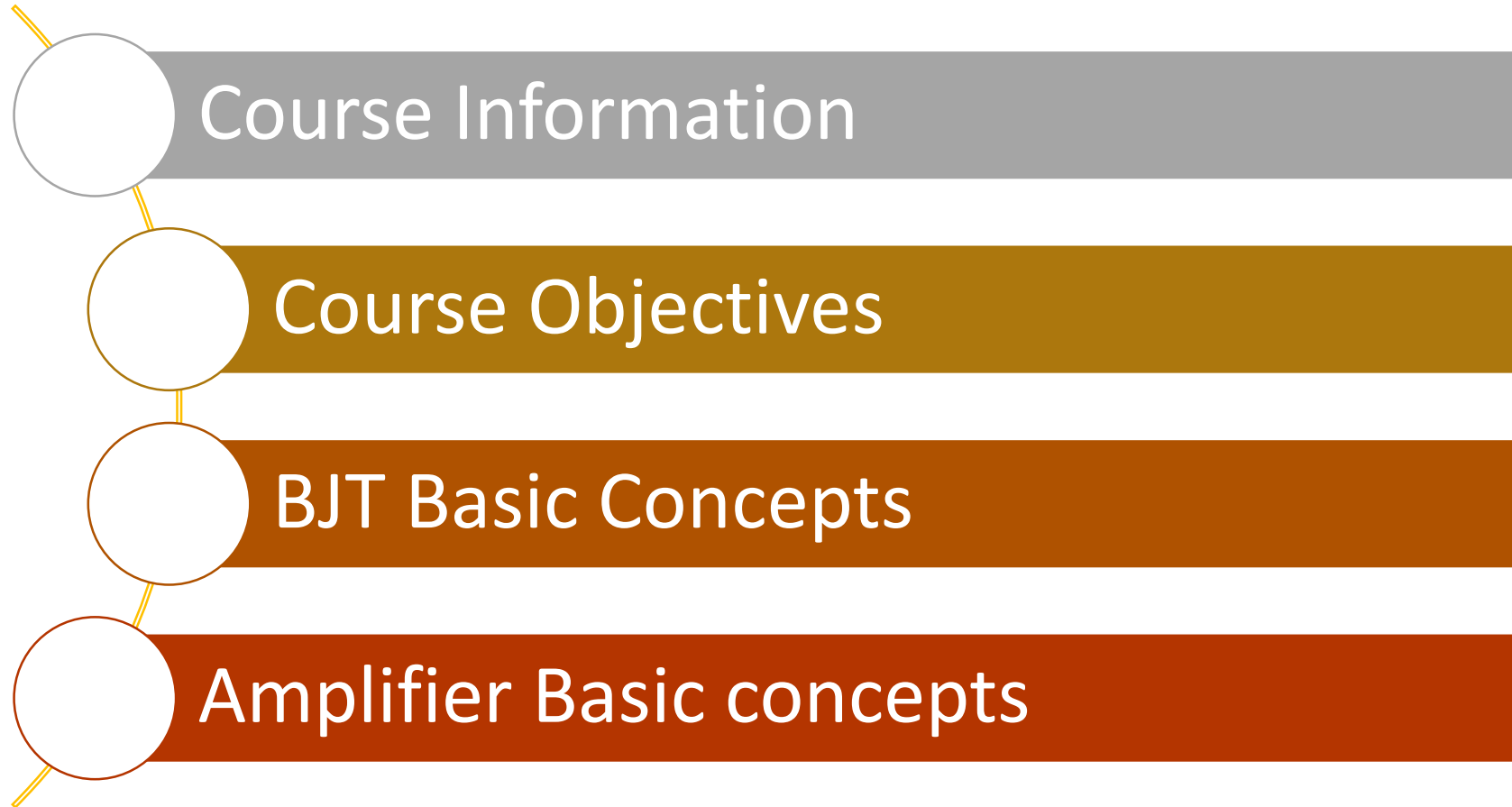
Lec. 1: Introduction and Basic Concepts

Instructor

**Dr. Maher Abdelrasoul**

**<http://www.bu.edu.eg/staff/mahersalem3>**

# Outline



# Course Information

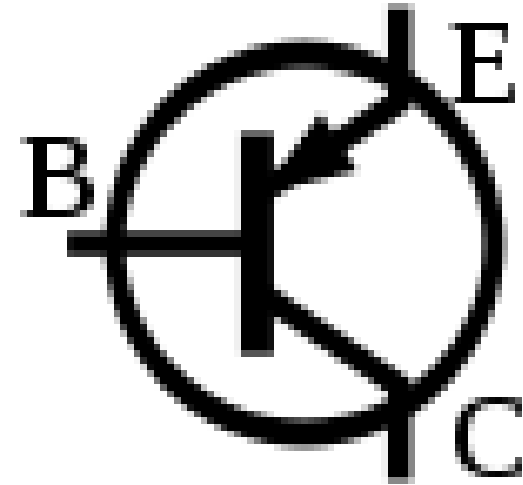
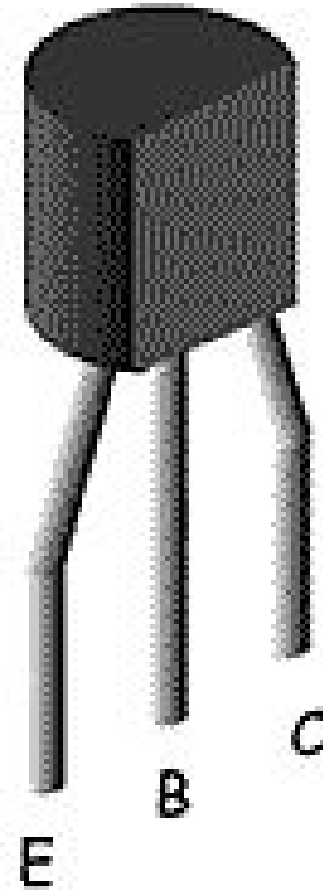
<b>Instructor:</b>	<b>Dr. Maher Abdelrasoul</b>
Lectures:	Sunday:10:40-12:10, Tuesday: 12:30 -2:00
Teaching Assistant:	Eng. Ibrahim, Eng. AbdelFattah
Text Book:	R. Boylestad, Electronic Devices and Circuit Theory, 11th edition, Prentice Hall
Credit:	150 Marks
Grading:	<ul style="list-style-type: none"><li>• Final Exam (60% → 90 Marks)</li><li>• Mid Term Exam (10% → 15 Marks)</li><li>• Homework and tutorials activities (10% → 15 Marks)</li><li>• Projects (20% → 30 Marks)</li></ul>

