Analog Electronics

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1st **semester**

Chapter 4

Transistor

Lecture 8

Transistor

- The transistor is the most important element in the world of electronics. It can be **used** as an amplifier for signals and can also be used as a switch.
- **There are two categories of transistors:**

1. Bipolar Junction Transistor (BJT)
2. Unipolar Junction Transistor (UJT)

This type has three parties:

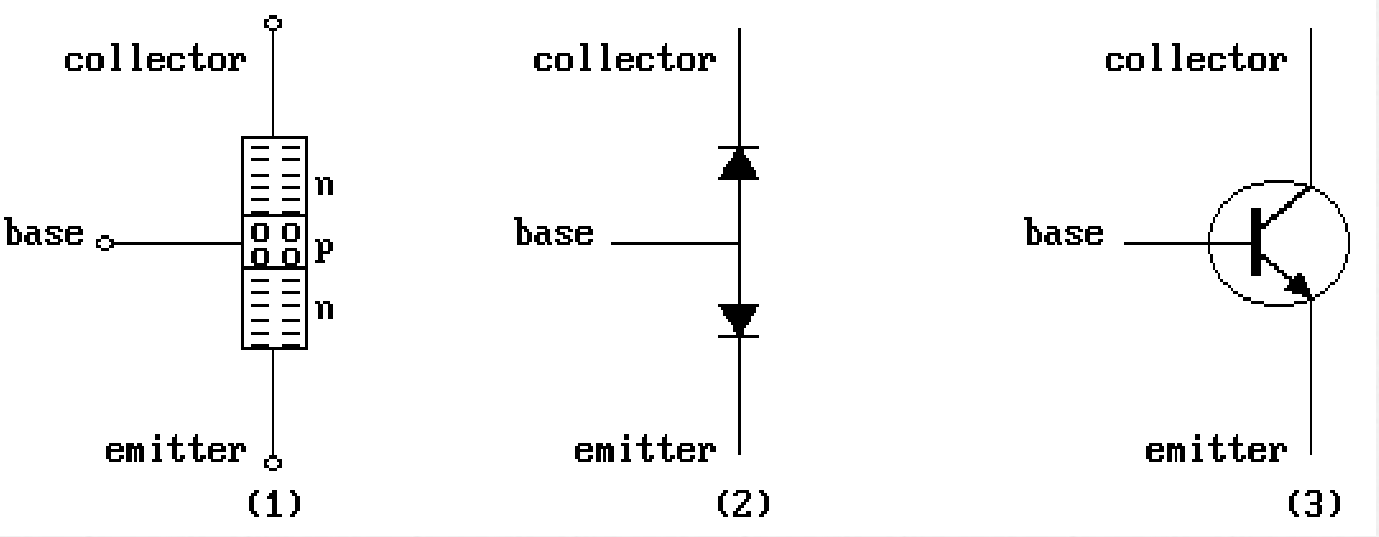
1. Base
2. Collector
3. Emitter

When this transistor is made up of a layer of P-type, surrounded by two layers of type n (as shown below), it is called the npn transistor,

Materials of n and p types can be obtained by adding impurities to semiconductor materials.

