ECE 312
Electronic Circuits (1)
Lec. 1: Introduction and Basic Concepts

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Outline

- Course Information
- Course Objectives
- BJT Basic Concepts
- Amplifier Basic concepts

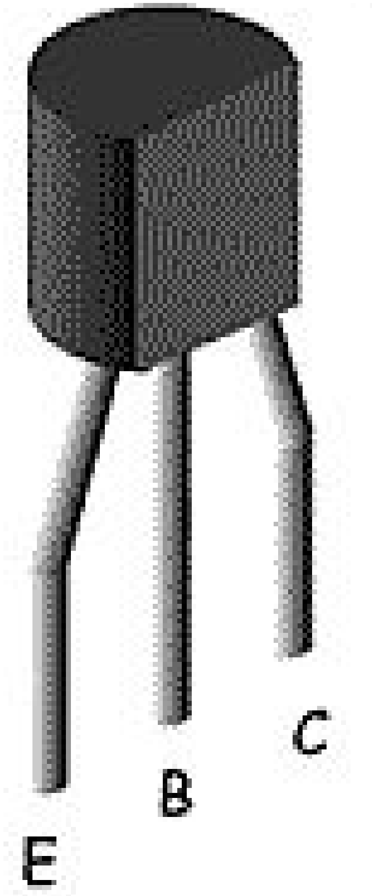
Course Information

Instructor:	**Dr. Maher Abdelrasoul**
Lectures:	Wednesdays : 12:30 -2:00, Thursday:10:40-12:10
Teaching Assistant:	Eng. AbdelFattah, Eng. Reem
Text Book:	R. Boylestad, Electronic Devices and Circuit Theory, 11th edition, Prentice Hall
Credit:	150 Marks
Grading:	• Final Exam (90 Marks) • Mid Term Exam (30 Marks) • Homework and tutorials activities (10 Marks) • Project (10 Marks) • Oral Exam (10 Marks)

Bipolar Junction Transistor

NPN

Not Pointing in



PNP

Pointing in Proudly

Course Objectives

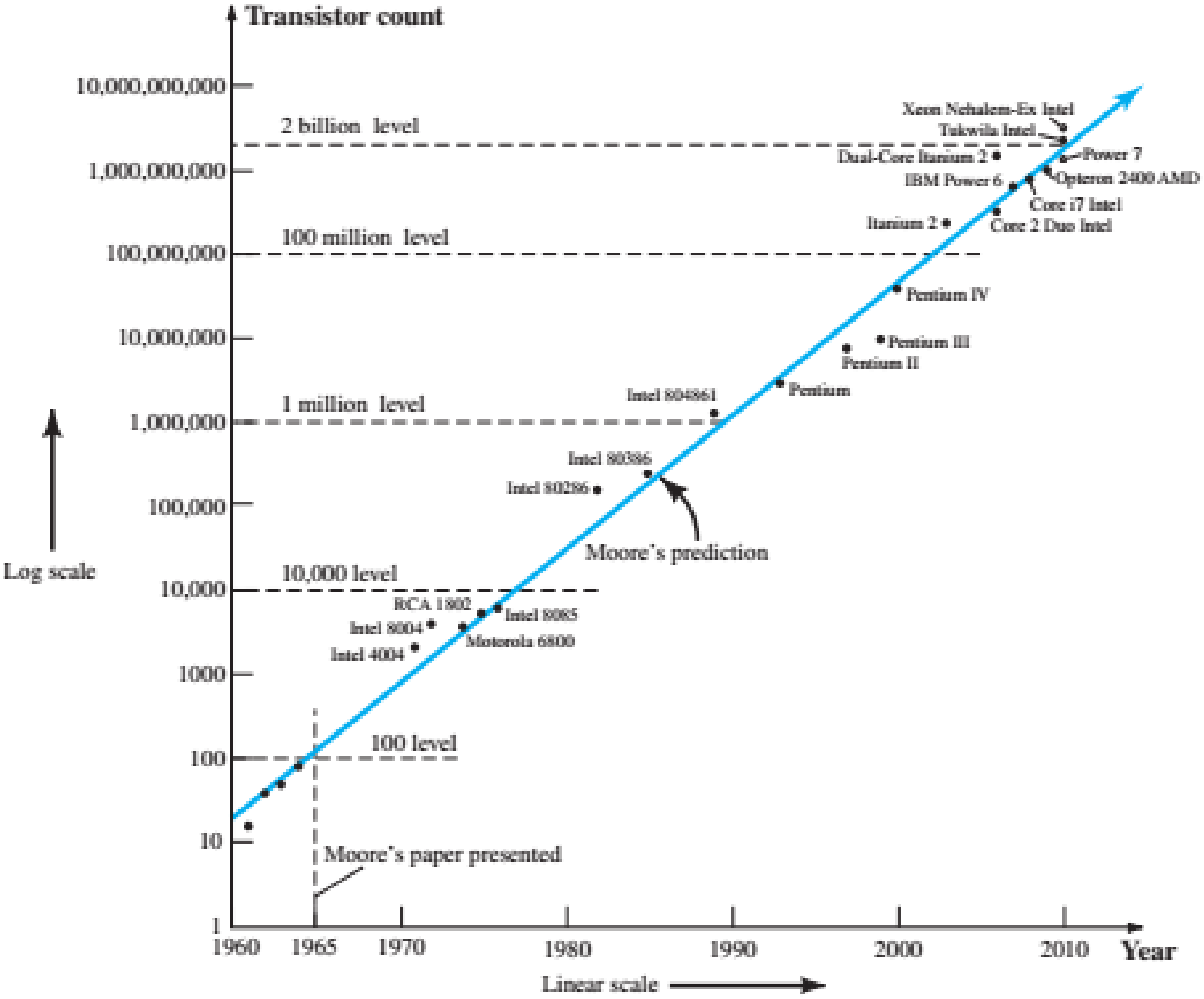
- Understand the transistor biasing, modeling, and its small signal analysis.

- 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.

