ECE 121
Electronics (1)
Lec. 1: Introduction to BJT

Instructor

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Outline

- Course Information
- Course Objectives
- BJT Introduction
- Transistor Construction
- Transistor Operation
- Transistor Configuration

Course Information

Instructor:	**Dr. Maher Abdelrasoul**
Lectures:	Tuesday:10:40-12:10, Thursday: 9:00 -10:30
Office Hours:	Tuesday, Thursday
Teaching Assistant:	Eng. Ibrahim
Text Book:	R. Boylestad, Electronic Devices and Circuit Theory, 11th edition, Prentice Hall
Credit:	90 Marks
Grading:	• Final Exam (50) • Mid Term Exam (25) • Oral exam, homework, and tutorials activities (15)

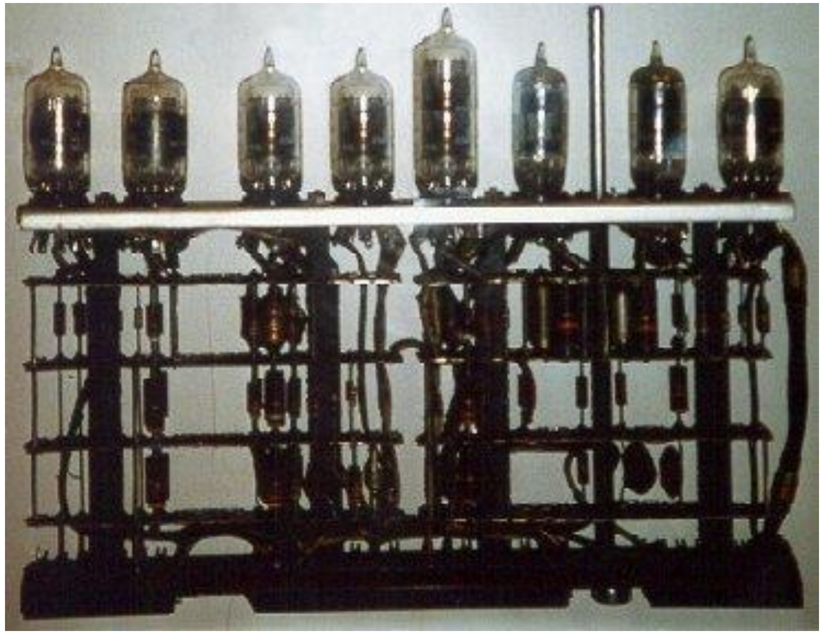
Course Objective is to understand the following:

- Bipolar Junction Transistors (BJTs) Fundamentals
- Transistor Biasing
- Transistor AC Models
- Voltage Amplifiers

What is a Transistor?

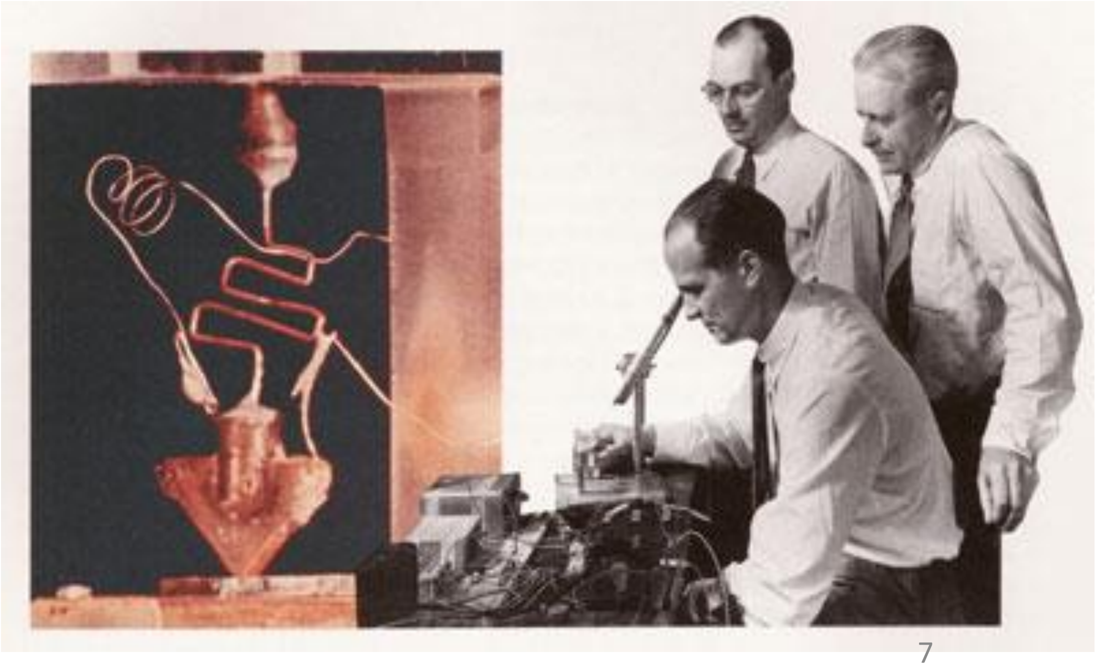
Before BJT → Vacuum tubes

- Purpose
  - Used as signal amplifiers and switches
  - Advantages
    - High power and frequency operation
    - Operation at higher voltages
    - Less vulnerable to electromagnetic pulses
  - Disadvantages
    - Very large and fragile
    - Energy inefficient
    - Expensive



Invention

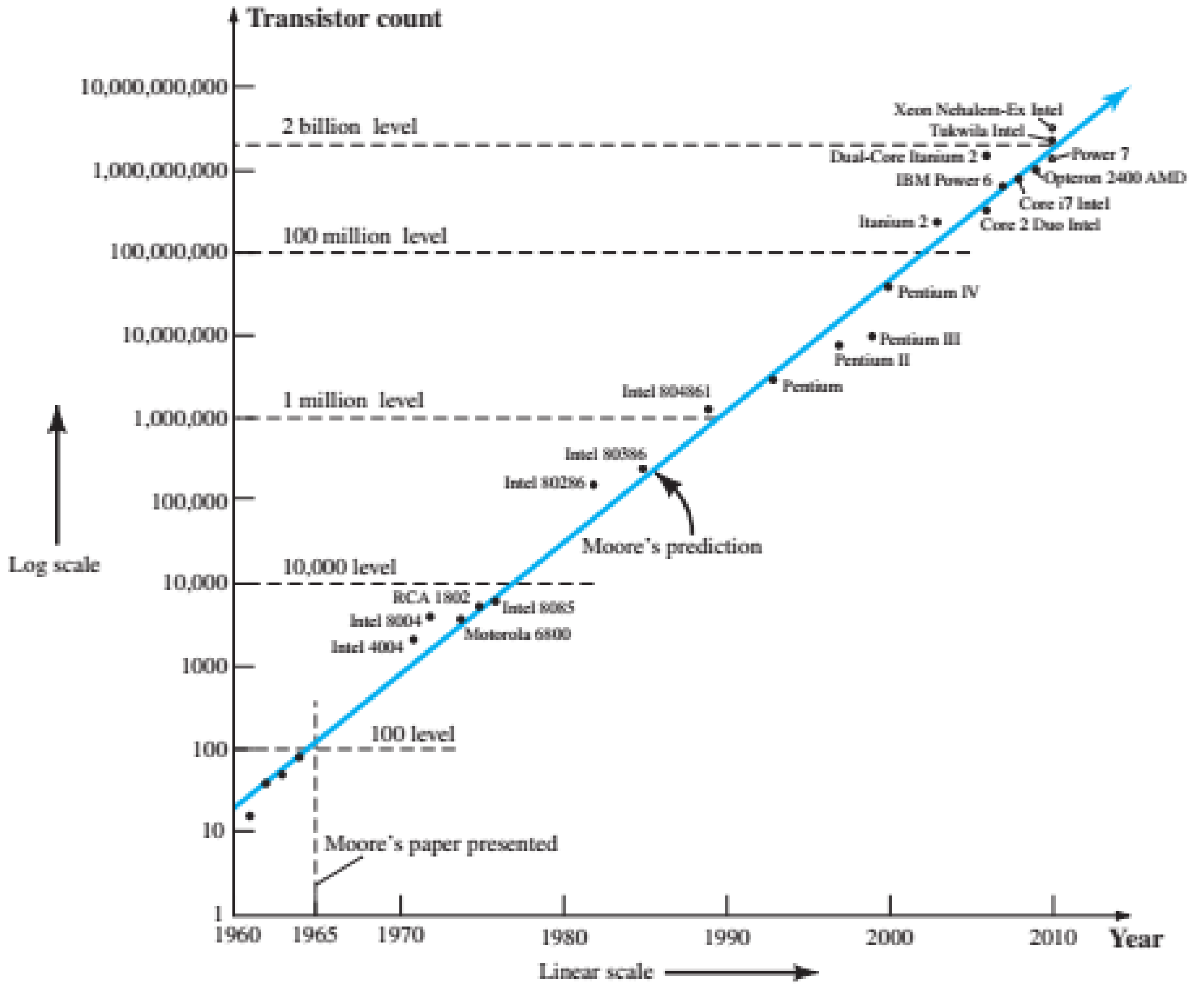
- Evolution of electronics
  - In need of a device that was small, robust, reliable, energy efficient and cheap to manufacture
- 1947
  - John Bardeen, Walter Brattain and William Schockly invented transistor
- Transistor Effect
  - “when electrical contacts were applied to a crystal of germanium, the output power was larger than the input.”