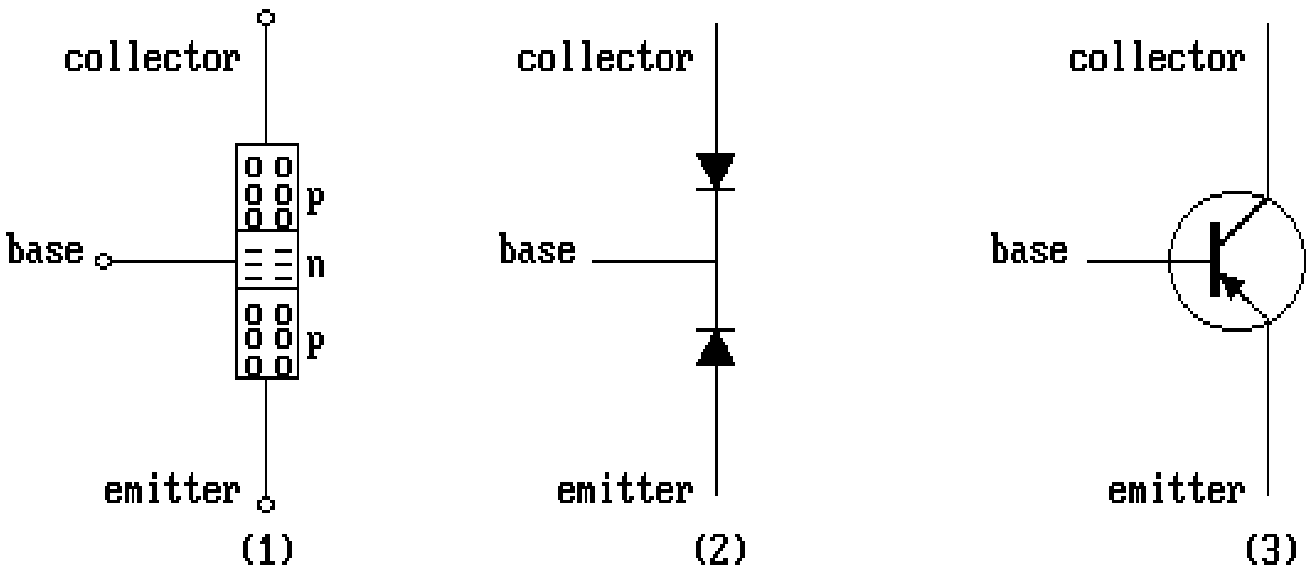
The shape "1" symbolizes the electrons, and the shape "2" symbolizes the gaps (1).

Part 3 shows the BJT transistor as shown in the circuit diagrams and the outward arrow symbolizes that this is the **npn** and indicates the direction of the conventional current.



The three semi-conductive classes behave as opposite Diodes (2)

- The following figure shows a **pnp** transistor where a type n layer is placed between two layers of type p in (1) and can be considered a **Diode** connected face to face. 2 The **arrow inside** the transistor symbol shows the traditional current path (3)



- **Silicon transistors** (silicon-like materials) are **better than their germanium counterparts**, where they can **work** at **higher temperatures, efforts, frequencies, and lower leakage rates**.

Structure of the Bipolar Junction Transistor (BJT)

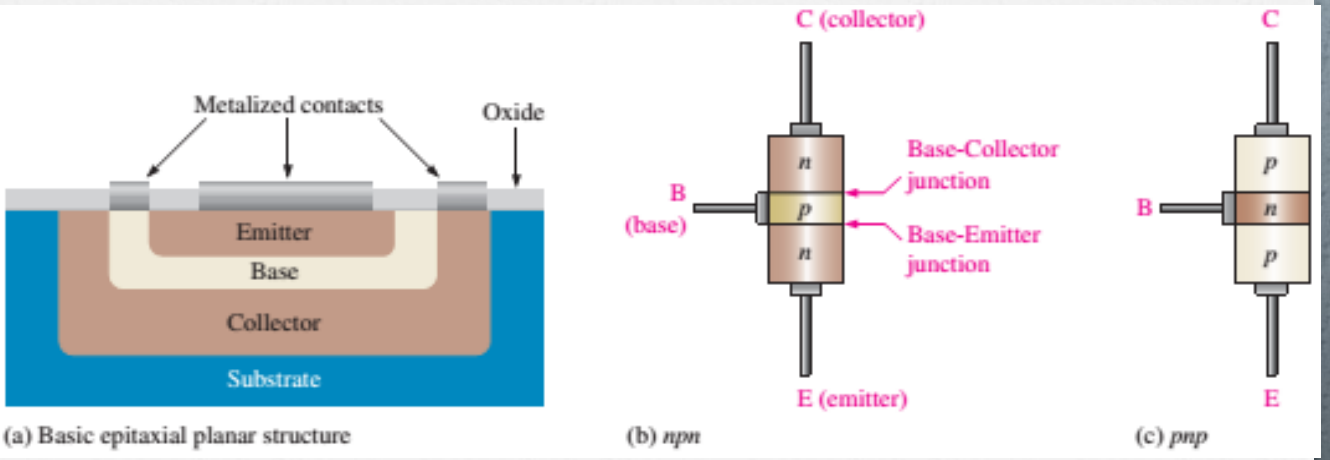
The **BJT** is constructed with three doped semiconductor regions **separated** by two pn junctions, as in Figure 1(a). Physical representations of the two types of BJTs are shown in Figures 1(b) and (c).