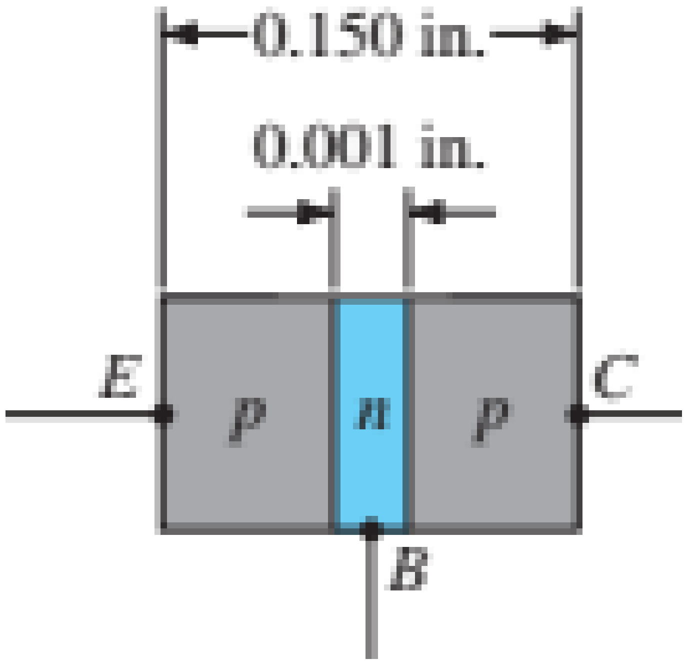
Transistor Development

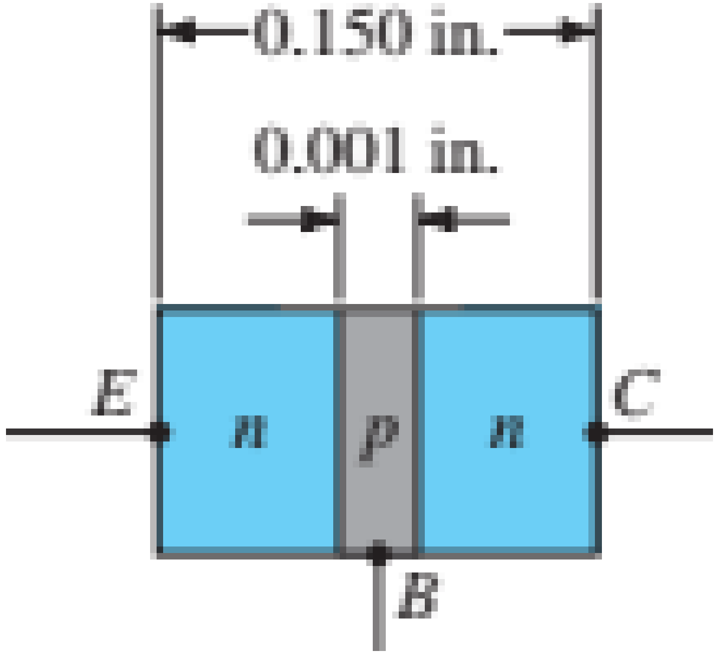
- **Moore’s law** predicts that the transistor count of an integrated circuit will double every 2 years.



