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CHAPTER 13
Diodes and Transistors

Most of the semiconductors that a digital system employs are fabricated as part of integrated circuits. Yet there are numerous instances in which discrete semiconductors, most notably diodes and transistors, are required to complete a system. Diodes are found in power supplies, where they serve as rectifiers and voltage references. It is difficult these days *not* to find a light emitting diode, or LED, in one's immediate vicinity, on some appliance or piece of electronic equipment. Discrete transistors are present in switching power supplies and in circuits wherein a digital IC must drive a heavy load. There are many other uses for diodes and transistors in analog circuit design, most notably in signal amplification. These more analog topics are not discussed here.

Diodes and transistors are explained in this chapter from the perspective of how they are applied in the majority of digital systems. As such, the level of theory and mathematics used to explain their operation is limited. The first portion of the chapter introduces diodes and provides examples of how they are used in common power and digital applications. Bipolar junction and field-effect transistors are discussed in the remainder of the chapter. The intent of this chapter is to show how diodes and transistors can be put to immediate and practical use in a digital systems context. As such, useful example circuits are presented whenever possible.

13.1 DIODES

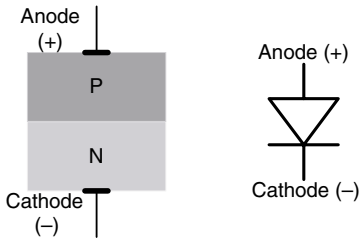

FIGURE 13.1 Diode structure and graphical representation.

An ideal diode is a nonlinear circuit element that conducts current only when the device is *forward biased*, i.e., when the voltage applied across its terminals is positive. It thereby behaves as a one-way electrical valve that prevents current from flowing under conditions of *reverse bias*. A diode has two terminals: the *anode* and *cathode*. For the diode to be forward biased, the anode must be at a more positive voltage than the cathode. Diodes are the most basic semiconductor structures and are formed by the junctions of two semiconductor materials of slightly differing properties. In the case of a silicon diode, the anode is formed from positively doped silicon, and the cathode is formed from negatively doped silicon. Along this *pn junction* is where the physical phenomenon occurs that creates a diode. Figure 13.1 shows the general silicon structure of a diode and its associated symbolic representation.

Real diodes differ from the ideal concept in several ways. Most significantly, a real diode must be forward biased beyond a certain threshold before the device will conduct. This threshold is called the