General Applications

Transistor Development

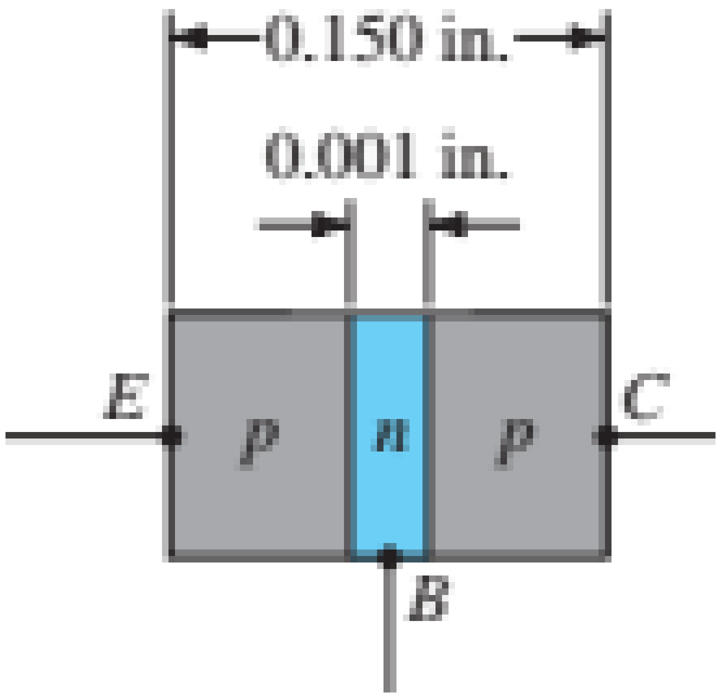
- **Moore's law** predicts that the transistor count of an integrated circuit will double every 2 years.

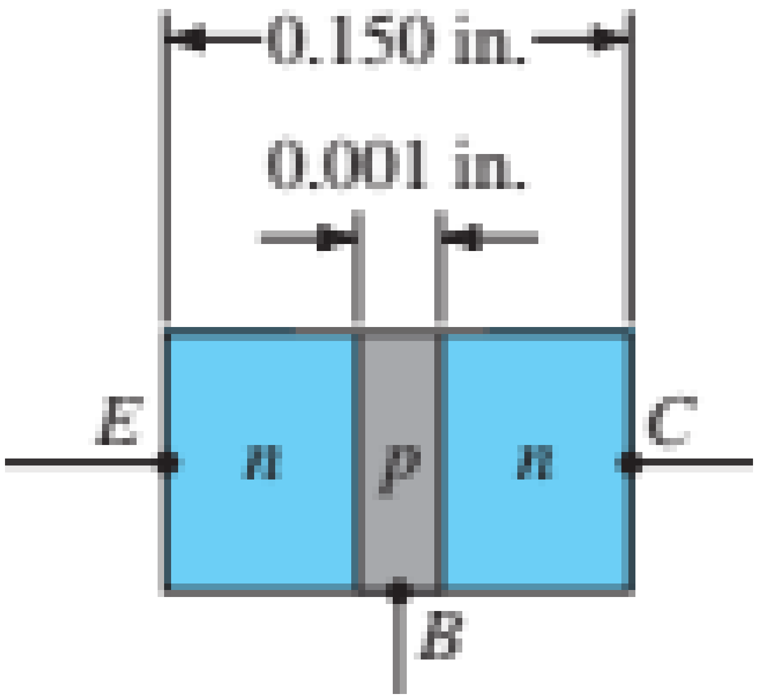


Where can the field go from here?

Transistor Construction$_1$

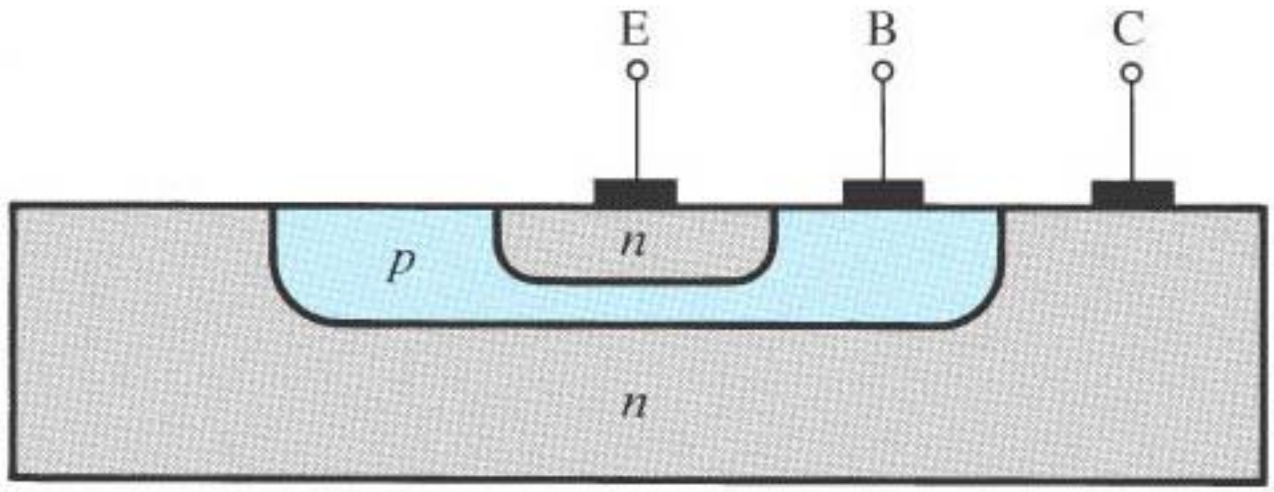
- The transistor is a three-layer semiconductor device consisting of either two *n*- and one *p*-type layers of material (npn transistor) or two *p*- and one *n*-type layers of material (pnp transistor).