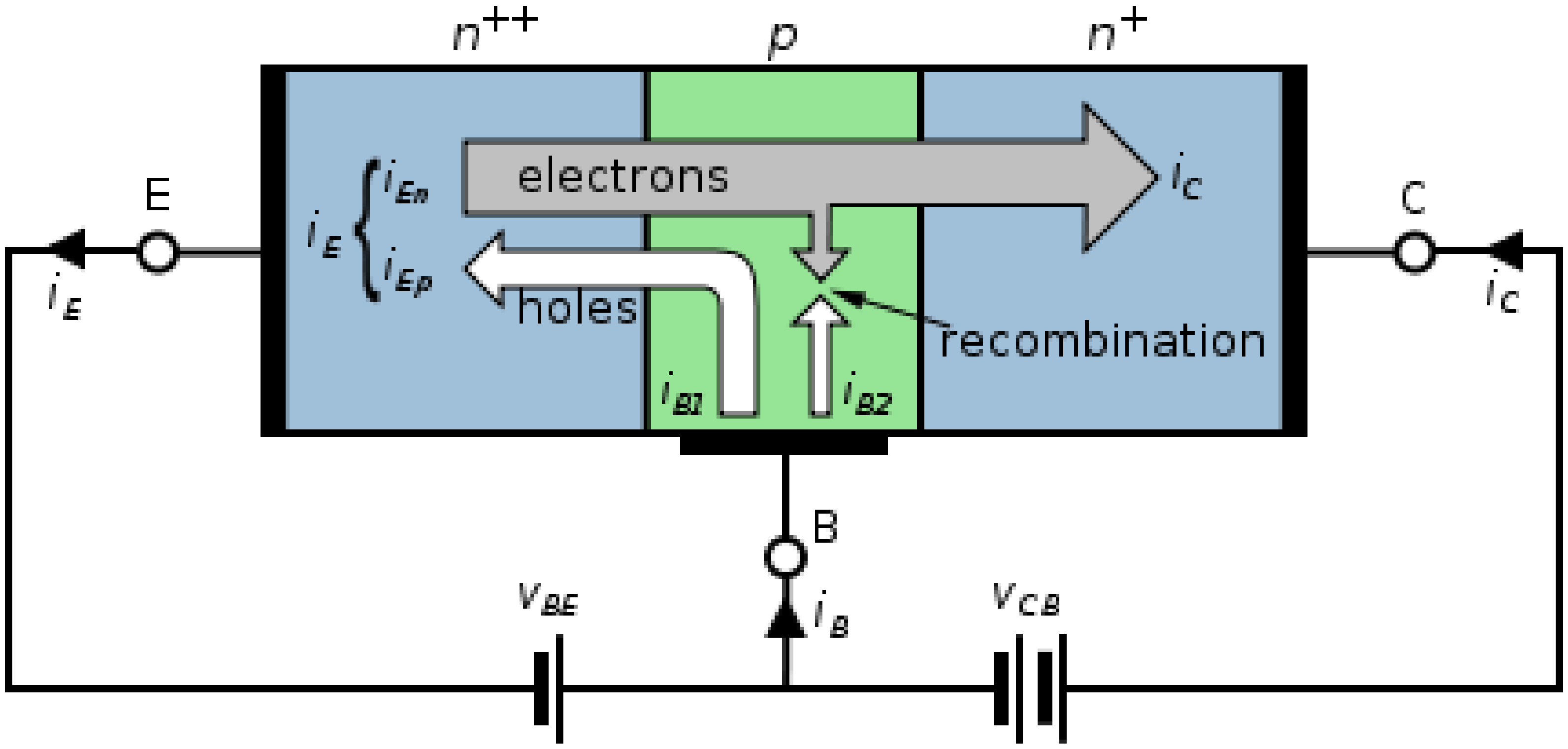
Transistor Construction

- 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



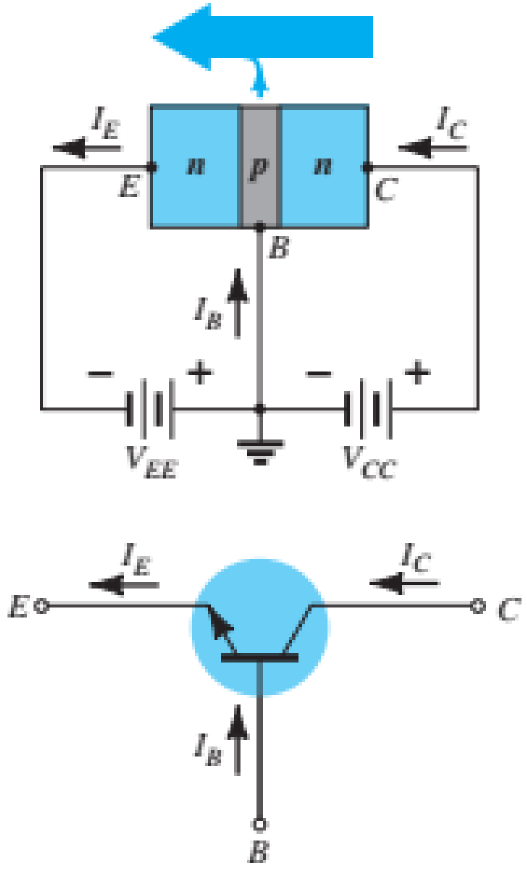
$$I_E = I_C + I_B$$

Transistor Configurations

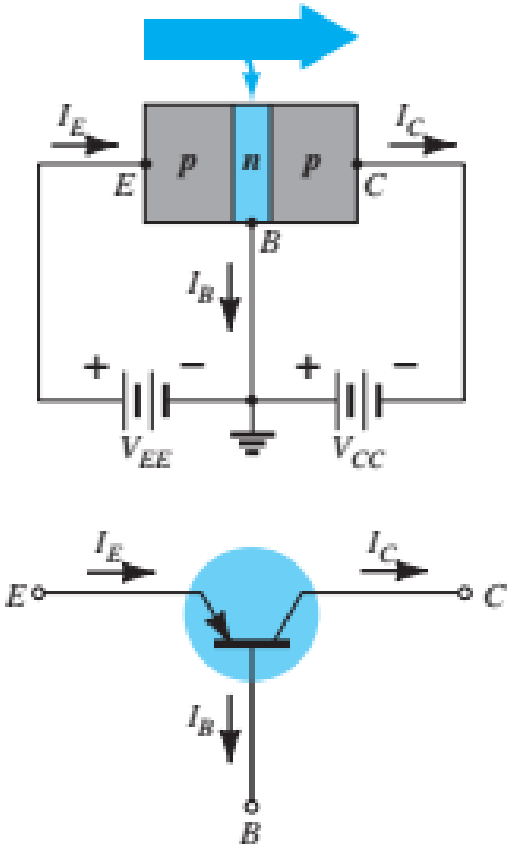
- Common-Base Configuration
- Common-Emitter Configuration
- Common-Collector Configuration

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.