One type consists of two n regions separated by a p region (**npn**), and the other type consists of two p regions separated by an n region (**pnp**).

The term **bipolar refers** to the **use of both holes and electrons** as current carriers in the transistor structure.

This **mode of operation** is contrasted with unipolar transistors, such as **field-effect transistors**, in which **only** one carrier type is employed (**electron or hole, ex.: diode**).

Figure1: Basic BJT construction.



The **pn junction** joining the **base and emitter regions** is called the **base-emitter** junction.

The **pn junction** joining the **base and collector regions** is called the **base-collector junction**.

A wire lead connects to each of the three regions.

These leads are labeled **E for the emitter**, **B for the base, and C for the collector**. The **base region** is **lightly doped** and **very thin** compared to the heavily doped emitter and the moderately doped collector regions.

Figure 2 shows the symbols for the **npn** and **pnp** bipolar junction transistors.

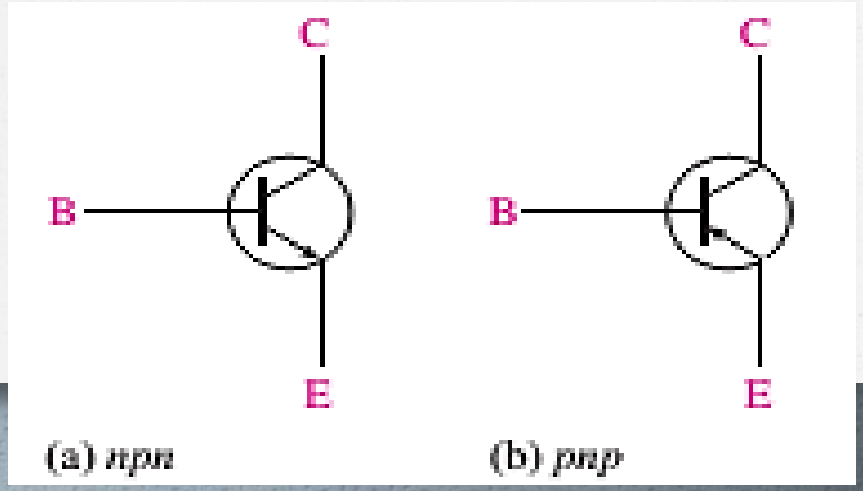


Figure 2: Standard BJT symbols.

BJT Biasing

In order to a **BJT** to **operate properly as an amplifier**, the two pn junctions must be **correctly biased with external dc voltages**.

Figure 3 shows a **bias arrangement for both npn and pnp BJTs for operation as an amplifier**.

In both cases, the base-emitter (**BE**) junction is **forward-biased,** and the base-collector (**BC**) junction is reverse-biased. **This condition is called forward-reverse bias**.

For the **npn** type shown, the **collector** is **more positive** than the **base**, which is **more positive** than the **emitter**.

For the **pnp** type, the **voltages** are reversed to maintain the **forward-reverse bias**.

