BIPOLAR JUNCTION TRANSISTORS (BJTs)

INTRODUCTION

- What is transistor?
  - **A three-terminal device whose output current, voltage and/or power are controlled by its input.**
- Commonly used in audio application as an amplifier, in switching application as a switch and in power supply voltage and current regulator circuit.
- 2 basic transistor types: BJT and FET
- These two transistor differ in their operating characteristic and their internal construction.

OBJECTIVES

- Describe the basic structure of the bipolar junction transistor (BJT)
- Explain and analyze basic transistor bias and operation
- Discuss the parameters and characteristics of a transistor and how they apply to transistor circuits

LECTURE OUTLINE

- ❑1. BJT structure
- ❑2. Basic BJT operations
- ❑3. BJT Characteristics and Parameters
- ❑4. BJT as an amplifier
- ❑5. BJT as a switch
- ❑6. Troubleshooting
- ❑Summary

1. BJT STRUCTURE

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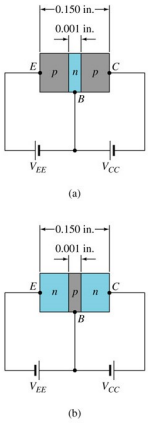
- The BJT is constructed with three doped semiconductor regions separated by two *pn* junctions.
- The three region are called emitter (E),base (B) and collector (C)
- The BJT have 2 types:
  1. Two *n* region separate by a *p* region – called *npn*
  2. Two *p* region separated by a *n* region – called *pnp*
- The pn junction joining the base region and the emitter region is called the *base-emiter* junction
- The pn junction joining the base region and the collector region is call *base-collector* junction
- The base region is lightly doped and very thin compared to the heavily doped emitter and the moderately doped collector region

Slide 1

Transistor Construction

There are two types of transistors: ***pnp*** and ***npn***-type.

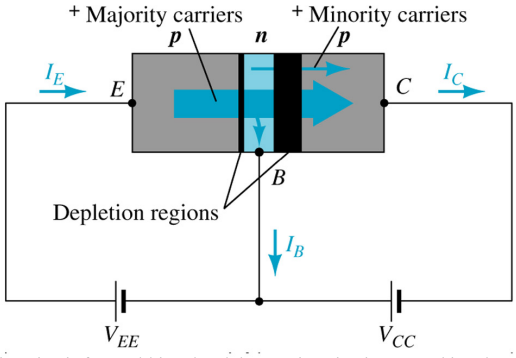


Note: the labeling of the transistor:
E - Emitter
B - Base
C - Collector

Slide 2

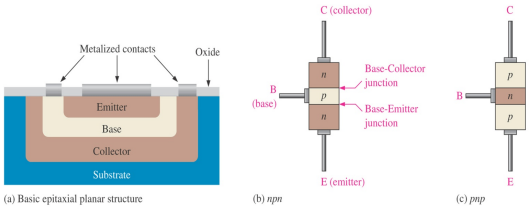
Transistor Operation

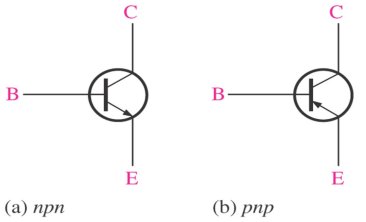
With the external sources (V_{EE} and V_{CC}) in the polarities as shown:



The E-B junction is forward-biased and the B-C junction is reverse biased.

1. BJT STRUCTURE





1. BJT STRUCTURE

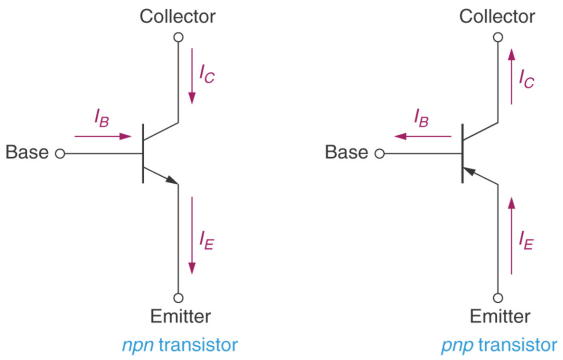
- BJT schematic symbol
- The arrow on schematic symbol is important because:
  - **Identify the component terminal**

    The arrow is always drawn on the emitter terminal. The terminal opposite emitter is collector and the center terminal is base.
  - **The arrow always points toward n-type material**

    If the arrow point toward base, transistor is pnp type. If it points toward emitter, transistor is npn type.