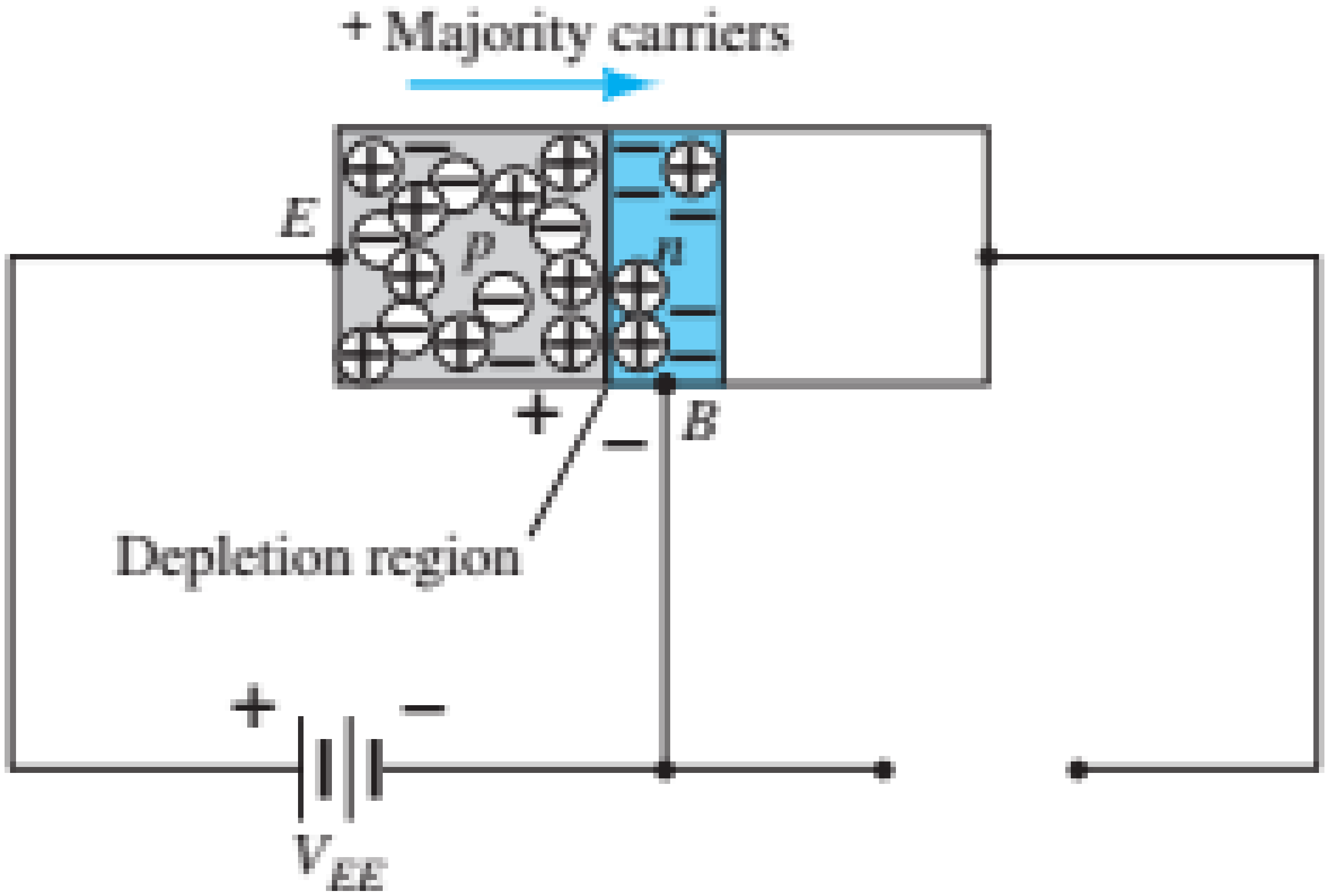
Transistor Construction$_2$

- The three layers are Emitter, Base and Collector
  - Base region is much thinner as compared to the collector and emitter
  - Emitter is heavily doped, Base is lightly and collector is intermediate
  - Collector regions is physically largest



