Bipolar Junction Transistor (BJT)

In 1951, William Schockley invented the first **junction transistor,** a semiconductor device that can amplify (enlarge) electronic signals such as radio and television signals. The transistor has led to many other semiconductor inventions, including the **integrated circuit (IC),** a small device that contains thousands of miniaturized transistors. Because of the IC, modern computers and other electronic miracles are possible. This chapter introduces the fundamental operation of a **bipolar junction transistor (BJT),** the kind that uses both free electrons and holes. The word bipolar is an abbreviation for "two polarities." This chapter will also explore how this BJT can be properly biased to act as a switch

The Unbiased Transistor

A transistor has three doped regions, as shown in Fig. 4-1. The bottom region is called the emitter, the middle region is the base, and the top region is the collector. In an actual transistor, the base region is much thinner as compared to the collector and emitter regions. The transistor of Fig. 4-1 is an npn device because there is a p region between two n regions. Recall that the majority carriers are free electrons in n-type material and holes in p-type material.

Transistors are also manufactured as pnp devices. A pnp transistor has an n region between two p regions. To avoid confusion between the npn and the pnp transistors, our early discussions will focus on the npn transistor.

Doping Levels

In Fig. 4-1, the emitter is heavily doped. On the other hand, the base is lightly doped. The doping level of the collector is intermediate, between the heavy doping of the

emitter and the light doping of the base. The collector is physically the largest of the three regions.

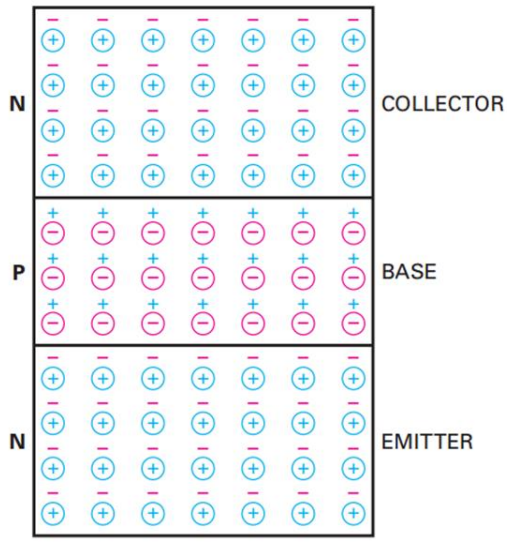
Emitter and Collector Diodes

The transistor of Fig. 4-1 has two junctions: one between the emitter and the base، and another between the collector and the base. Because of this, a transistor is like two back-to-back diodes. The lower diode is called the emitter-base diode, or simply the emitter diode. The upper diode is called the collector-base diode, or the collector diode.

Before and After Diffusion

Figure 4-1 shows the transistor regions before diffusion has occurred. Because of their repulsion for each other, the free electrons in the n regions will spread in all directions. Some of the free electrons in the n region will diffuse across the junction and recombine with the holes in the **p** region. Visualize the free electrons in each n region crossing the junction and recombining with holes The result is two depletion layers, as shown in Fig. 4-2a. For each of these depletion layers, the barrier potential is approximately 0.7 V at 25°C for a silicon

Figure 4-1 Structure of a transistor.



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