3

Transmission-Line Theory

The theory of electric waves along uniform transmission lines is reviewed in this chapter. A uniform line is defined as one whose dimensions and electrical properties are identical at all planes transverse to the direction of propagation. The analysis includes a study of the reflection characteristics of terminated lines. The results allow us to apply ac circuit concepts to lines whose lengths are *not* negligible compared to the operating wavelength. (The restriction regarding line lengths was discussed in Sec 1–1). An interesting consequence of this analysis is that the impedance of a circuit can be dramatically altered by the addition of a small length of transmission line. This impedance transforming property of a line is a powerful design tool at microwave frequencies. Several illustrative examples are given in this and subsequent chapters.

3–1 CIRCUIT REPRESENTATION OF TRANSMISSION LINES

Transmission lines provide one method of transmitting electrical energy between two points in space, antennas being the other (Appendix F). Figure 1–4 shows four types of lines used at microwave frequencies. The open two-wire line is the most popular at the lower frequencies, the TV twin-lead being a familiar example. UHF and cable TV systems utilize low-loss coaxial cable as a transmission line. Modern microwave practice involves considerable use of coaxial lines at frequencies up to 30 GHz and hollow waveguides from 3 to 300 GHz.

In principle, any transmission line can be analyzed by solving Maxwell's equations and applying the appropriate boundary conditions for the particular line geometry. An example of this is the analysis of hollow waveguides described in Sec. 5–5. A simpler technique that utilizes ac circuit concepts is given in this chapter. As