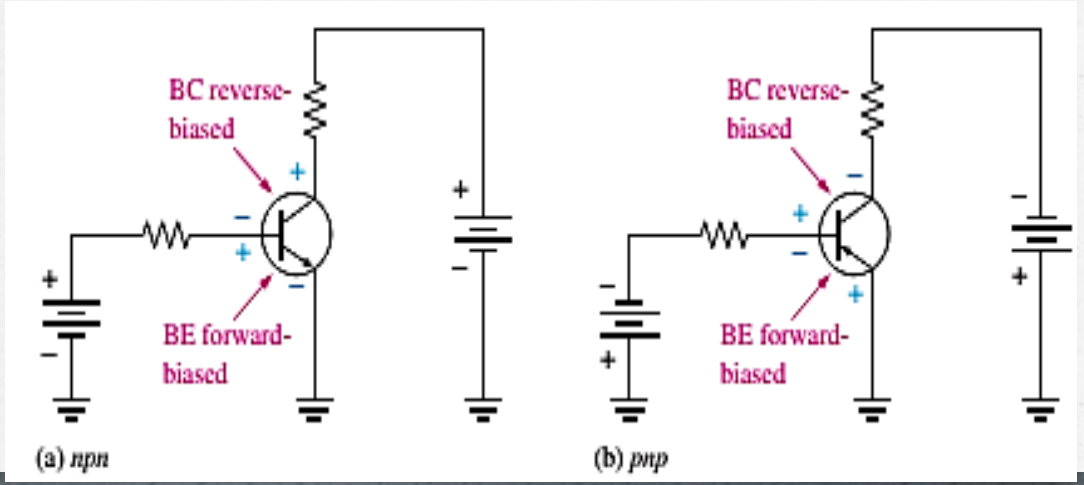


Figure 3:
Forward-reverse bias of a BJT.

The **heavily doped** **n-type** emitter region has a **very high density of conduction-band** (free) **electrons,** as indicated in Figure below.

These free electrons **easily** diffuse through the **forward-biased BE junction** into the lightly doped and very thin **p-type base region**.

The **base** has a **low** **density of holes**, which are the **majority carriers,** as **represented by the white circles.**

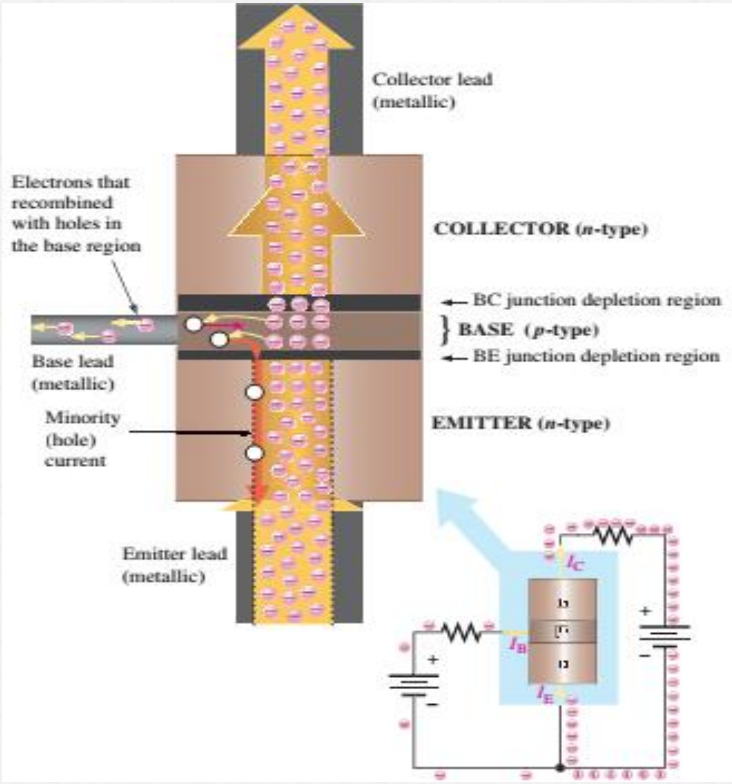


Figure: BJT operation showing electron flow.

1- A very little free electron recombines with holes in the base and **moves as valence electrons** through the **base region** and **into the emitter region as hole current**.

The **valence electrons leave** the crystalline structure of the **base**, **become free electrons** in the metallic base lead, and **produce the external base curren**t.

2- The majority of free electrons move toward the reverse-biased BC junction and are swept across into the collector region by the attraction of the positive collector **supply voltage**.

The **free electrons** move **through** the collector region, into the **external circuit**, and then return into the emitter region **along** with **the base current.**