# Bipolar Junction Transistor



**NPN**

Not Pointing in



**PNP**

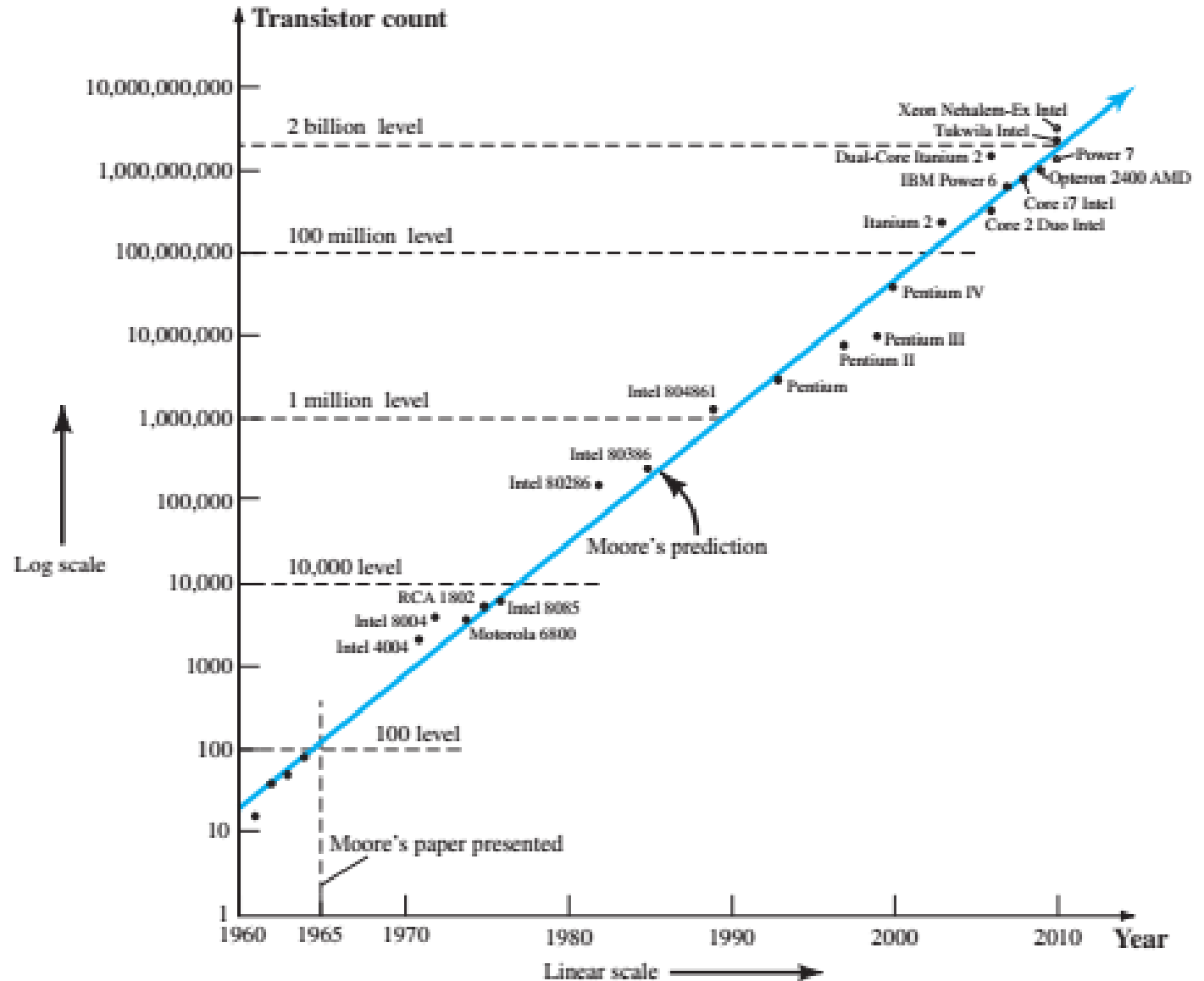
Pointing in Proudly

# Course Objectives

- Understand the transistor biasing, modeling, and its small signal analysis.
- Analyze the transistor circuits at low, medium and high frequencies and study its frequency response using bode plots.
- Explain the operation of tuned amplifiers and power amplifiers.

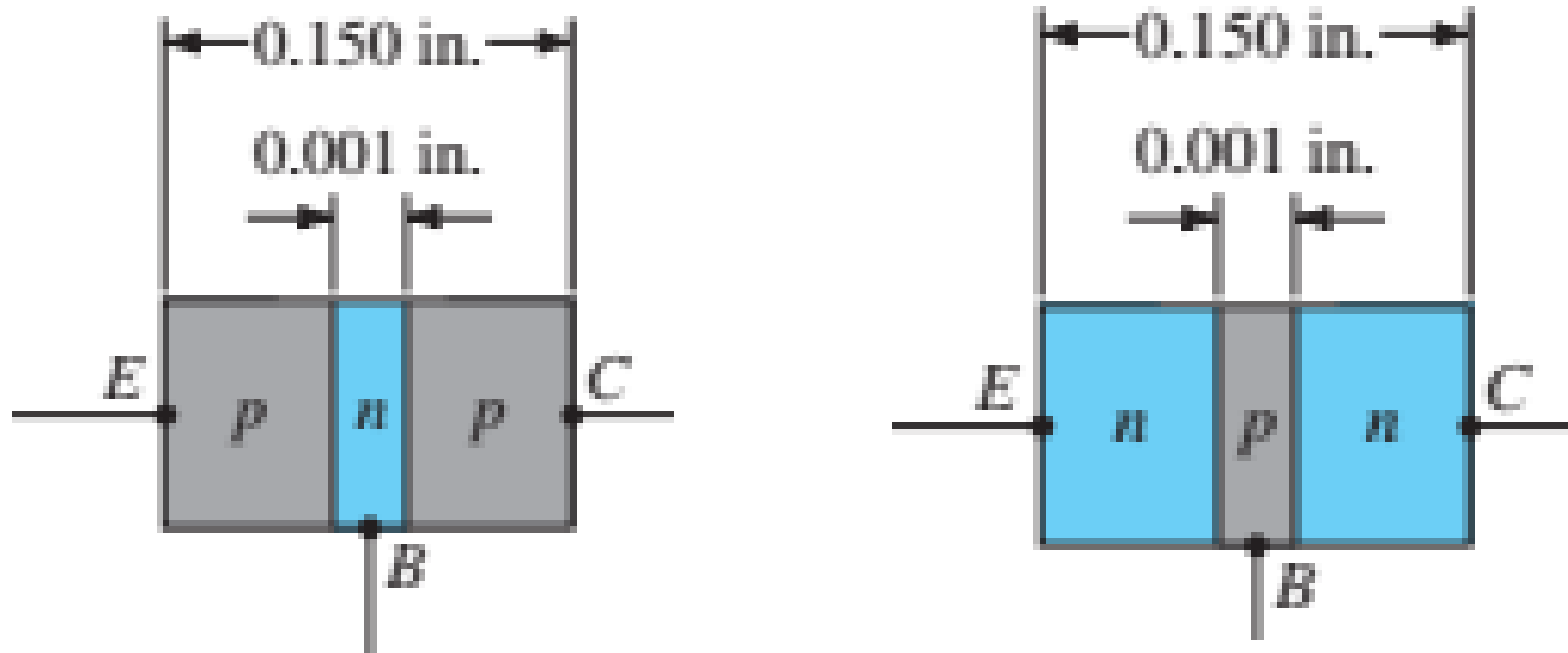
# Transistor Development

- **Moore's law** predicts that the transistor count of an integrated circuit will double every 2 years.