1. BJT STRUCTURE

- Transistor terminal current



1. BJT STRUCTURE

Transistor Currents:

➢The directions of the currents in *npn* transistor and *pnp* transistor are shown in the figure.

➢The emitter current (I_E) is the sum of the collector current (I_C) and the base current (I_B)

$$I_E = I_B + I_C$$

➢$I_B << I_E$ or I_C

➢The capital letter – dc value

➢Transistor is a current-controlled device - the value of collector and emitter currents are determined by the value of base current.

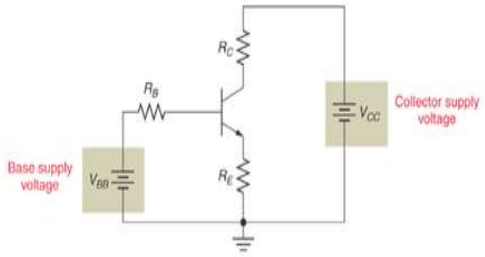
➢An increase or decrease in value of I_B causes similar change in values of I_C and I_E.

$$I_C = \beta_{DC} I_B$$

Current gain (β) → factor by which current increases from base of transistor to its collector.

1. BJT STRUCTURE

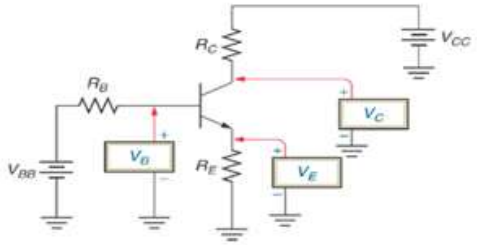
- **Transistor Voltages**:
  - V_{CC} – collector supply voltage. This is a power supply voltage applied directly to collector of transistor.
  - V_{BB} – base supply voltage. this is dc voltage used to bias base of transistor.
  - V_{EE} – emitter supply voltage. dc biasing voltage and in many cases, VEE is simply a ground connection.



(a) Transistor supply voltages

1. BJT STRUCTURE

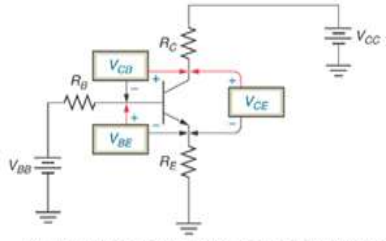
- **Transistor Voltages**:
- V_C – dc voltage measured from collector terminal of component to ground
- V_B – dc voltage measured from base terminal to ground.
- V_E – dc voltage measured from emitter terminal to ground.



(b) Transistor terminal voltages to ground

1. BJT STRUCTURE

- **Transistor Voltages**:
- V_{CE} – dc voltage measured from collector to emitter terminal of transistor.
- V_{BE} – dc voltage measured from base to emitter terminal of transistor.
- V_{CB} – dc voltage measured from collector to base terminal of transistor.



(c) The voltages measured across the transistor junctions

2. BJT OPERATION

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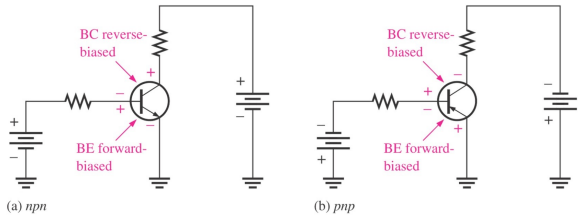
- To operate the transistor properly, the two pn junction must be correctly biased with external dc voltages.
- The figure shows the proper bias arrangement for both *npn* and *pnp* transistor for its operation as an amplifier.



2. BJT OPERATION

- Transistor is made of 3 separate semiconductor materials that joined together to form two pn junction.
- Point at which emitter and base are joined forms a single pn junction → base-emitter junction
- Collector-base junction → point where base and collector meet.