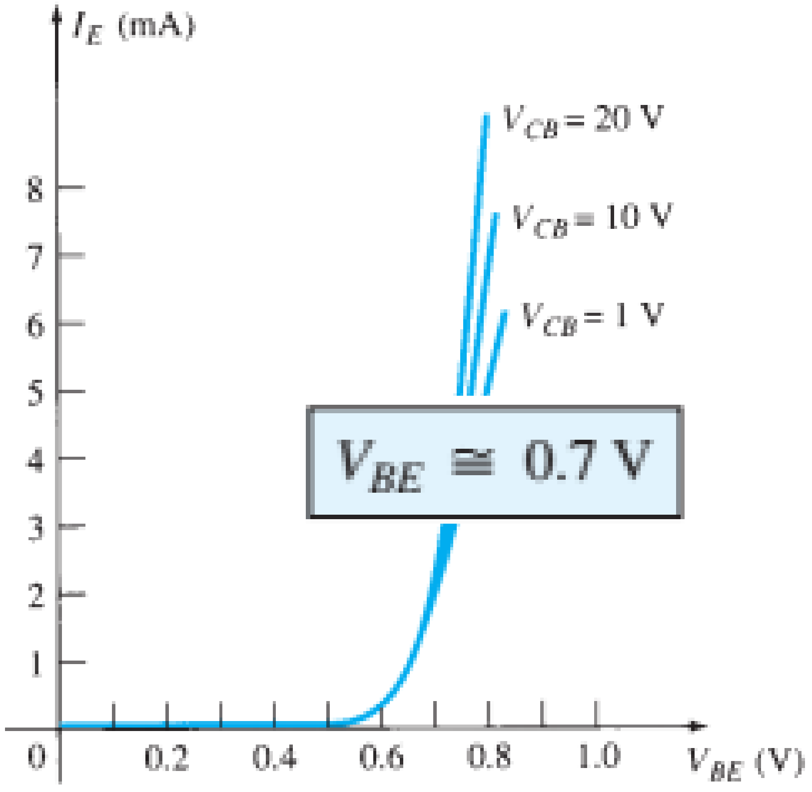


npn

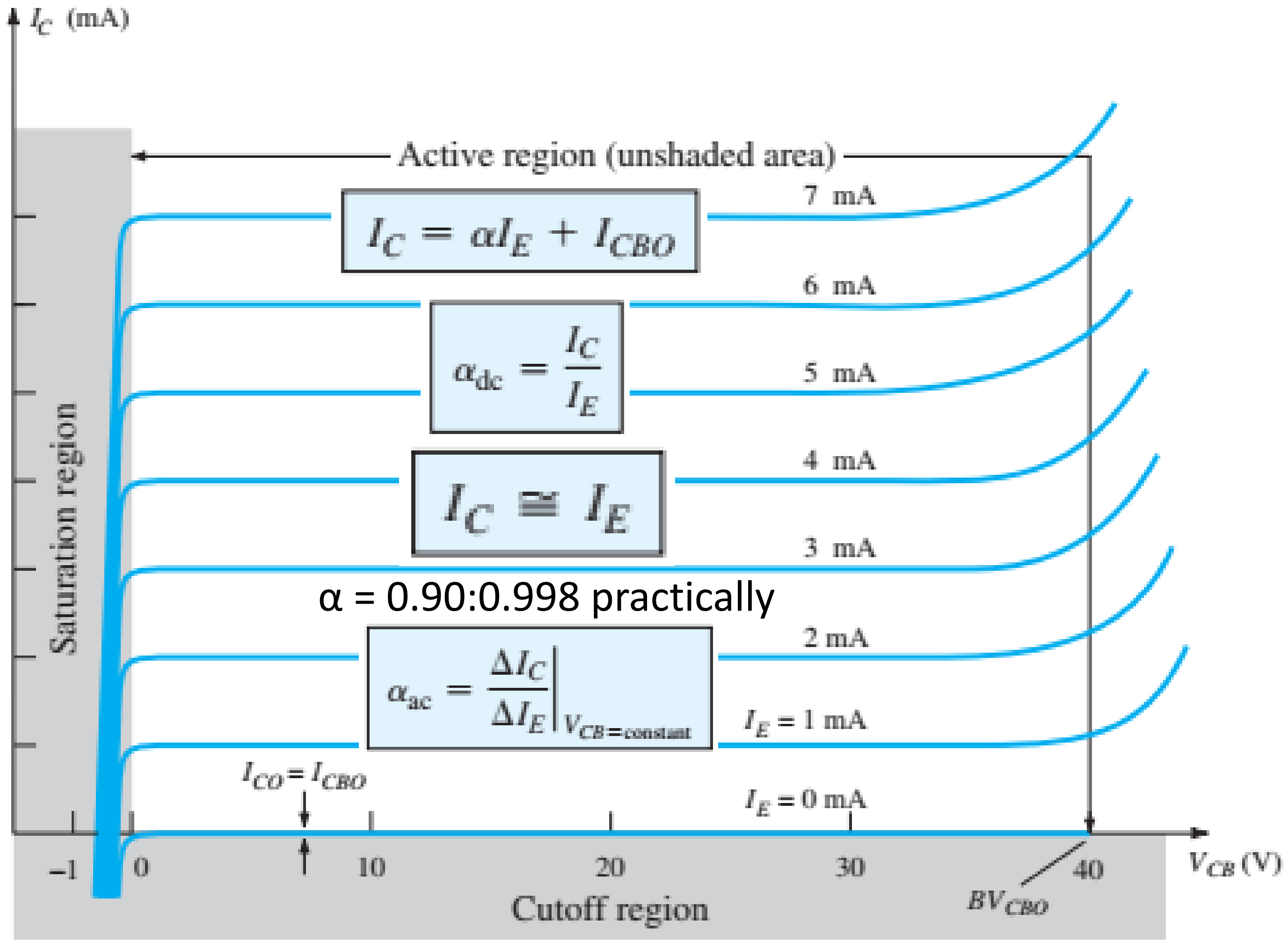


pnp

1. Common-Base Configuration (2)



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

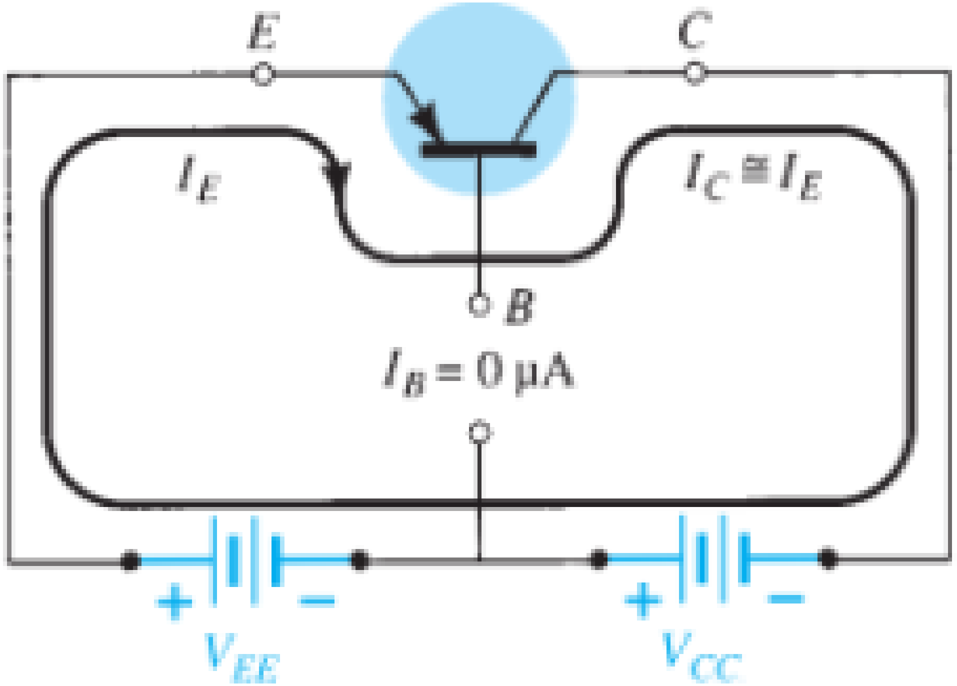


Output or collector characteristics for a common-base transistor amplifier.

1. Common-Base Configuration (3)

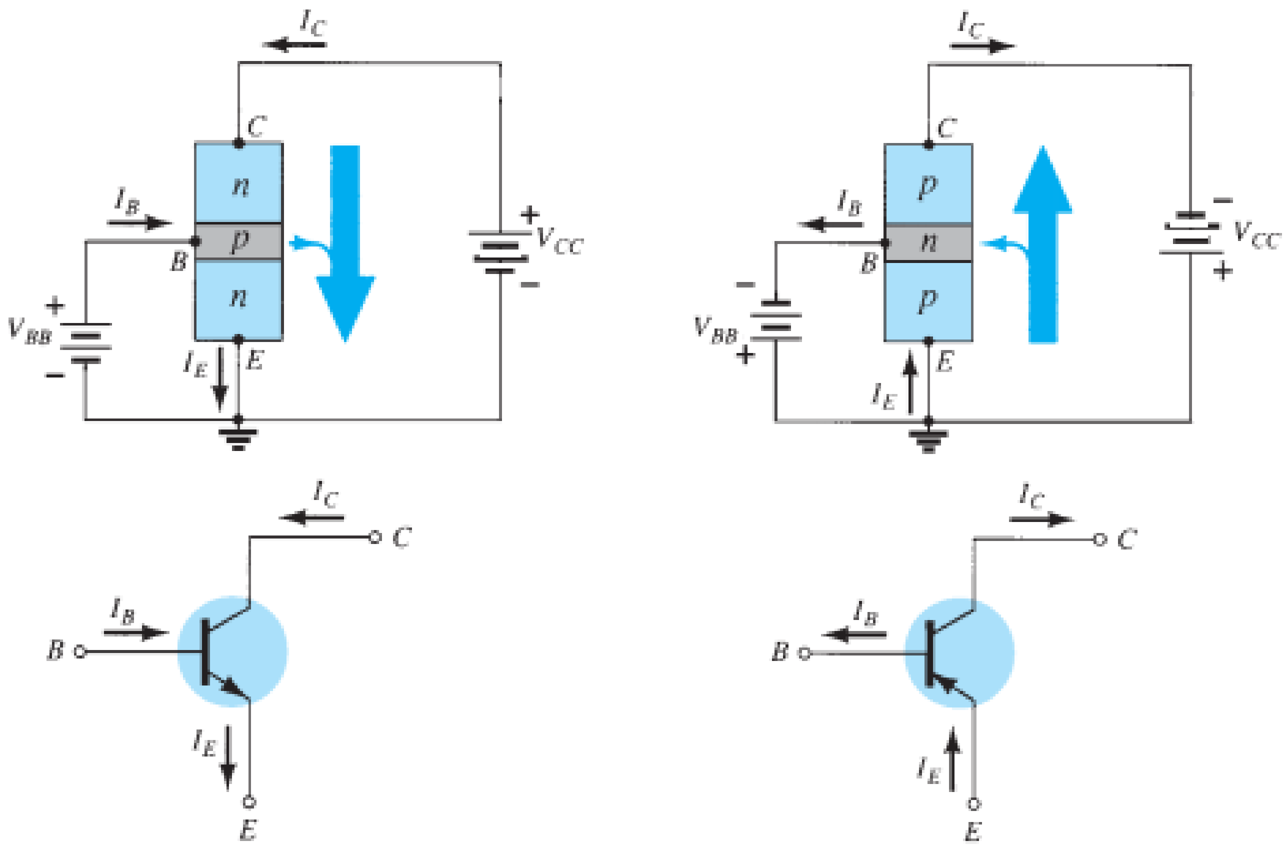
- Biasing of a CB pnp tr. in the active region:

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



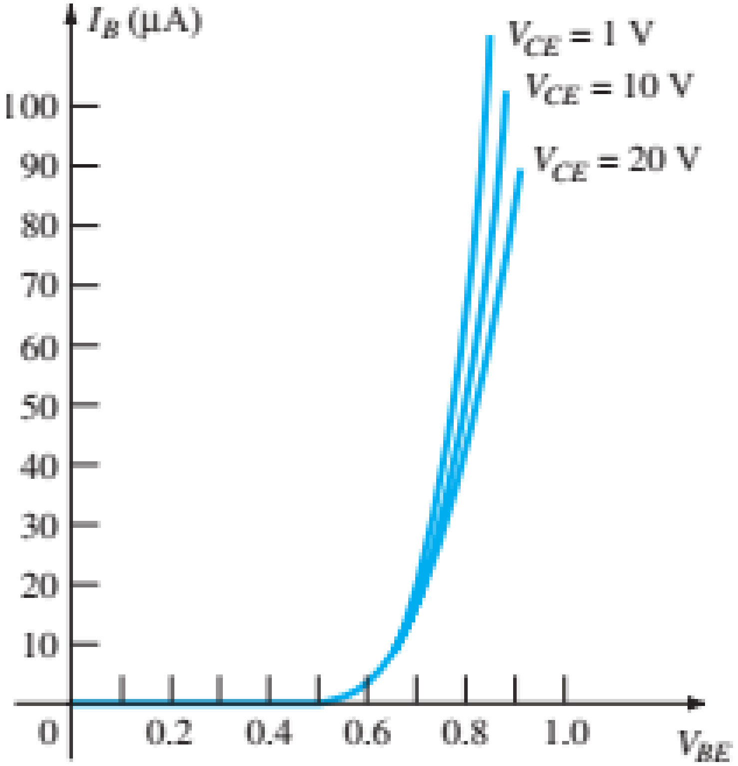
2. Common-Emitter Configuration (1)

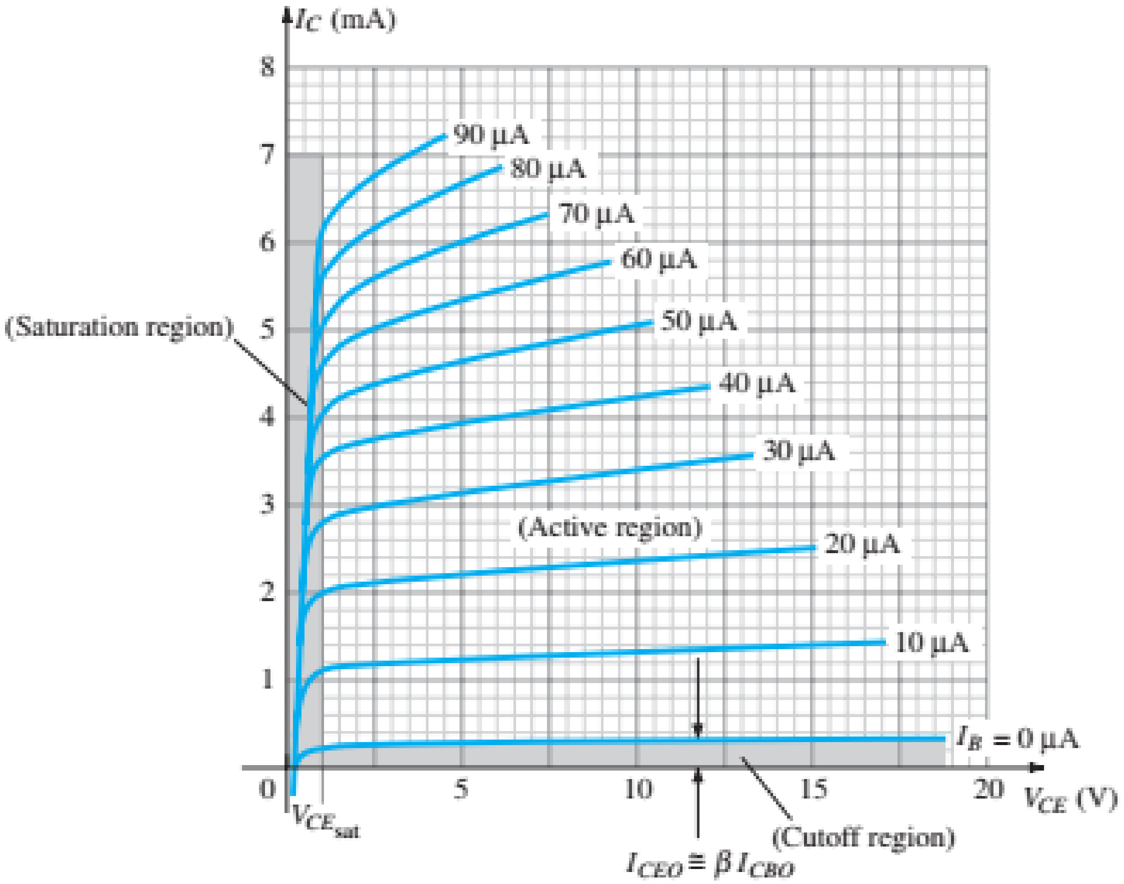
- It is called the *common-emitter configuration* because the emitter is common to both the input and output terminals (in this case common to both the base and
collector terminals).