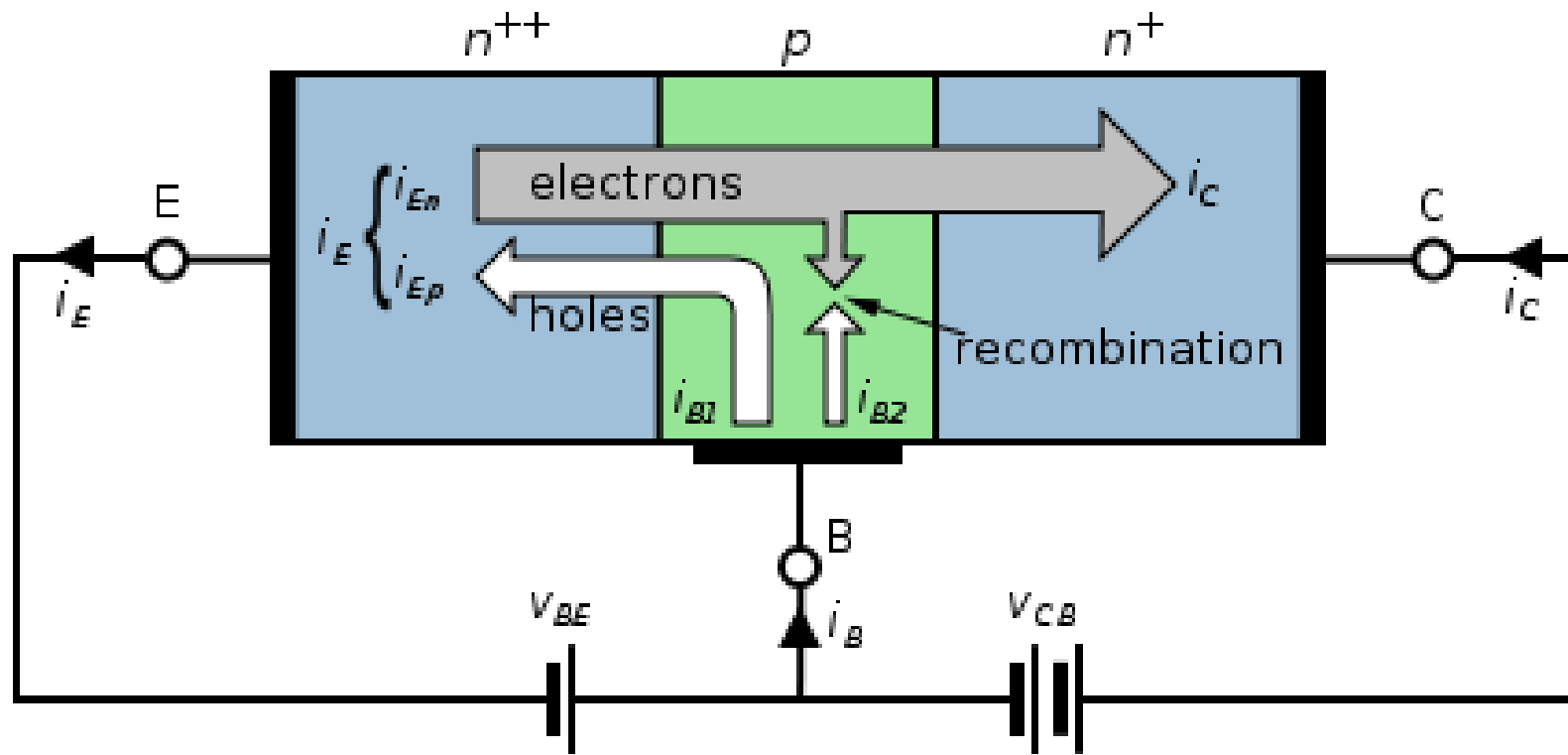


# Transistor Construction

- The transistor is a three-layer semiconductor device consisting of either two  $n$ - and one  $p$ -type layers of material (npn transistor) or two  $p$ - and one  $n$ -type layers of material (pnp transistor).



