3–3 THE VARACTOR DIODE

The junction capacitance of diodes varies with the amount of reverse bias. Varactor diodes are specially designed to take advantage of this characteristic and are used as voltage-controlled capacitors rather than traditional diodes. These devices are commonly used in communication systems. Varactor diodes are also referred to as *varicaps* or *tuning diodes.*

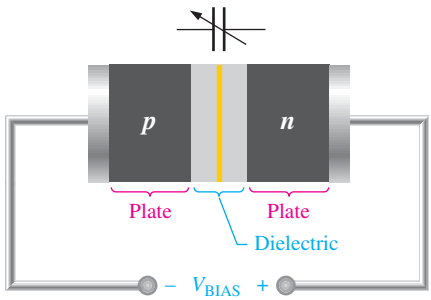
After completing this section, you should be able to

- **Describe the varactor diode characteristic and analyze its operation**
- Discuss the basic operation of a varactor
  - ◆ Explain why a reverse-biased varactor acts as a capacitor ◆ Calculate varactor capacitance ◆ Identify the varactor schematic symbol
- Interpret a varactor diode datasheet
  - ◆ Define and discuss capacitance tolerance range ◆ Define and discuss capacitance ratio ◆ Discuss the back-to-back configuration
- Discuss and analyze the application of a varactor in a resonant band-pass filter

A **varactor** is a diode that always operates in reverse bias and is doped to maximize the inherent capacitance of the depletion region. The depletion region acts as a capacitor dielectric because of its nonconductive characteristic. The *p* and *n* regions are conductive and act as the capacitor plates, as illustrated in Figure 3–21.

▶ FIGURE 3–21

The reverse-biased varactor diode acts as a variable capacitor.



Basic Operation

Recall that capacitance is determined by the parameters of plate area (A), dielectric constant (ϵ), and plate separation (d), as expressed in the following formula:

$$C = \frac{A\epsilon}{d}$$

As the reverse-bias voltage increases, the depletion region widens, effectively increasing the plate separation, thus decreasing the capacitance. When the reverse-bias voltage decreases, the depletion region narrows, thus increasing the capacitance. This action is shown in Figure 3–22(a) and (b). A graph of diode capacitance (C_T) versus reverse voltage for a certain varactor is shown in Figure 3–22(c). For this particular device, C_T varies from 30 pF to slightly less than 4 pF as V_R varies from 1 V to 30 V.

In a varactor diode, these capacitance parameters are controlled by the method of doping near the *pn* junction and the size and geometry of the diode's construction. Nominal varactor capacitances are typically available from a few picofarads to several hundred picofarads. Figure 3–23 shows a common symbol for a varactor.

▲ FIGURE 3–23

Varactor diode symbol.