npn *pnp*

2. Common-Emitter Configuration (2)





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

β=50:400 practically

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

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

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

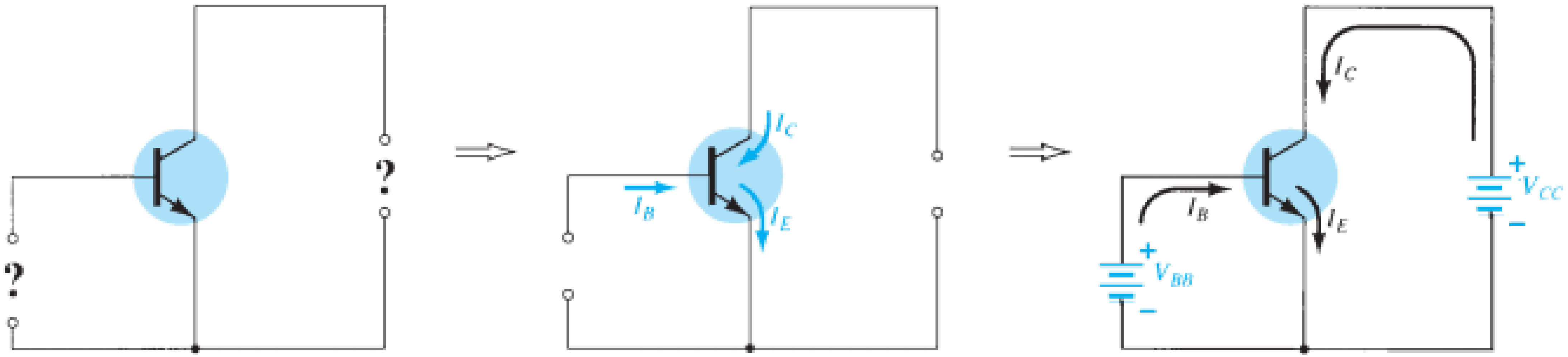
$$I_C = \beta I_B$$

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

2. Common-Emitter Configuration (3)

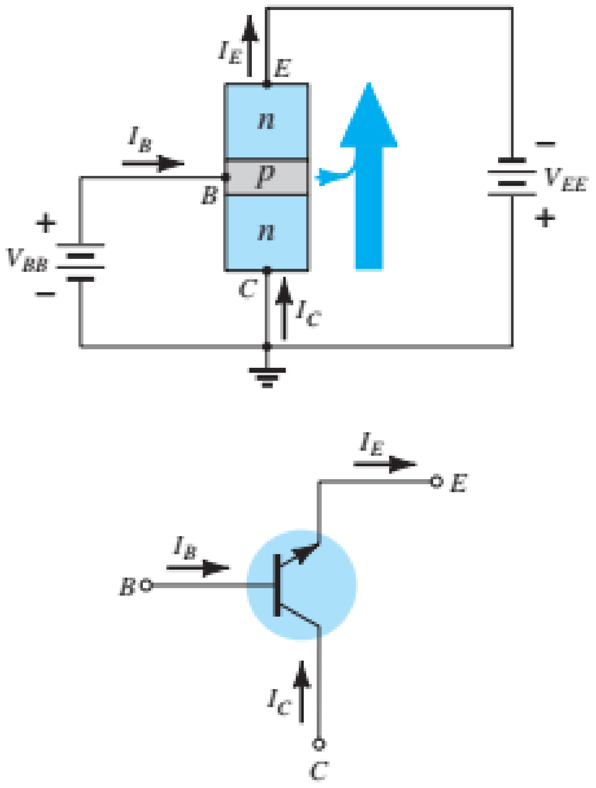
- Biasing of a CE npn tr. in the active region:

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

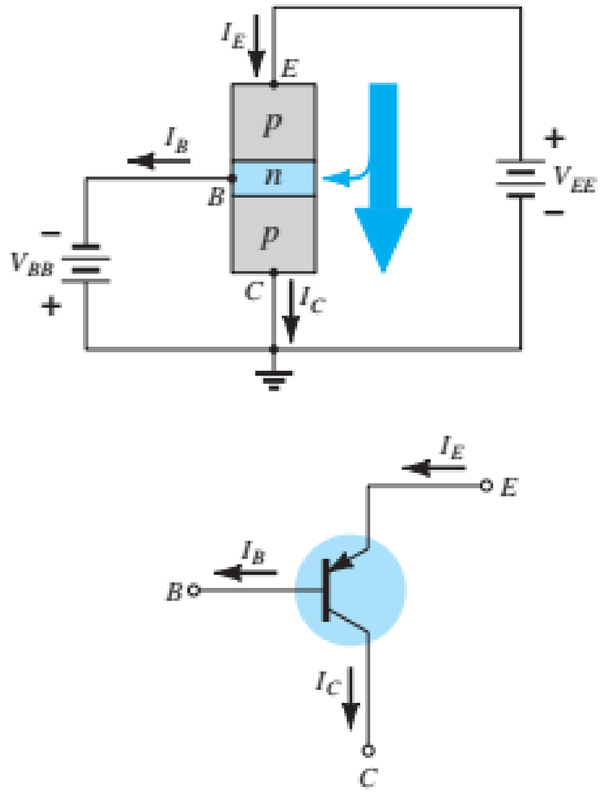


3. Common-Collector Configuration (1)

- 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.



npn

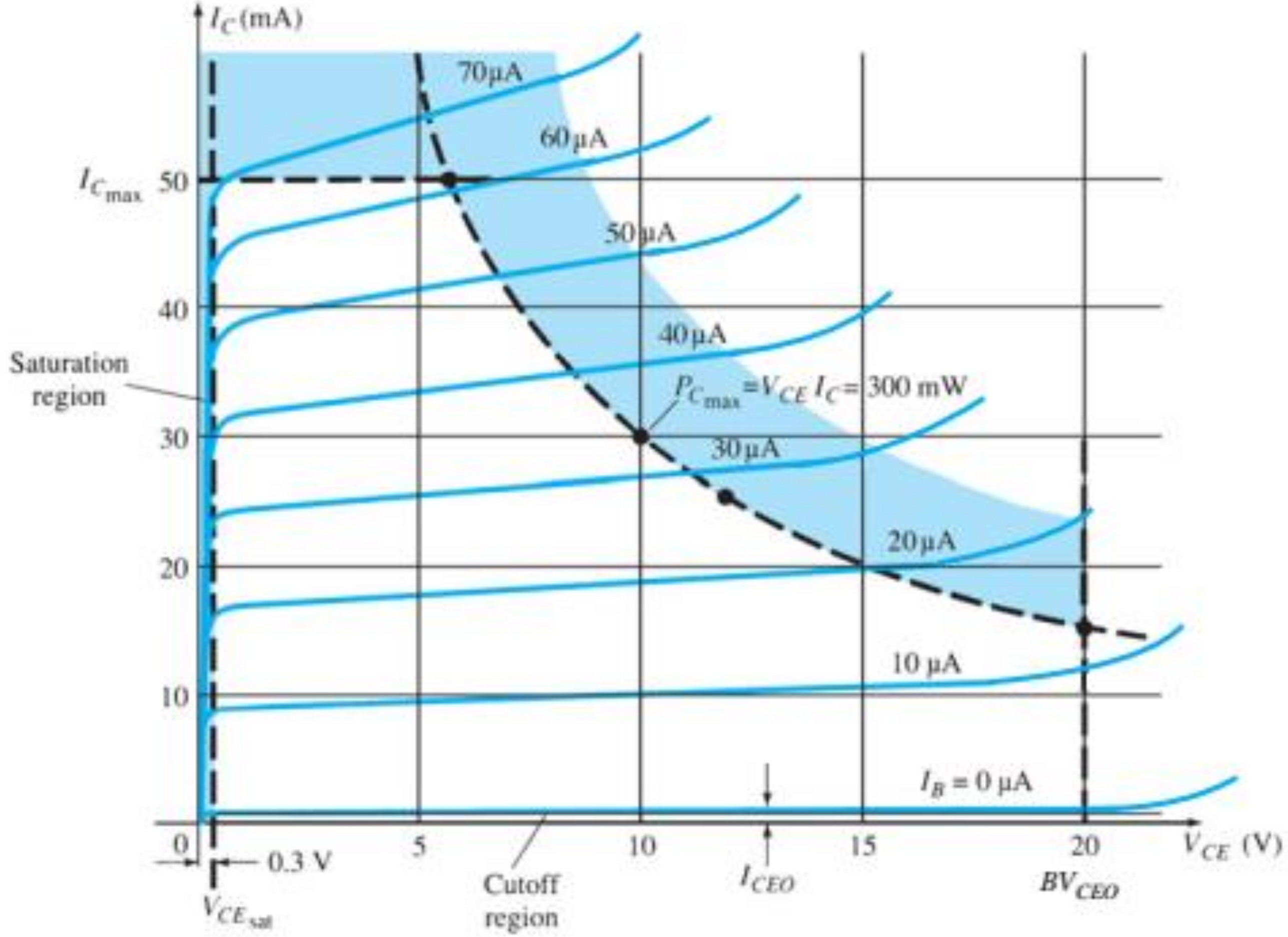


pnp

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 ($I_c \approx I_E$).