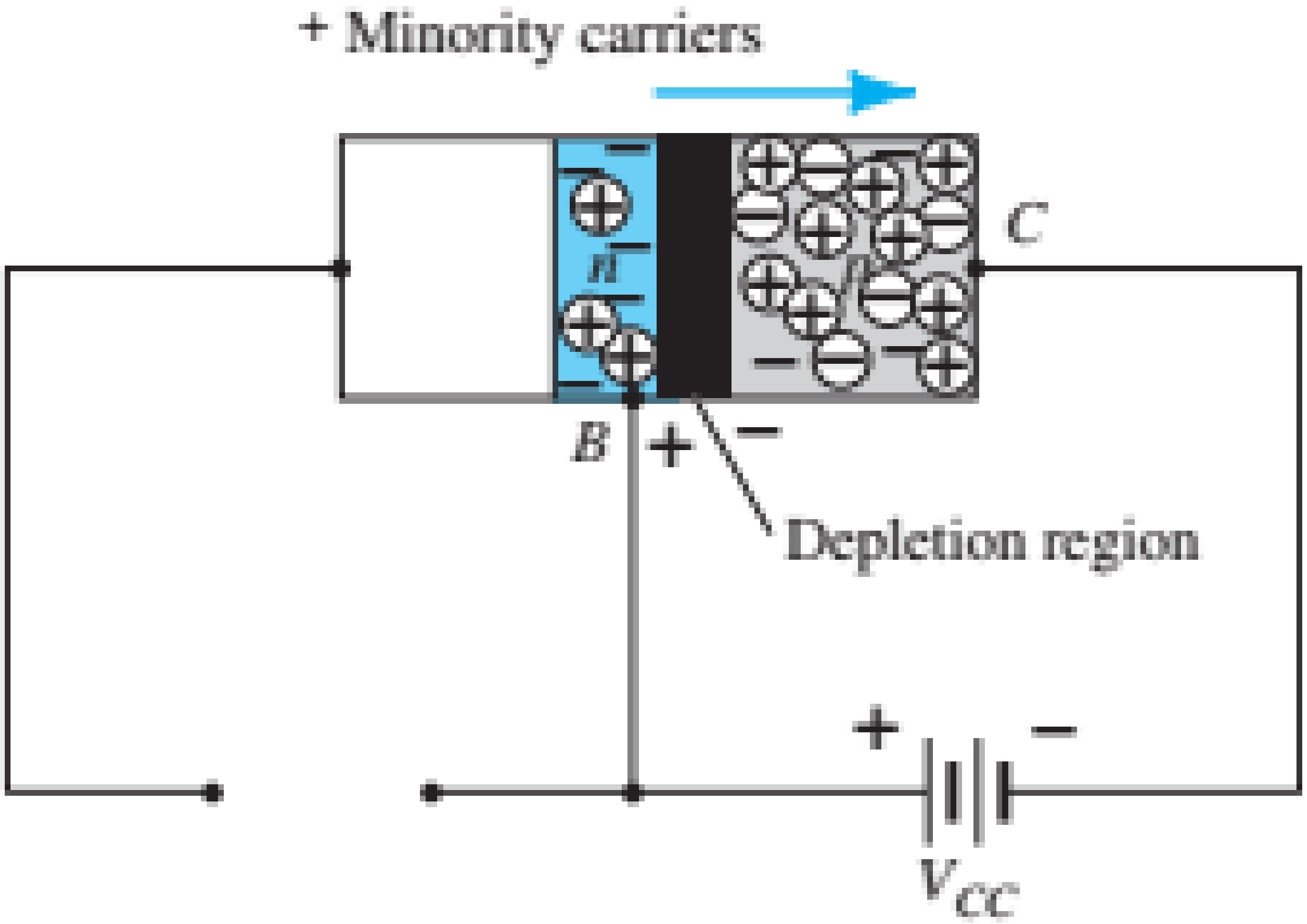
Transistor Operation$_1$

- The operation discussed in pnp transistor



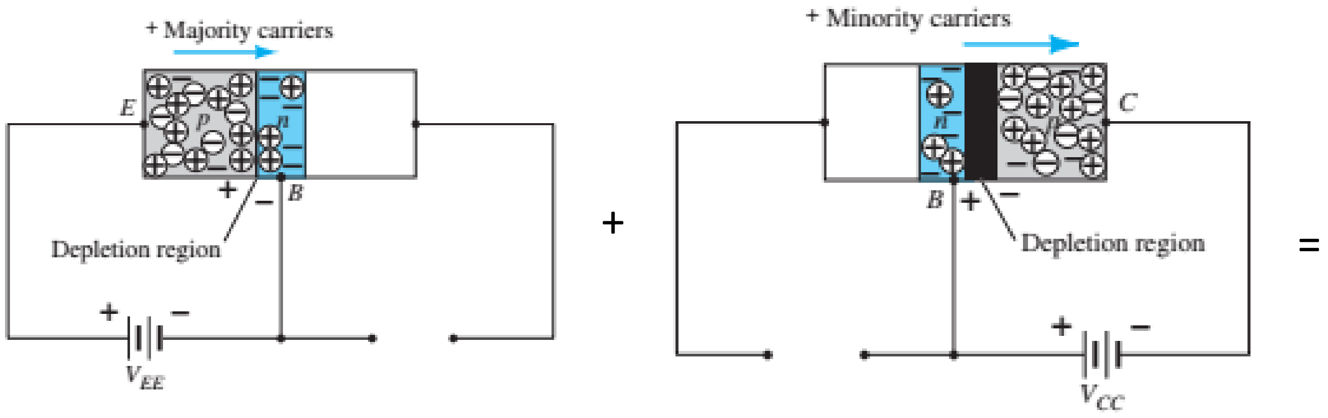
Transistor Operation$_2$

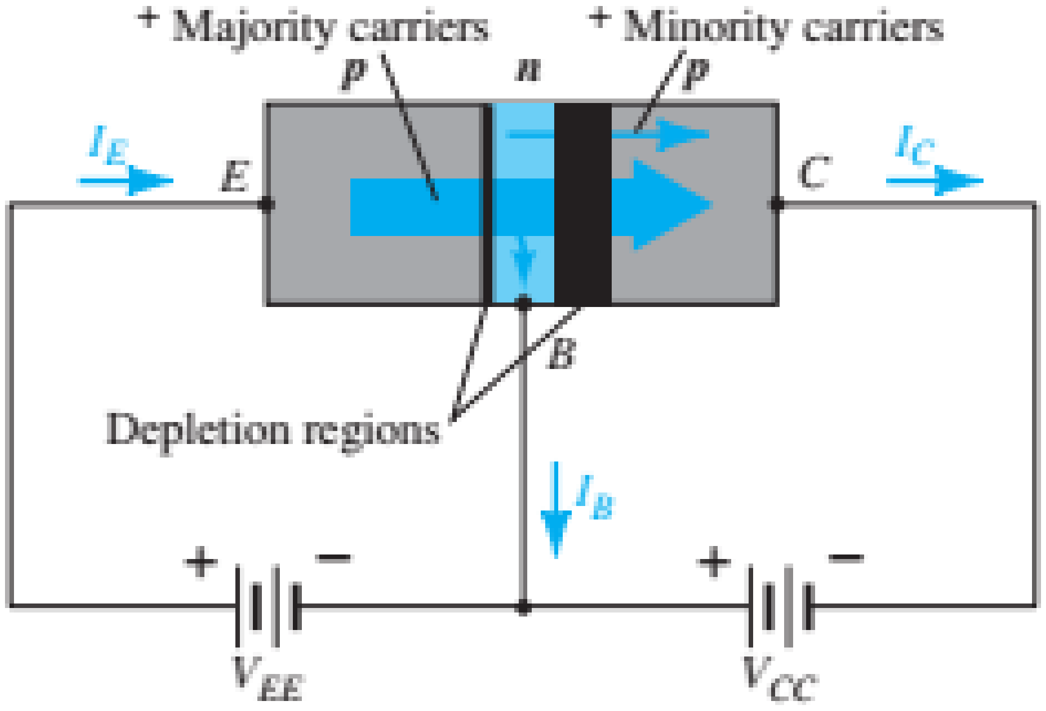
- The operation discussed in pnp transistor



Transistor Operation

- The operation discussed in pnp transistor





- The collector current by Kirchhoff’s law

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

- In Electronic analysis

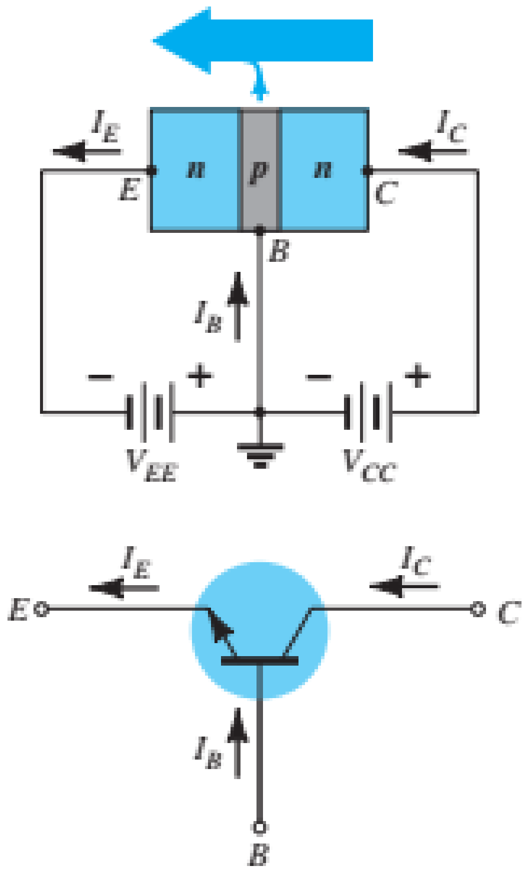
$$I_E = I_C + I_B$$

Transistor Configuration

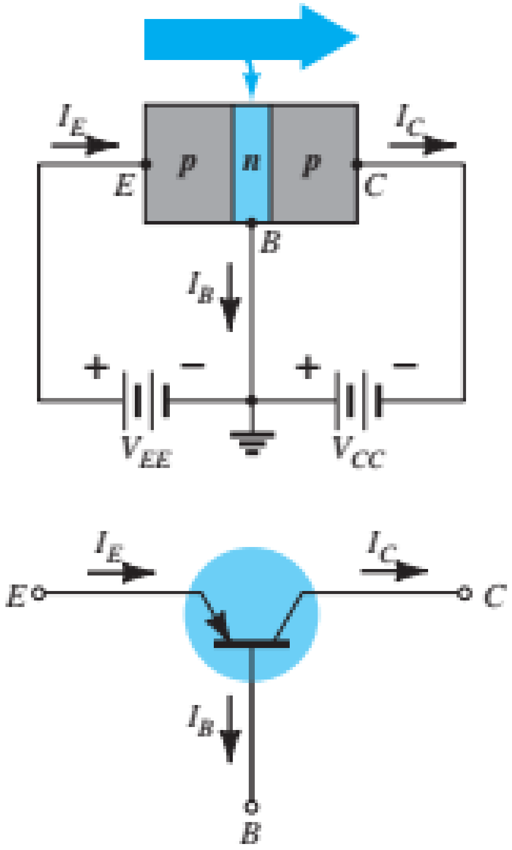
- Common-Base Configuration
- Common-Emitter Configuration
- Common-Collector Configuration

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.