# Current in BJT



$$I_E = I_C + I_B$$

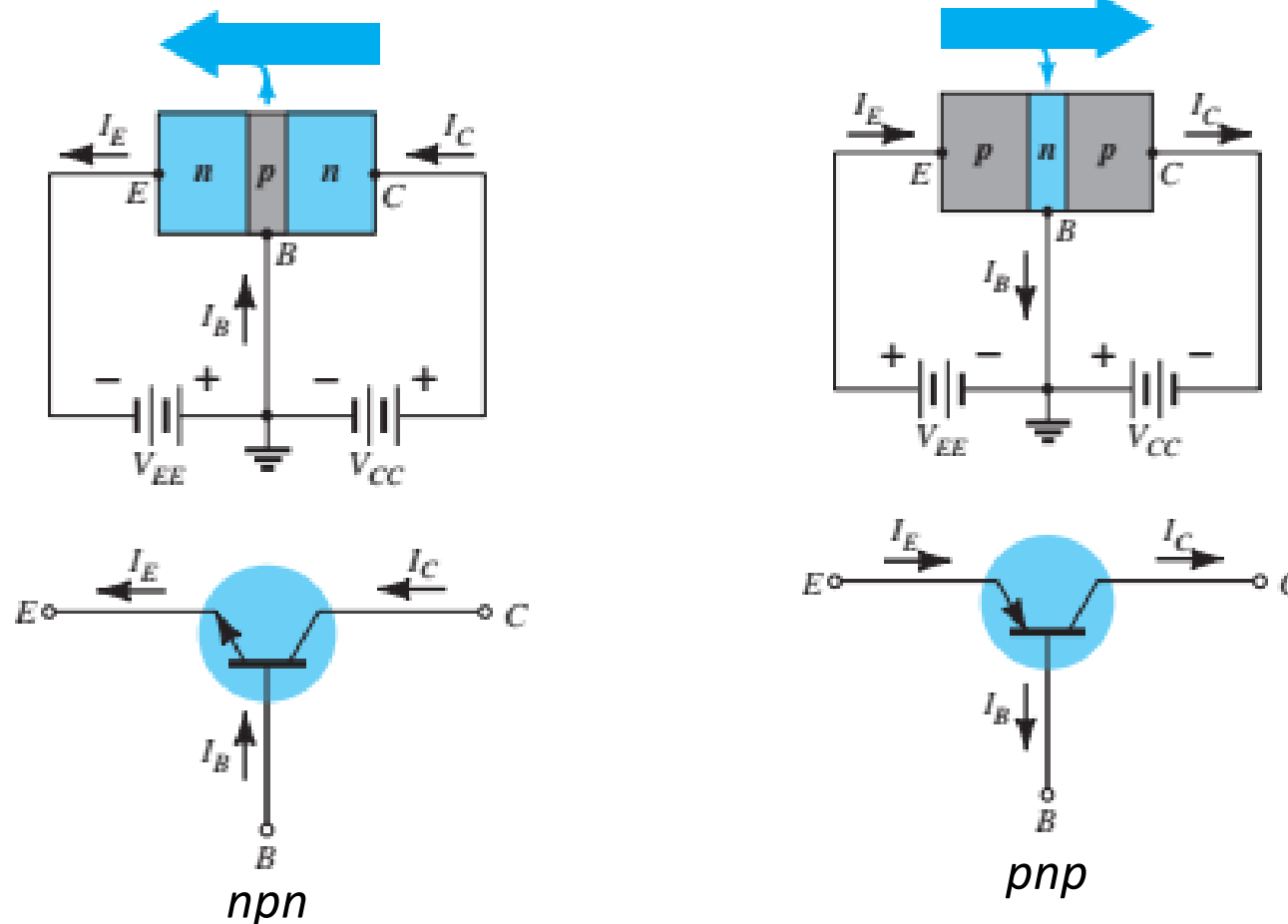


# Transistor Configurations

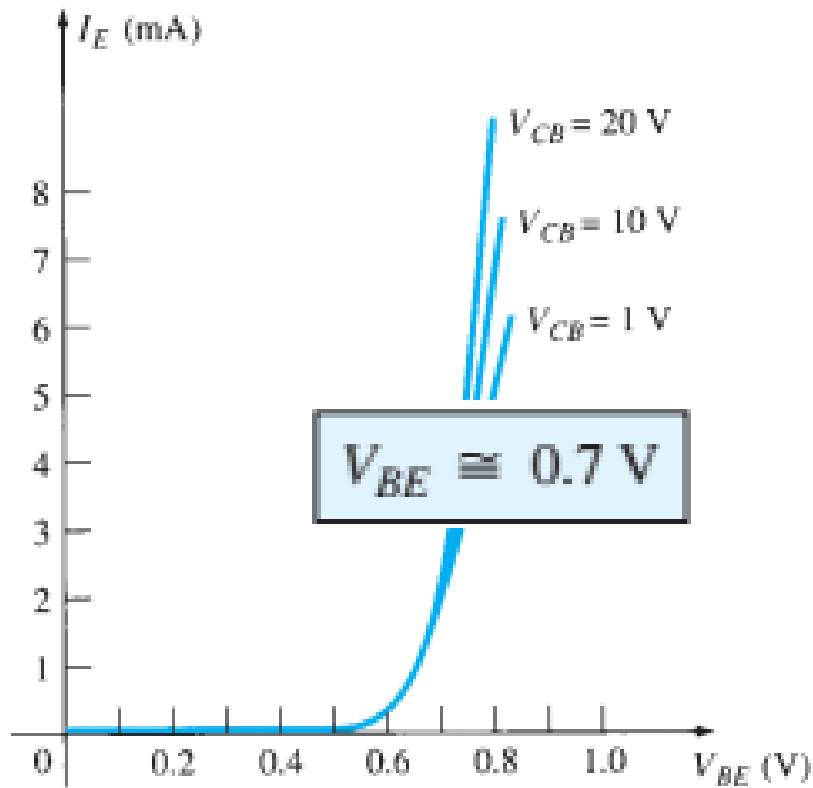


# 1. Common-Base Configuration (1)

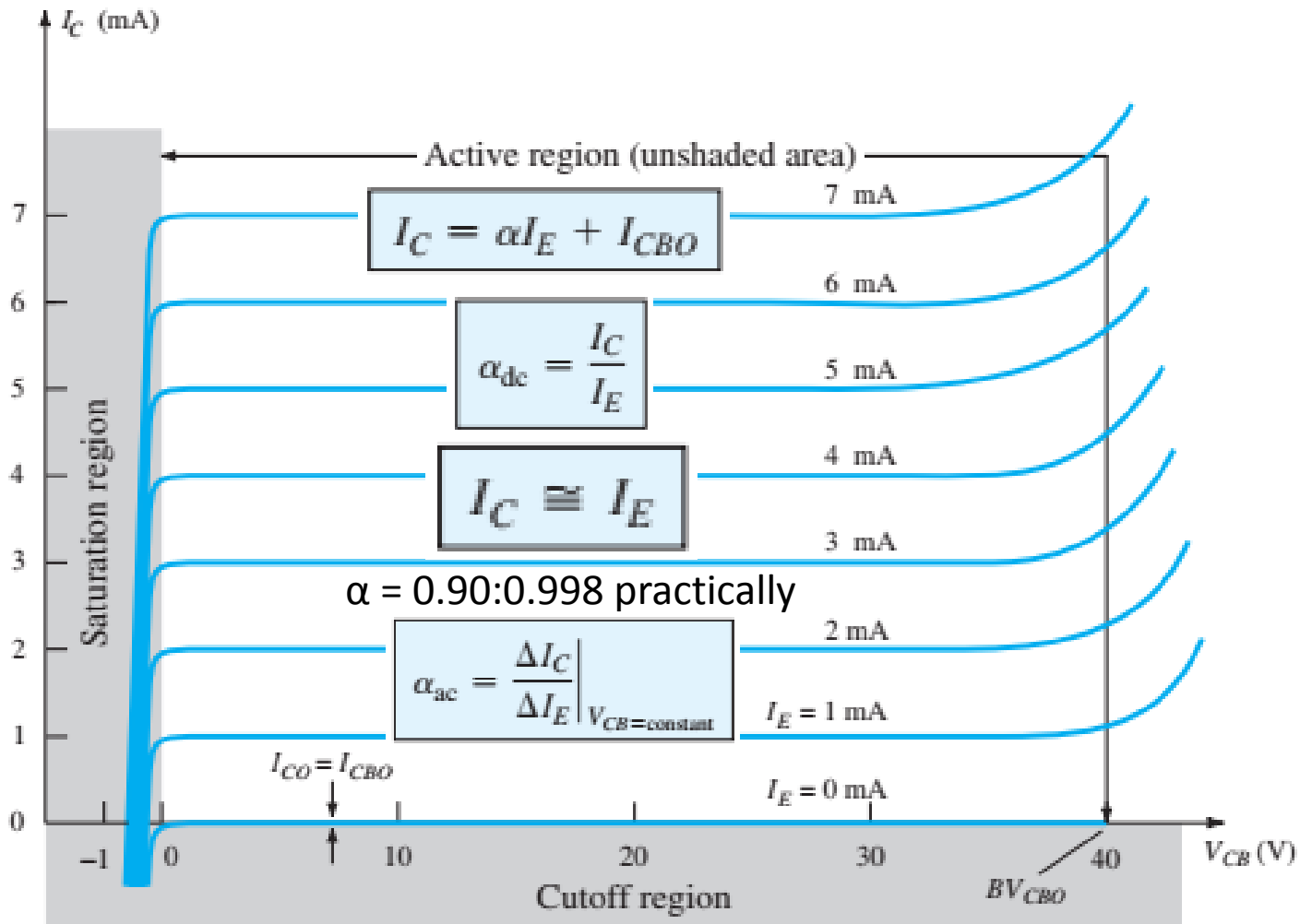
- The common-base terminology is derived from the fact that the base is common to both the input and output sides of the configuration.



# 1. Common-Base Configuration (2)



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

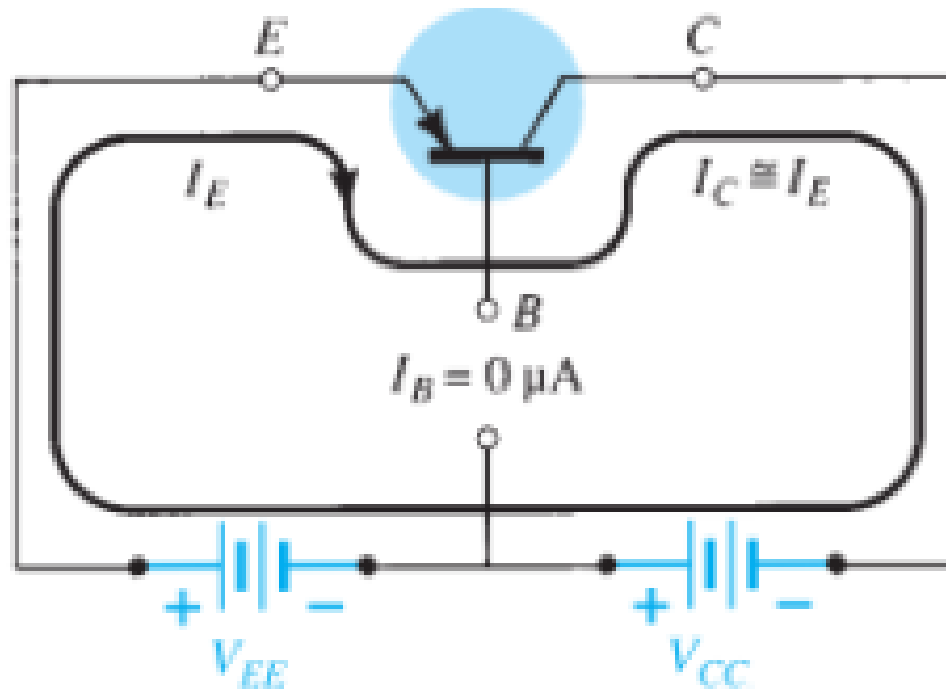


Output or collector characteristics for a common-base transistor amplifier.

# 1. Common-Base Configuration (3)

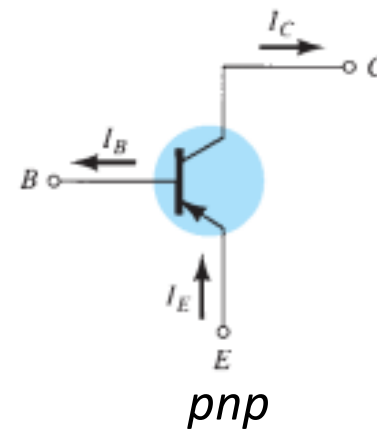
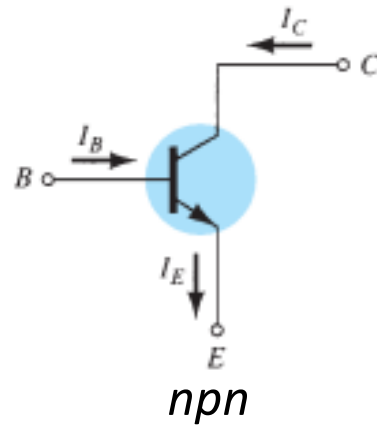
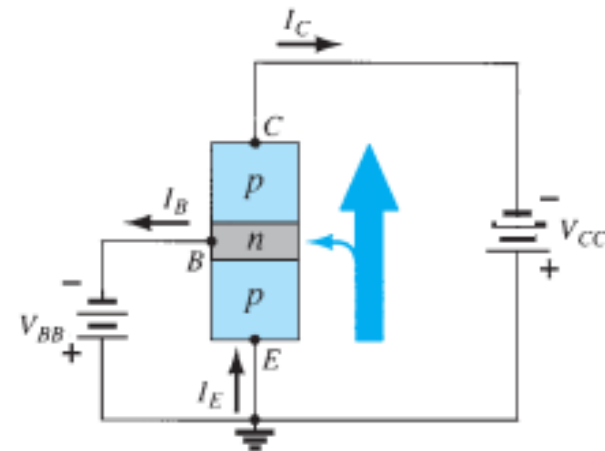
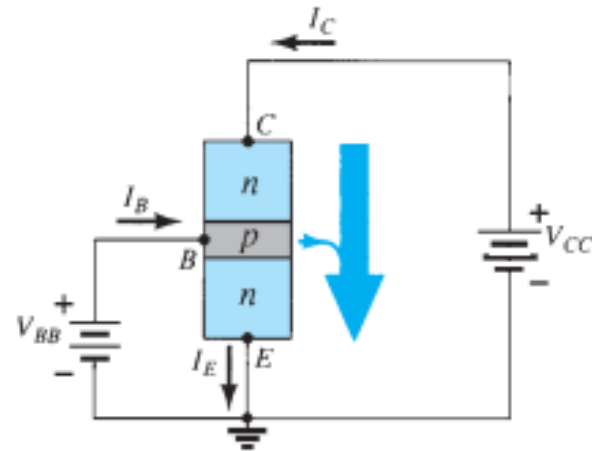
- Biasing of a CB pnp tr. in the active region:

*In the active region the base–emitter junction is forward-biased, whereas the collector–base junction is reverse-biased.*

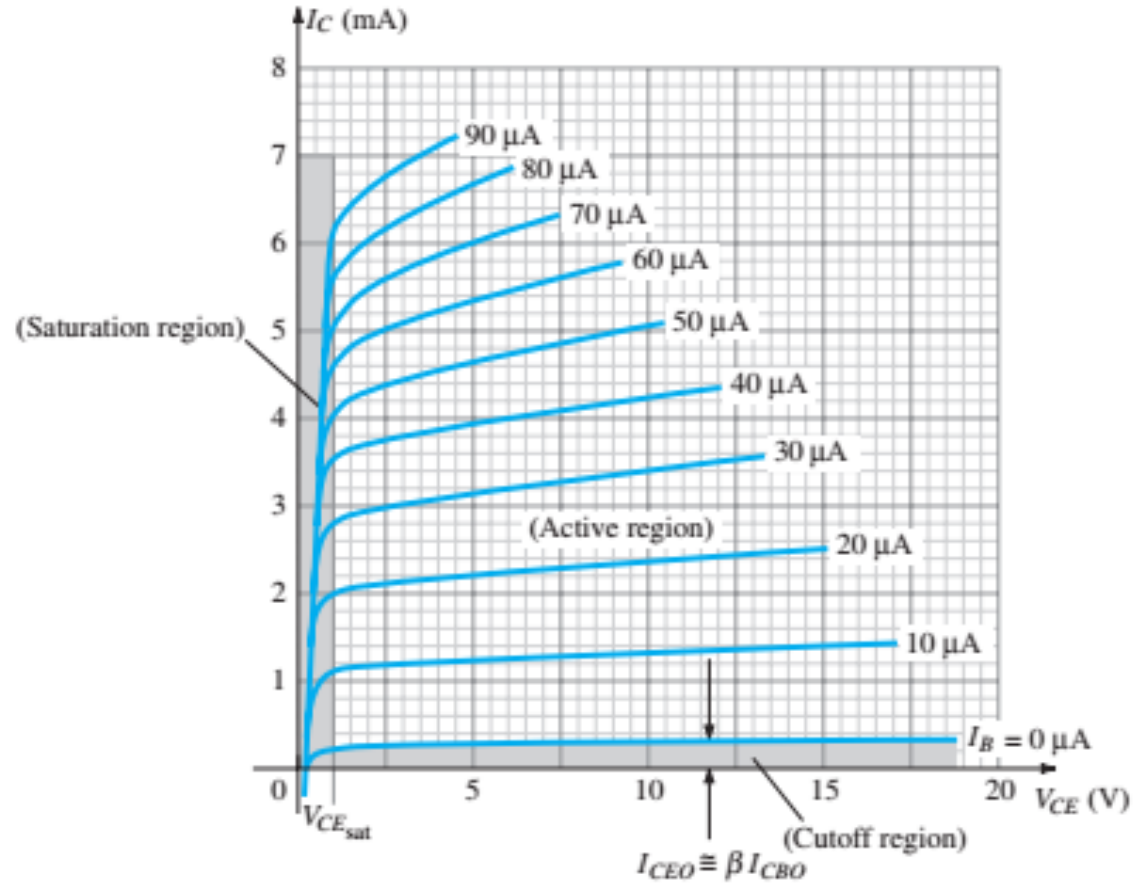
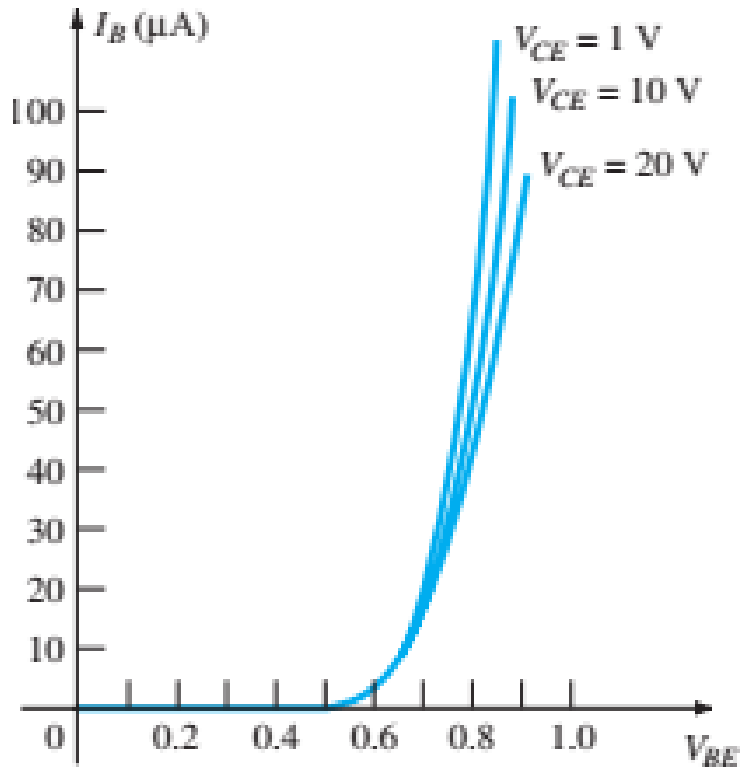


## 2. Common-Emitter Configuration (1)

- It is called the *common-emitter configuration* because the emitter is common to both the input and output terminals (in this case common to both the base and collector terminals).



