

# **CHAPTER 1:**

## **ZENER DIODE THEORY**

### **Introduction**

The zener diode is a semiconductor device unique in its mode of operation and completely unreplaceable by any other electronic device. Because of its unusual properties it fills a long-standing need in electronic circuitry. It provides, among other useful functions, a constant voltage reference or voltage control element available over a wide spectrum of voltage and power levels.

The zener diode is unique among the semiconductor family of devices because its electrical properties are derived from a rectifying junction which operates in the reverse breakdown region. In the sections that follow the reverse biased rectifying junction, some of the terms associated with it, and properties derived from it will be discussed fully.

The zener diode is fabricated from the element silicon. Special techniques are applied in the fabrication of zener diodes to create the required properties. These special production techniques will be discussed in detail in Chapter 2.

This manual was prepared to acquaint the engineer, the equipment designer and manufacturer, and the experimenter with the fundamental principles, design characteristics, applications, and advantages of this important semiconductor device.

### **Semiconductor Theory**

The active portion of a zener diode is a semiconductor PN junction. PN junctions are formed in various kinds of semiconductor devices by several techniques. Among these are the widely used techniques known as alloying and diffusion which are utilized in fabricating zener PN junctions to provide excellent control over zener breakdown voltage.

At the present time, zener diodes use silicon as the basic material in the formation of their PN junction. Silicon is in Group IV of the periodic table (tetravalent) and is classed as a "semiconductor" due to the fact that it is a poor conductor in a pure state. When controlled amounts of certain "impurities" are added to a semiconductor it becomes a better conductor of electricity. Depending on the type of impurity added to the basic semiconductor, its conductivity may take two different forms, called P- and N-type respectively.

N-type conductivity in a semiconductor is much like the conductivity due to the drift of free electrons in a metal. In pure silicon at room temperature there are too few free electrons to conduct current. However, there are ways of introducing free electrons into the crystal lattice as we shall now see. Silicon is a tetravalent element, one with four valence electrons in the outer shell; all are virtually locked into place by the covalent bonds of the crystal lattice structure, as shown schematically in Figure 1-1A. When controlled amounts of donor