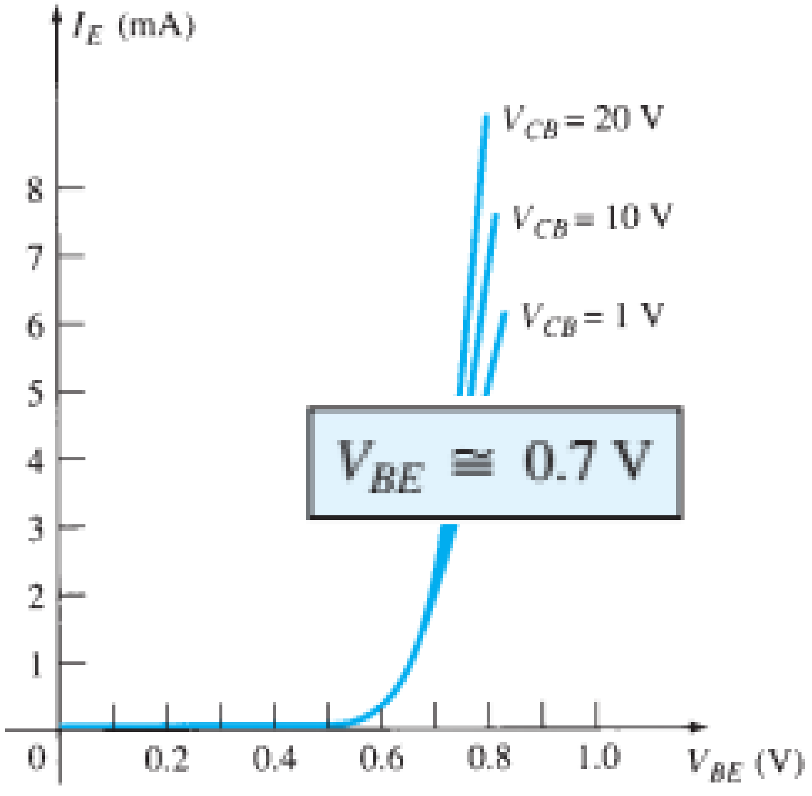


npn

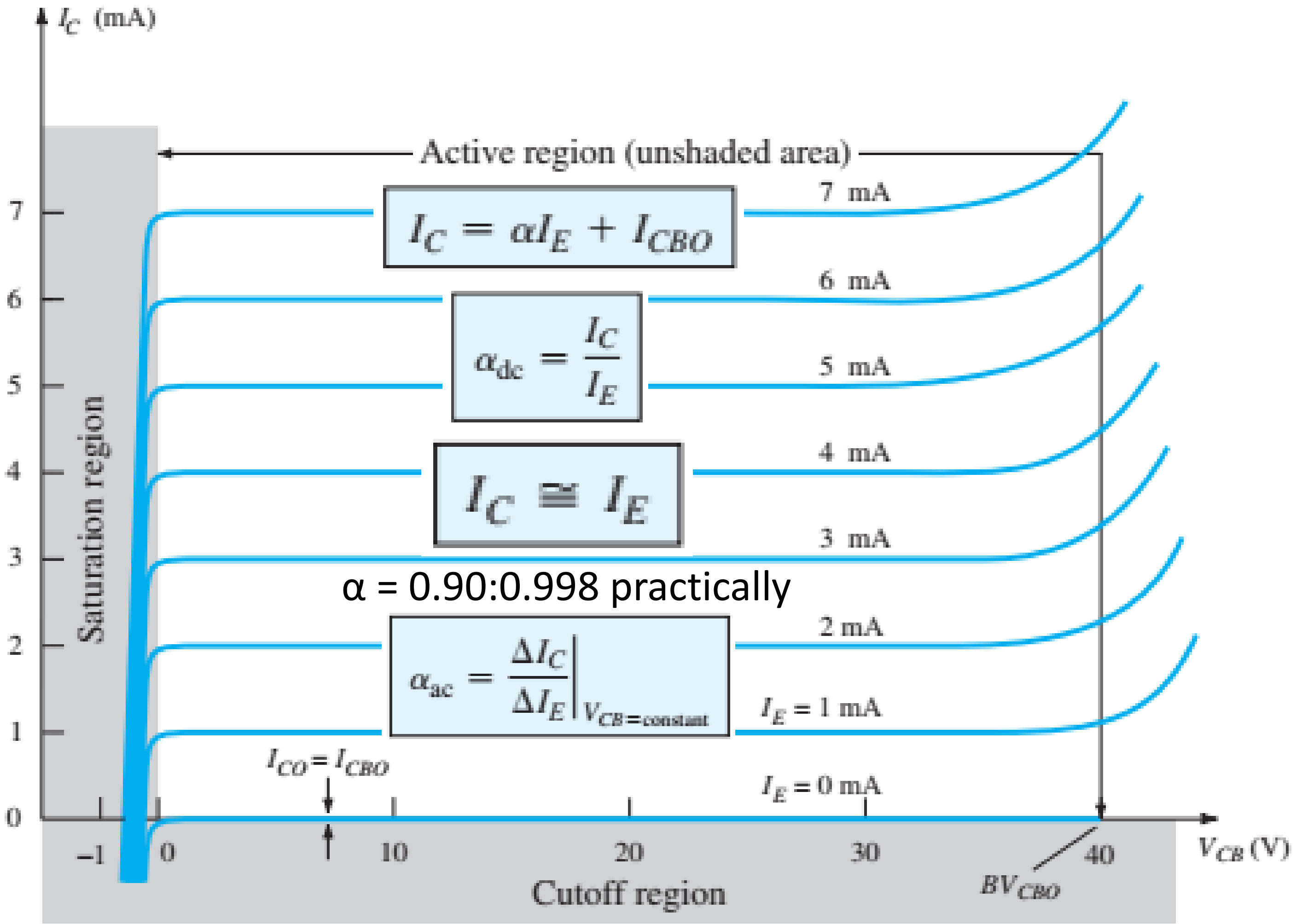


pnp

1. Common-Base Configuration$_2$



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

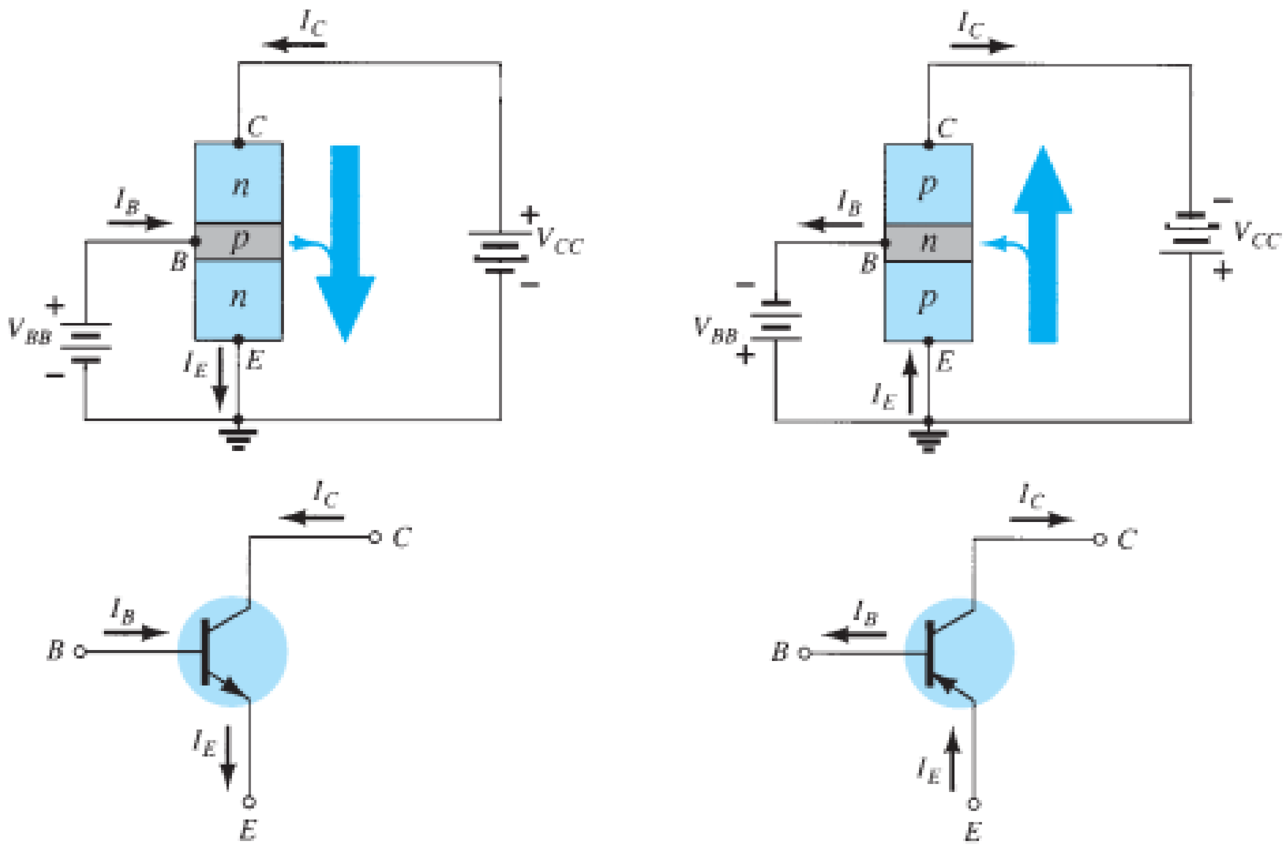


α = 0.90:0.998 practically

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