# 2. Common-Emitter Configuration (2)



$$\beta_{dc} = \frac{I_C}{I_B}$$

$\beta=50:400$  practically

$$\beta_{ac} = \frac{\Delta I_C}{\Delta I_B} \Big|_{V_{CE}=\text{constant}}$$

$$\alpha = \frac{\beta}{\beta + 1}$$

$$\beta = \frac{\alpha}{1 - \alpha}$$

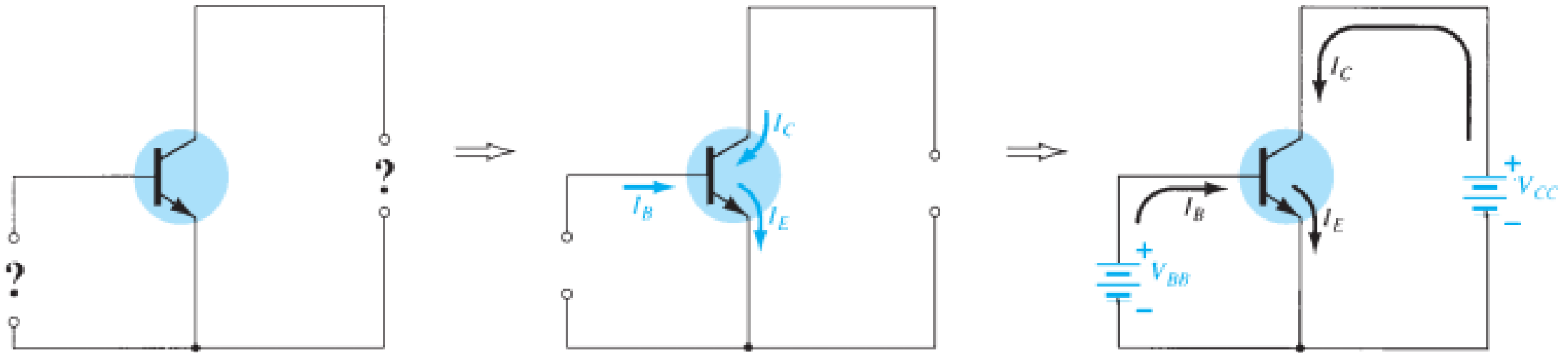
$$I_C = \beta I_B$$

$$I_E = (\beta + 1) I_B$$

## 2. Common-Emitter Configuration (3)

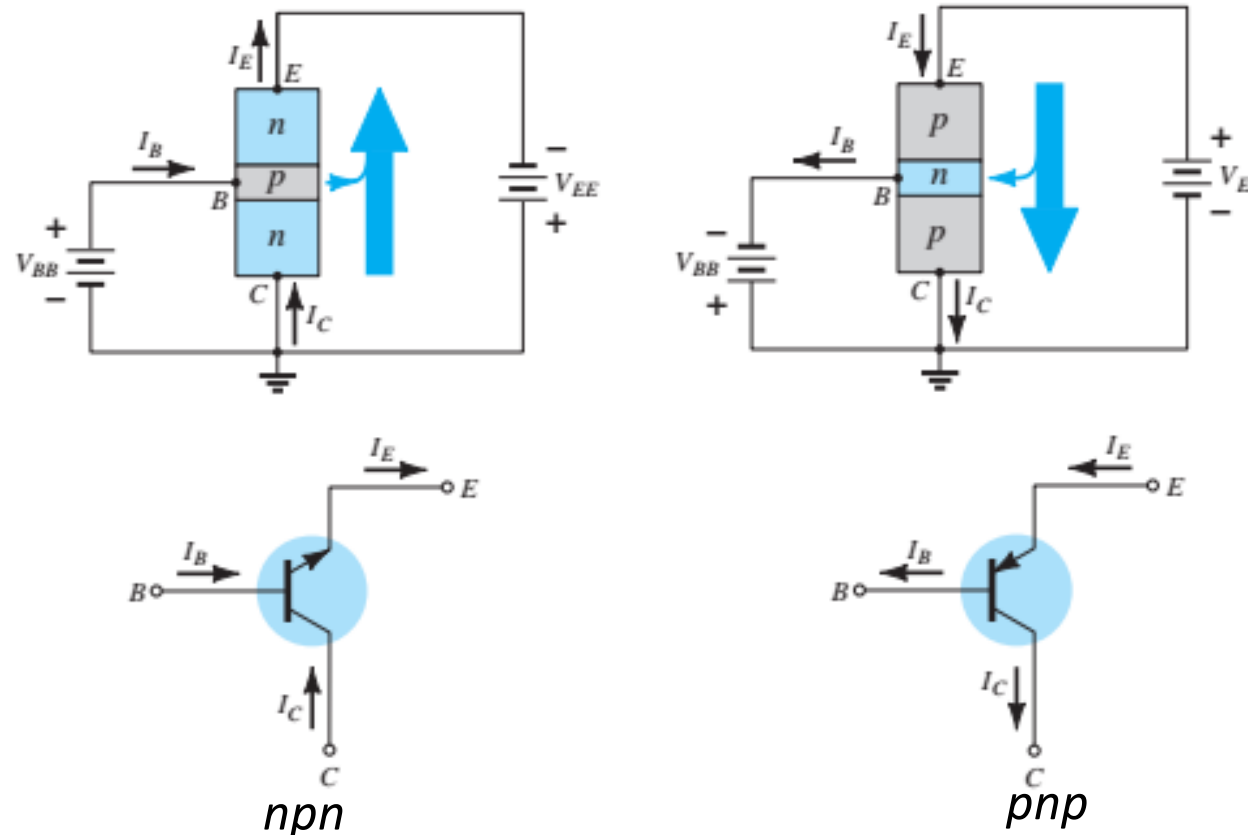
- Biasing of a CE npn tr. in the active region:

*In the active region of a common-emitter amplifier, the base-emitter junction is forward-biased, whereas the collector-base junction is reverse-biased.*



# 3. Common-Collector Configuration (1)

- The common-collector configuration is used primarily for impedance-matching purposes since it has a high input impedance and low output impedance, opposite to that of the common-base and common emitter configurations.

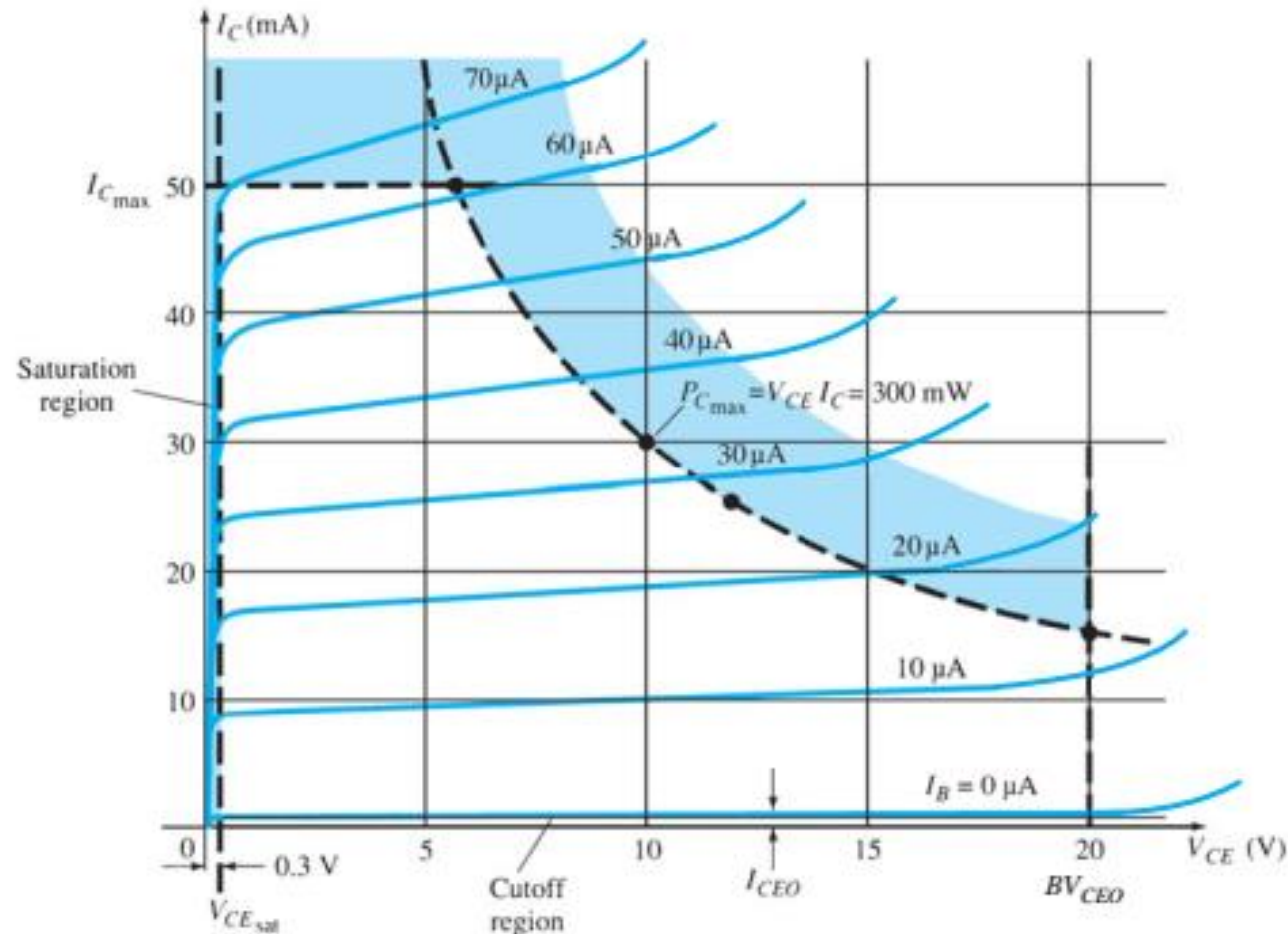




# 3. Common-Collector Configuration (2)

- Limits of operation

*Defining the linear (undistorted) region of operation for a transistor*



The output characteristics of the common-collector configuration are the same as for the common-emitter configuration ( $I_C \approx I_E$ ).

$$P_{C_{max}} = V_{CE} I_C$$

$$I_{CE0} \cong I_C \cong I_{C_{max}}$$
$$V_{CE_{sat}} \cong V_{CE} \cong V_{CE_{max}}$$
$$V_{CE} I_C \cong P_{C_{max}}$$

# Transistor Configuration Sheet

- Since the specification sheet is the communication link between the manufacturer and user, it is particularly important that the information provided be recognized and correctly understood.

## OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ( $I_C = 1.0 \text{ mA}$ , $I_E = 0$ )	$V_{(BR)CEO}$	30		Vdc
Collector-Base Breakdown Voltage ( $I_C = 10 \mu\text{A}$ , $I_E = 0$ )	$V_{(BR)CBO}$	40		Vdc
Emitter-Base Breakdown Voltage ( $I_E = 10 \mu\text{A}$ , $I_C = 0$ )	$V_{(BR)EBO}$	5.0	-	Vdc
Collector Cutoff Current ( $V_{CB} = 20 \text{ Vdc}$ , $I_E = 0$ )	$I_{CBO}$	-	50	nA
Emitter Cutoff Current ( $V_{BE} = 3.0 \text{ Vdc}$ , $I_C = 0$ )	$I_{EBO}$	-	50	nA

## ON CHARACTERISTICS

DC Current Gain(1) ( $I_C = 2.0 \text{ mA}$ , $V_{CE} = 1.0 \text{ Vdc}$ ) ( $I_C = 50 \text{ mA}$ , $V_{CE} = 1.0 \text{ Vdc}$ )	$h_{FE}$	50 25	150 -	-
Collector-Emitter Saturation Voltage(1) ( $I_C = 50 \text{ mA}$ , $I_B = 5.0 \text{ mA}$ )	$V_{CE(sat)}$	-	0.3	Vdc
Base-Emitter Saturation Voltage(1) ( $I_C = 50 \text{ mA}$ , $I_B = 5.0 \text{ mA}$ )	$V_{BE(sat)}$	-	0.95	Vdc

Small-Signal Current Gain ( $I_C = 2.0 \text{ mA}$ , $V_{CE} = 10 \text{ Vdc}$ , $f = 1.0 \text{ kHz}$ )	$h_{fe}$	50	200	-
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## MAXIMUM RATINGS

Rating	Symbol	2N4123	Unit
Collector-Emitter Voltage	$V_{CEO}$	30	Vdc
Collector-Base Voltage	$V_{CBO}$	40	Vdc
Emitter-Base Voltage	$V_{EBO}$	5.0	Vdc
Collector Current - Continuous	$I_C$	200	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	$T_J, T_{stg}$	-55 to +150	°C

## Limits of Operation

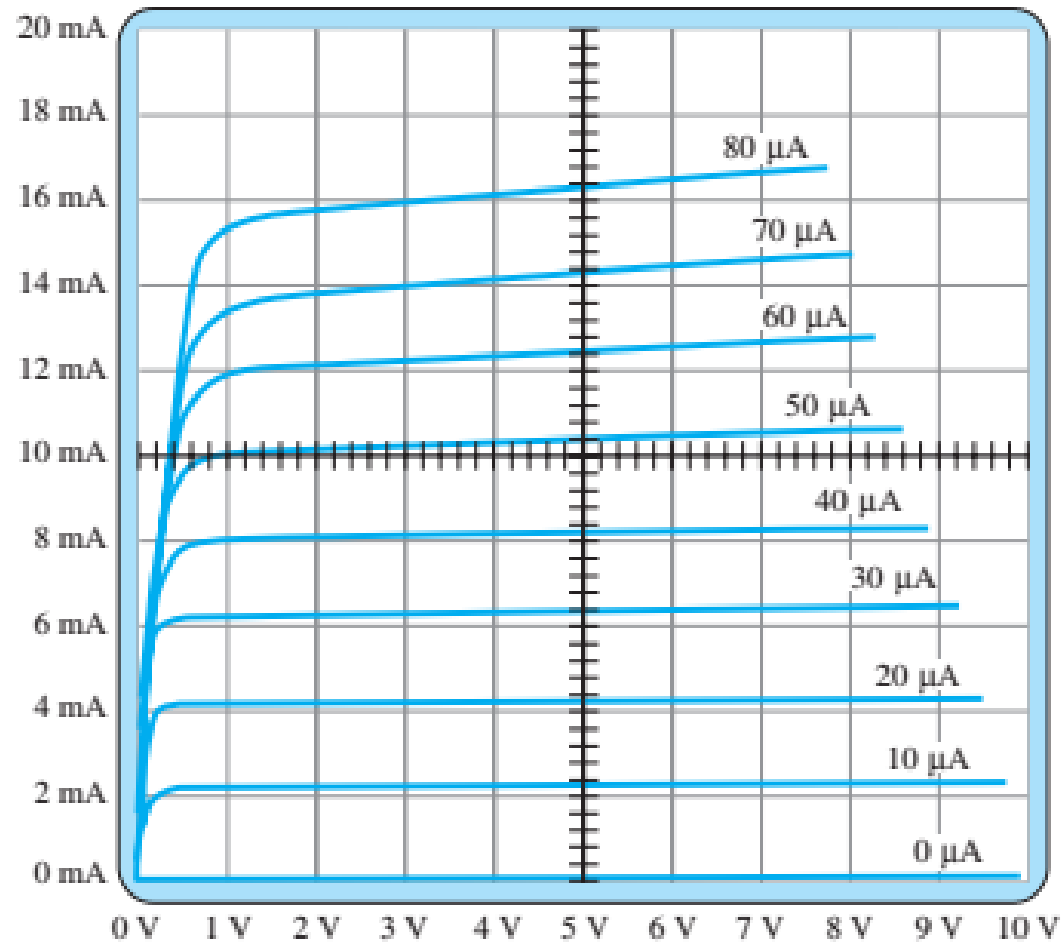
$$7.5 \mu\text{A} \leq I_C \leq 200 \text{ mA}$$

$$0.3 \text{ V} \leq V_{CE} \leq 30 \text{ V}$$

$$V_{CE} I_C \leq 650 \text{ mW}$$

# Transistor Testing

## 1. Curve Tracer



Curve tracer response to 2N3904 npn transistor.