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

$$I_{CEO} \leqq I_C \leqq I_{C_{max}}$$
$$V_{CE_{sat}} \leqq V_{CE} \leqq V_{CE_{max}}$$
$$V_{CE} I_C \leqq P_{C_{max}}$$

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 mAdc, I_E = 0)	$V_{(BR)CEO}$	30		Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40		Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	50	nAdc

ON CHARACTERISTICS

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

Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	200	–

FAIRCHILD
SEMICONDUCTOR ™

2N4123

General Purpose Transistor NPN Silicon

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	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°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

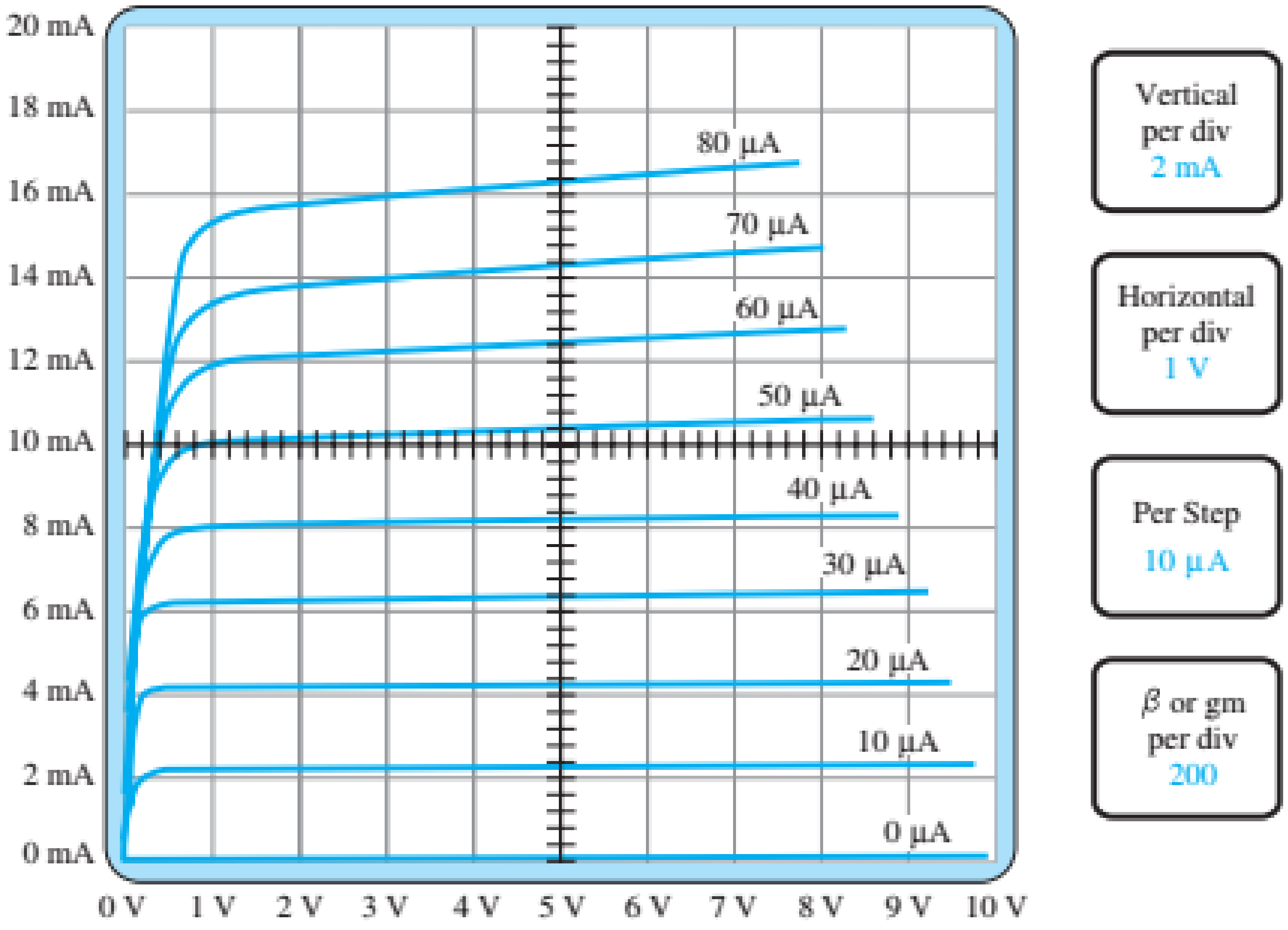
$$7.5\ \mu A \leqq I_C \leqq 200\ mA$$

$$0.3\ V \leqq V_{CE} \leqq 30\ V$$

$$V_{CE} I_C \leqq 650\ mW$$

Transistor Testing

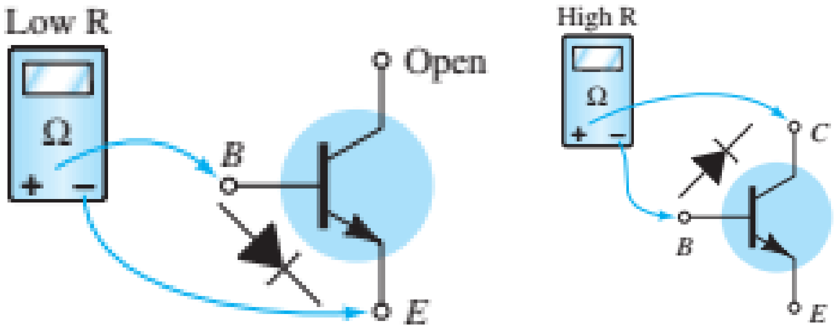
1. Curve Tracer



Curve tracer response to 2N3904 npn transistor.