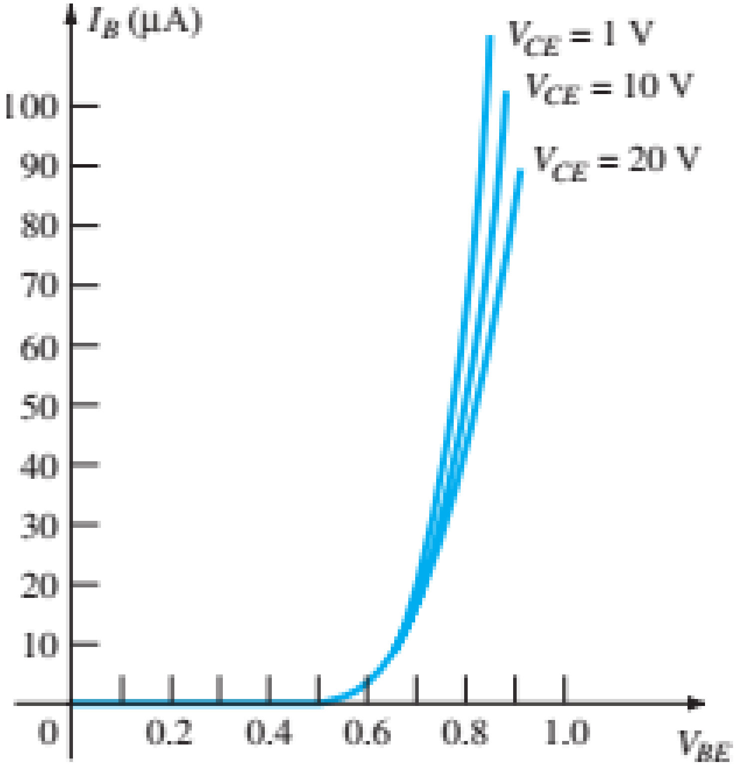
2. Common-Emitter Configuration$_1$

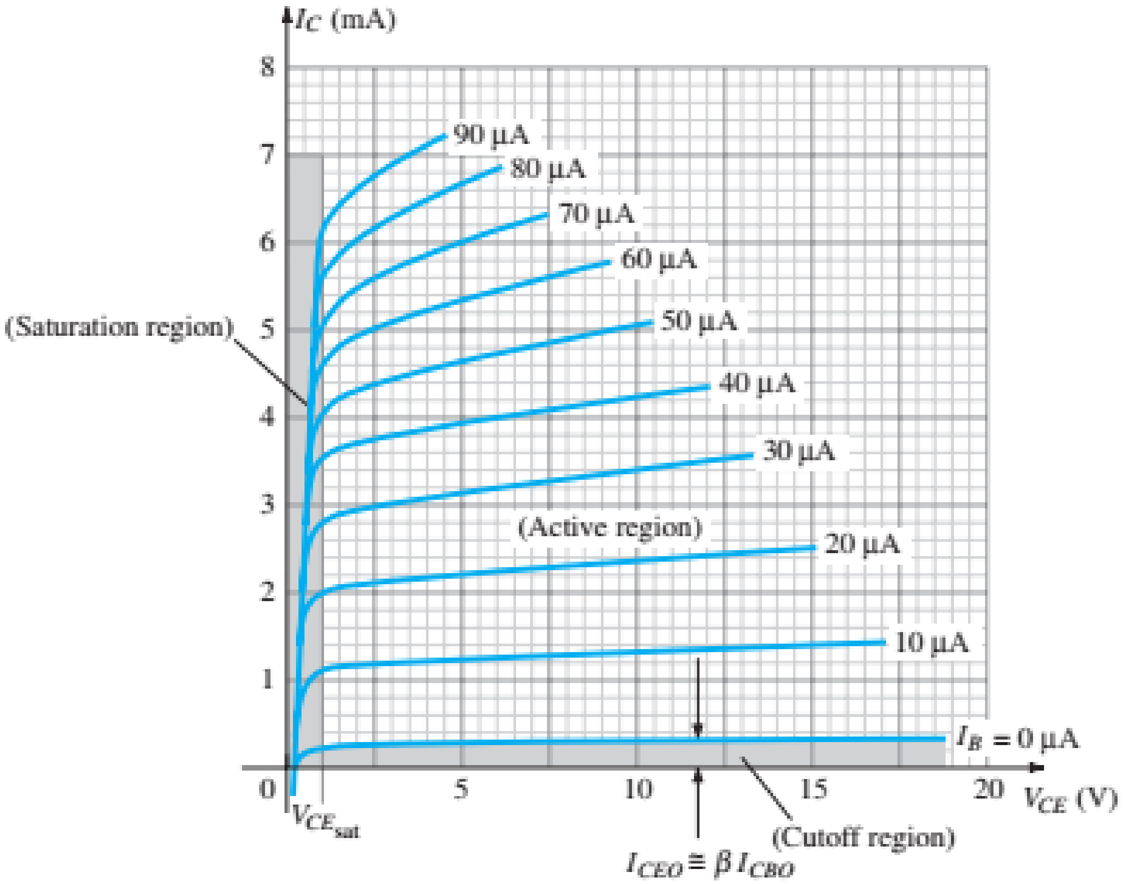
- It is called the *common-emitter configuration* because the emitter is common to both the input and output terminals (in this case common to both the base and
collector terminals).