Vertical per div  
2 mA

Horizontal per div  
1 V

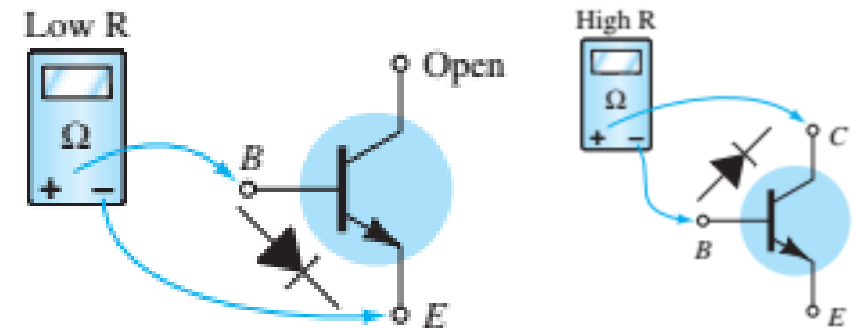
Per Step  
10  $\mu A$

$\beta$  or gm per div  
200

## 2. Transistor Testers

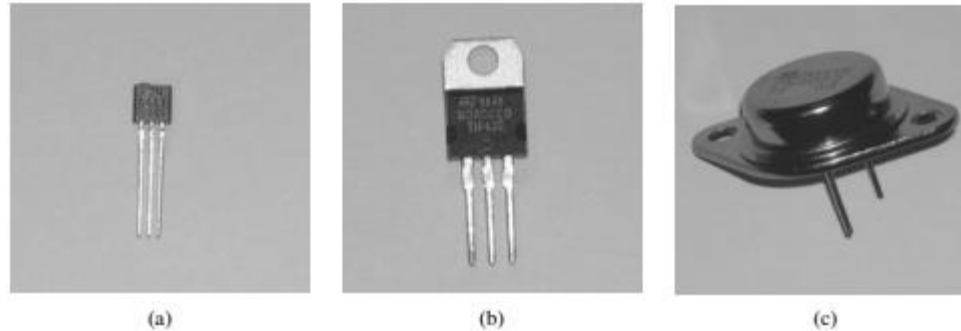


## 3. Ohmmeter



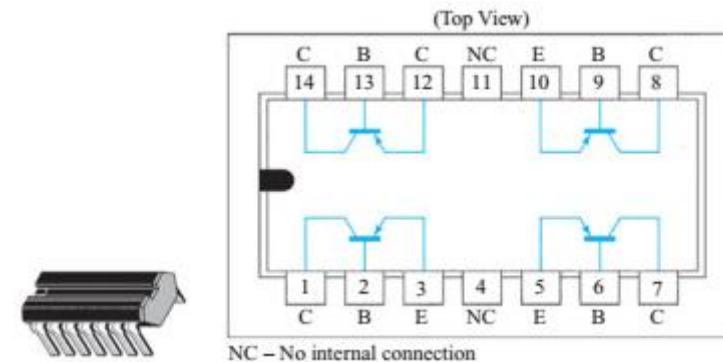
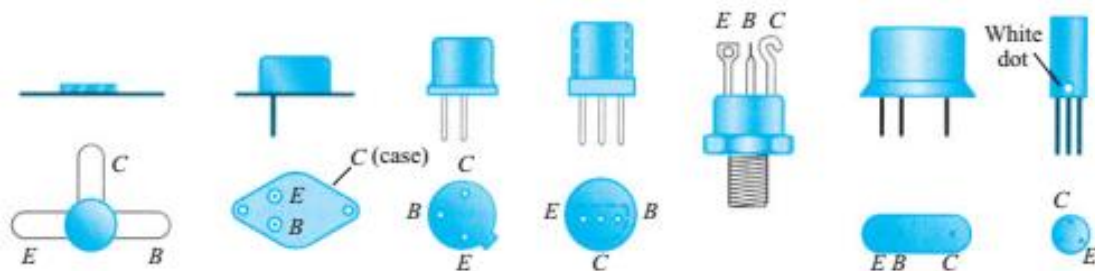
# Transistor Casing and Terminal Identification

- Casing



*Various types of general-purpose or switching transistors:  
 (a) low power; (b) medium power; (c) medium to high power.*

- Terminal Identification

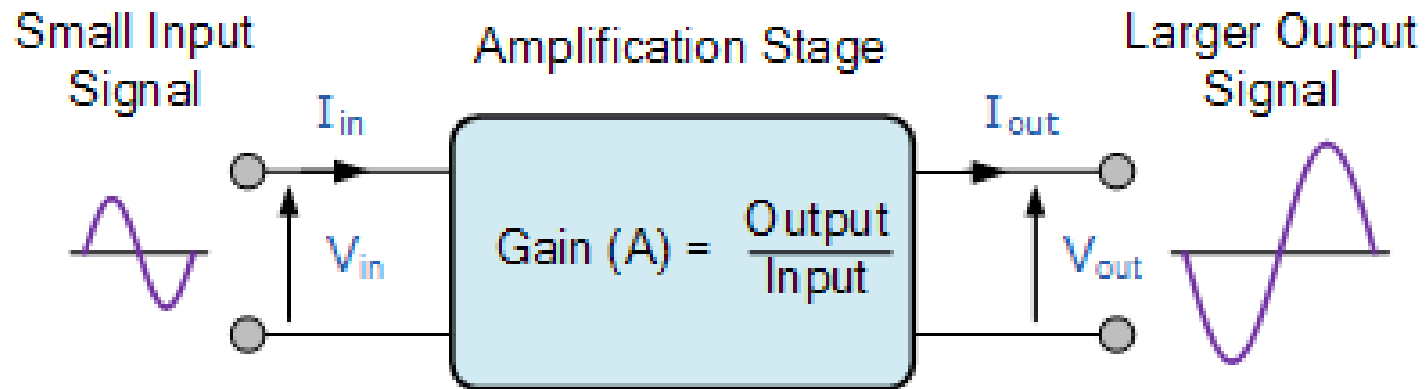


*Type Q2T2905 Texas Instruments quad  
 pnp silicon transistor*

# BASIC CONCEPTS of Amplifiers

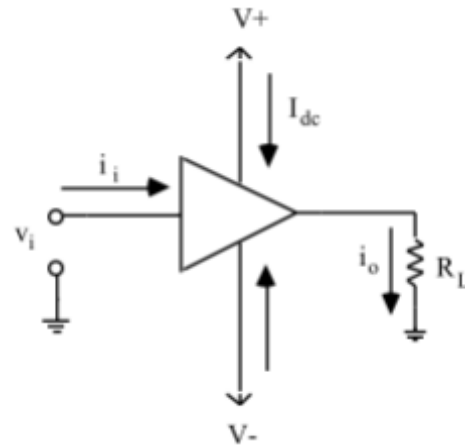
# Amplifier

- An amplifier is an electronic device that can increase the **power** of a signal.
- The amount of amplification provided by an amplifier is measured by its gain: the ratio of output to input.



# Amplifier Power Supply

- An amplifier uses electric power from a power supply to increase the amplitude of a signal.
- Most analog amplifiers use two power supply voltages or “rails”.



- Some amplifiers use only one power supply, but some times they internally split that signal voltage into two rails by making an artificial ground voltage half way from the real ground to the supply voltage

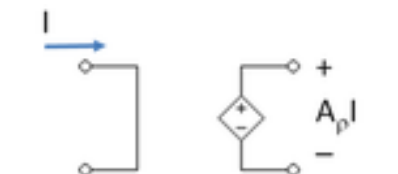
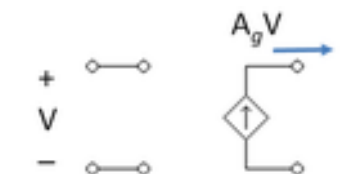
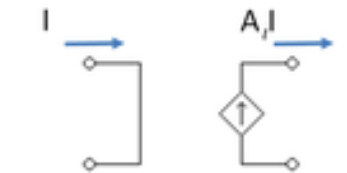
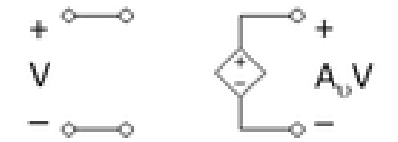
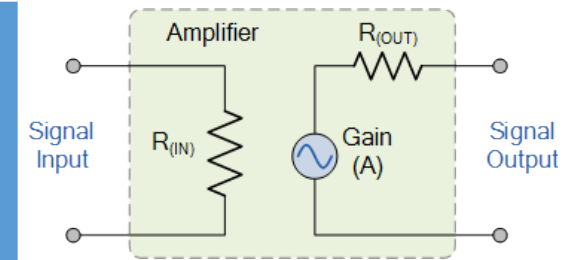
# Important Characteristics of an Amplifier

- The quality of an amplifier is measured by a series of specifications called figures of merit. They are as follows:
  1. **Gain:** Perhaps the most important, the ratio between the magnitudes of input and output signals.
  2. **Bandwidth:** The frequency range at which the amplifier can operate.
  3. **Noise:** The amount of unwanted extra information included in the output.
  4. **Skew Rate:** The maximum rate of change of output.
  5. **Stability:** The ability to provide constant and reliable output.
  6. **Linearity:** The degree of proportionality between input and output signals.
  7. **Efficiency:** Another very important characteristic, it is the ratio between the output power and power consumed.
  8. **Output Dynamic Range:** Ratio between the largest and smallest useful output levels.
  9. **Input/output Impedance**



# Amplifier Categories

Amplifier Type	Input	Output	Input impedance ( $R_{in}$ )	Output impedance ( $R_{out}$ )
Voltage ( $A_v$ )	$V_{in}$	$V_{out}$	$\infty$	0
Current ( $A_i$ )	$I_{in}$	$I_{out}$	0	$\infty$
Transconductance ( $G_m$ )	$V_{in}$	$I_{out}$	$\infty$	$\infty$
Transresistance ( $R_m$ )	$I_{in}$	$V_{out}$	0	0



Thank You!