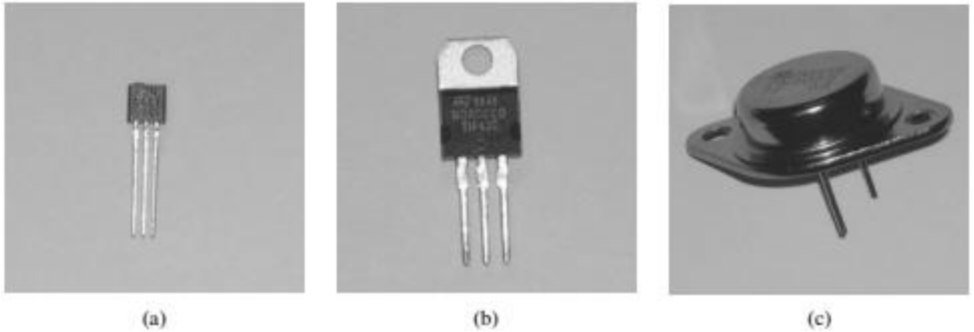
2. Transistor Testers

3. Ohmmeter



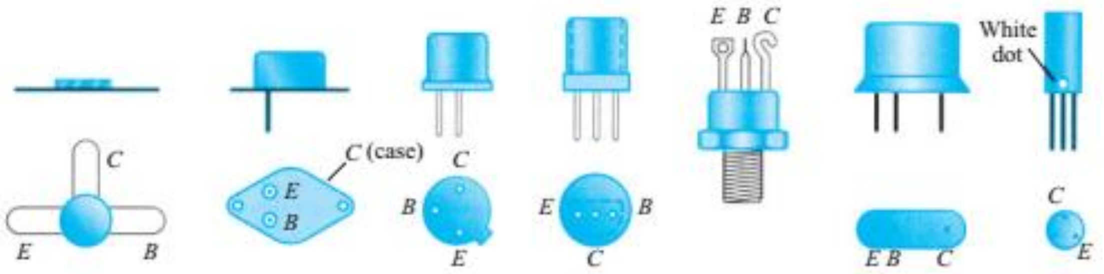
Transistor Casing and Terminal Identification

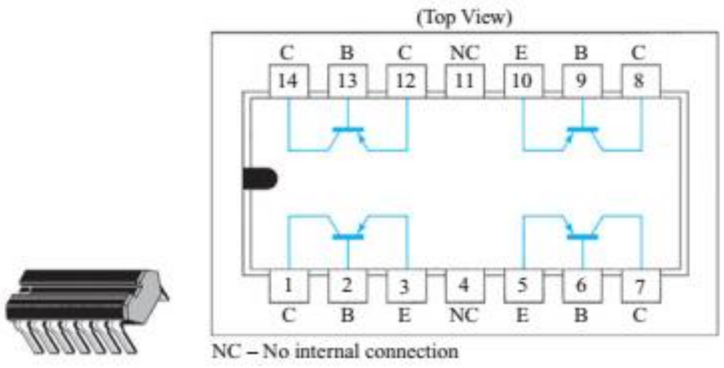
- Casing



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

- Terminal Identification



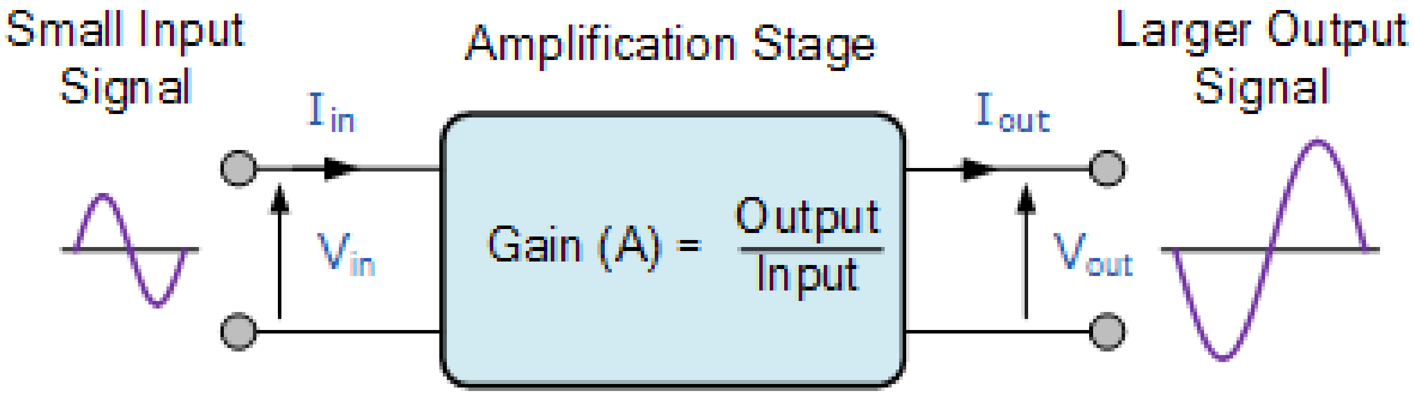


Type Q2T2905 Texas Instruments quad pnp silicon transistor

BASIC CONCEPTS of Amplifiers

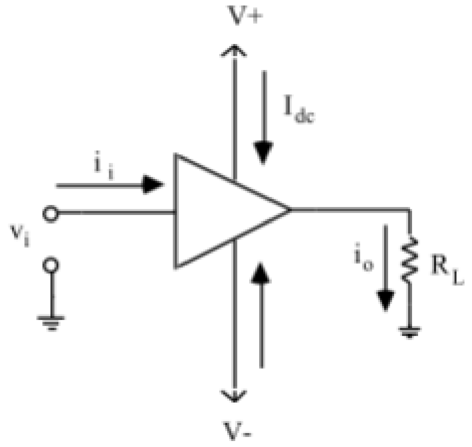
Amplifier

- 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”.



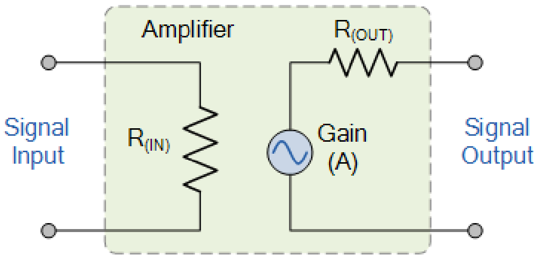
- Some amplifiers use only one power supply, but some times they internally split that signal voltage into two rails by making an artificial ground voltage half way from the real ground to the supply voltage

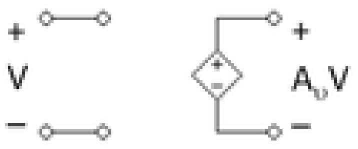
Important Characteristics of an Amplifier

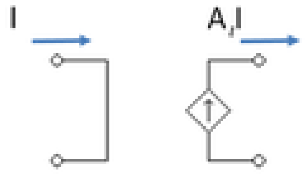
- The quality of an amplifier is measured by a series of specifications called figures of merit. They are as follows:
  1. **Gain:** Perhaps the most important, the ratio between the magnitudes of input and output signals.
  2. **Bandwidth:** The frequency range at which the amplifier can operate.
  3. **Noise:** The amount of unwanted extra information included in the output.
  4. **SLew 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**

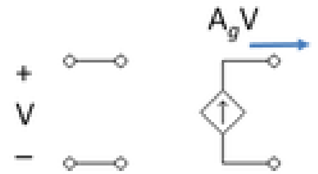
Amplifier Categories

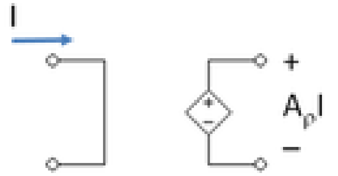
Amplifier Type	Input	Output	Input impedance (Rin)	Output impedance (Rout)
Voltage (Av)	V_{in}	V_{out}	∞	0
Current (Ai)	I_{in}	I_{out}	0	∞
Transconductance (Gm)	V_{in}	I_{out}	∞	∞
Transresistance (Rm)	I_{in}	V_{out}	0	0












Thank You!