npn *pnp*

2. Common-Emitter Configuration$_2$





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

β=50:400 practically

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

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

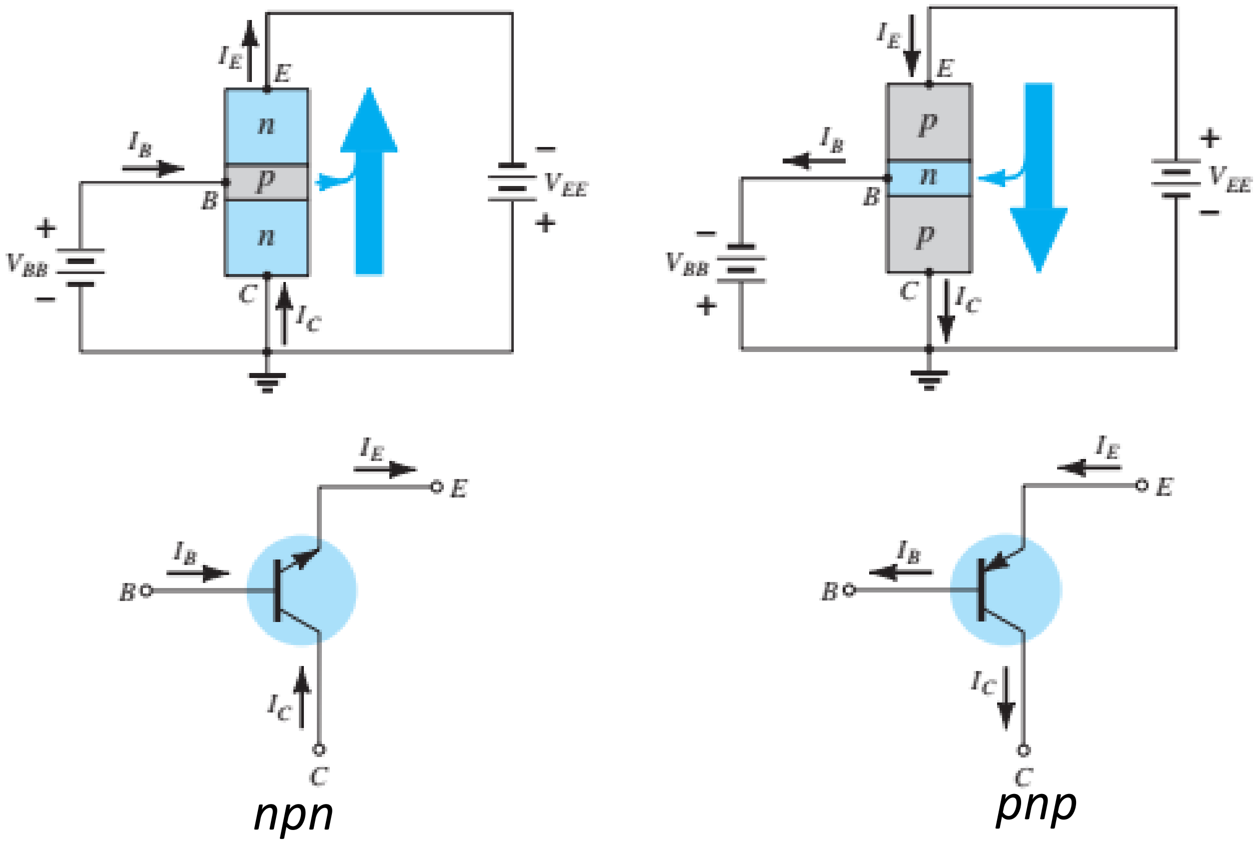
$$\beta = \frac{\alpha}{1 - \alpha}$$

$$I_C = \beta I_B$$

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

3. Common-Collector Configuration$_1$

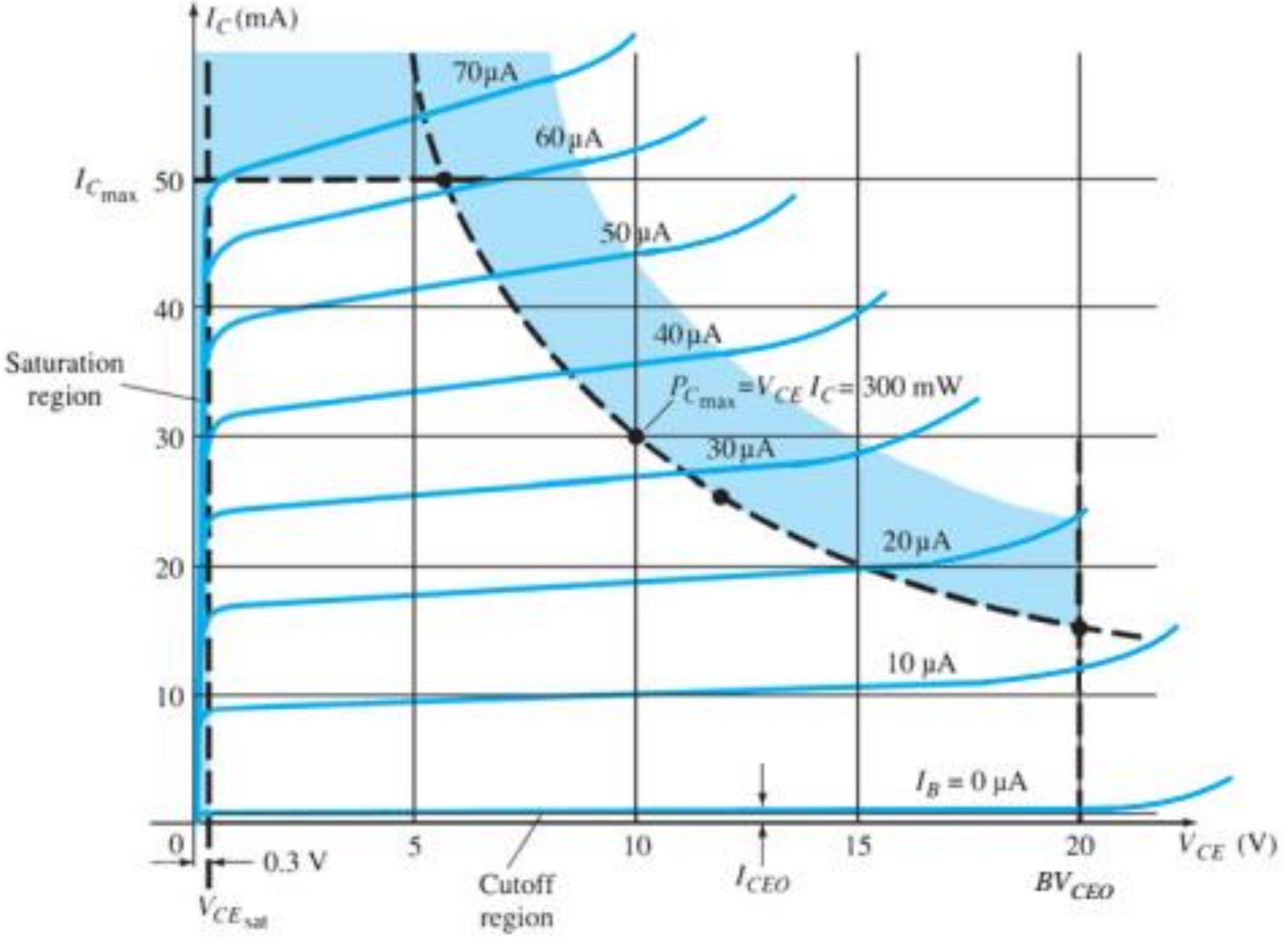
- The common-collector configuration is used primarily for impedance-matching purposes since it has a high input impedance and low output impedance, opposite to that of the common-base and common emitter configurations.



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 ($I_c \approx I_E$).

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

$$I_{CEO} \leqq I_C \leqq I_{C_{max}}$$

$$V_{CE_{sat}} \leqq V_{CE} \leqq V_{CE_{max}}$$

$$V_{CE} I_C \leqq P_{C_{max}}$$

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	–

MAXIMUM RATINGS

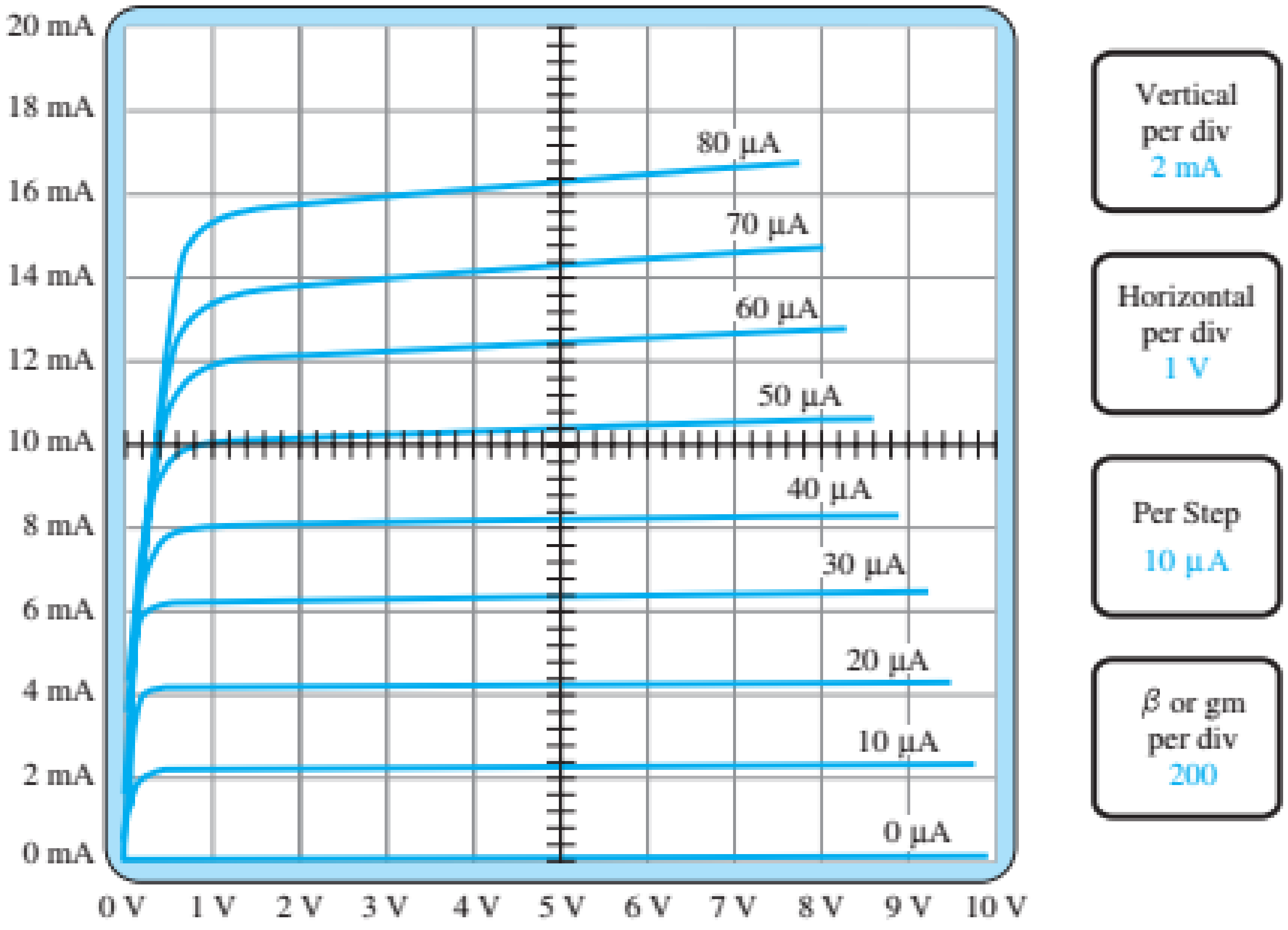
Rating	Symbol	2N4123	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature 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

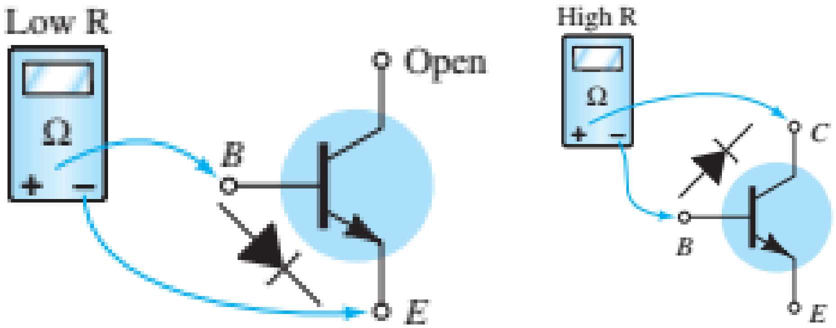
1. Curve Tracer



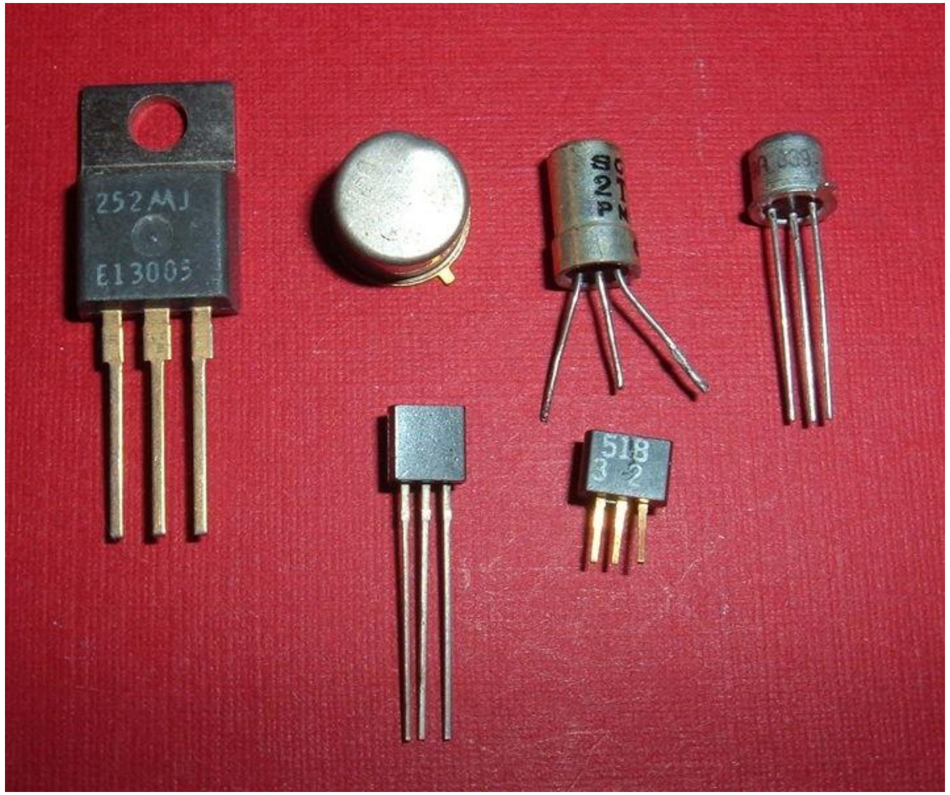
Curve tracer response to 2N3904 npn transistor.

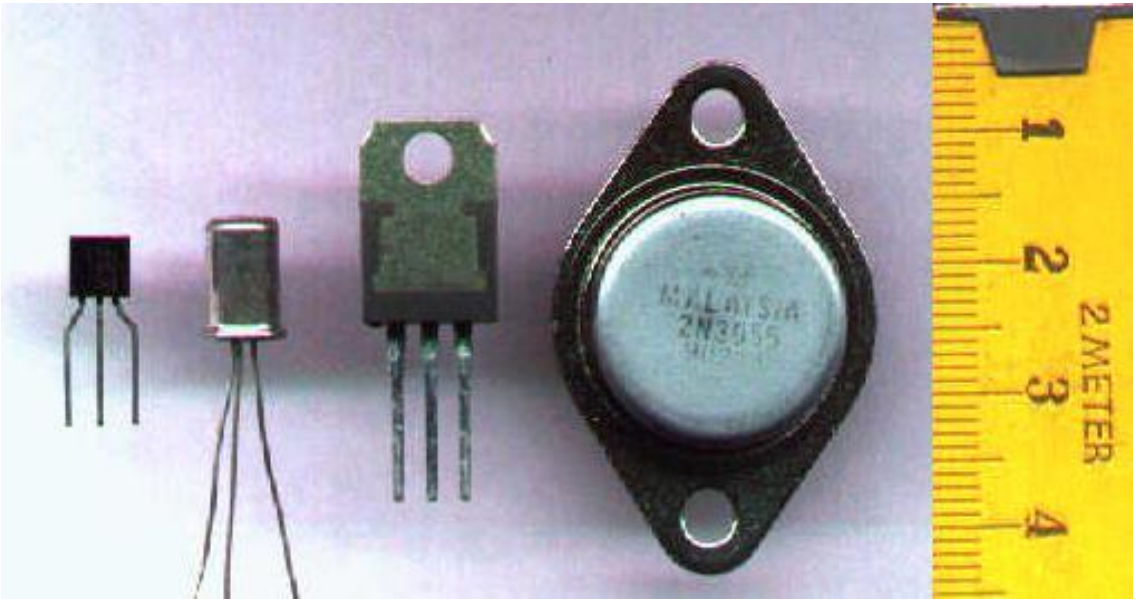
2. Transistor Testers

3. Ohmmeter



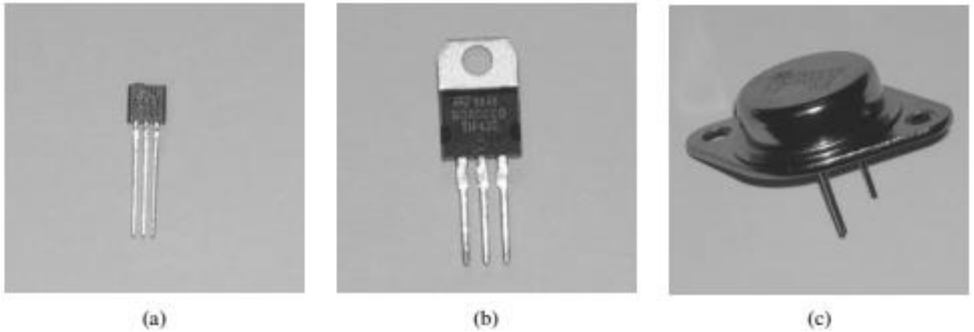
Modern Transistors





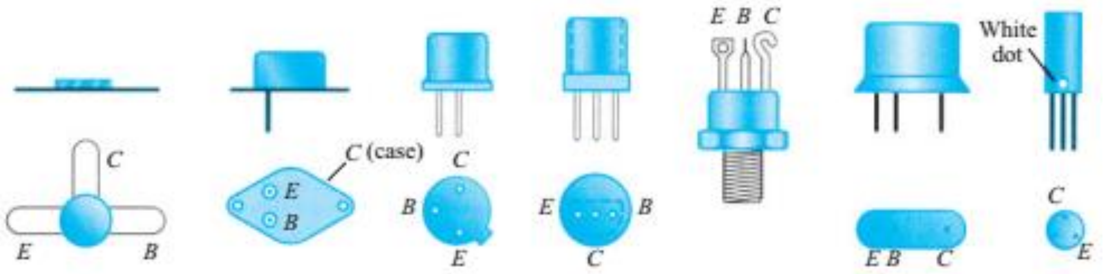
Transistor Casing and Terminal Identification

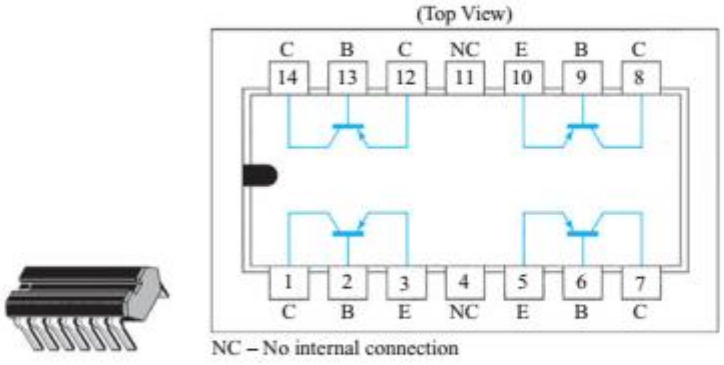
- Casing



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


Thank You!