THE ANALYSIS & DESIGN OF LINEAR CIRCUITS by THOMAS & ROZA

−5000 leads to an exponential term that also decays to zero, leaving a steady-state response of $20u(t)$. ∎

PARADOXES

TEST SIGNALS

(1) While the transfer function is a useful concept, it is clear that we cannot find the circuit response until we are given an input signal. Here, we encounter a central paradox of circuit analysis. In practice, the input signal is a carrier of information and is therefore unpredictable. We could spend a lifetime studying a circuit for various inputs and still not treat all possible signals that might be encountered in practice. What we must do is calculate the responses due to certain standard test signals. Although these test signals may never occur as real input signals, their responses tell us enough to understand the signal processing capabilities of a circuit.

(2) INITIAL CONDITIONS UNPREDICTABLE ALSO

(3) COMPONENT VALUES ARE VARIABLE FROM THE MANUFACTURING PROCESS.

The two premier test signals used are the pulse and the sinusoid. The study of pulse response divides into two extreme cases, short and long. When the pulse is very short compared to the circuit response time, the sudden injection of energy causes a circuit response long after the input returns to zero. The short pulse is modeled by an impulse, and the resulting *impulse response* is treated in Sec. 11–3. At the other extreme, the long pulse has a duration that greatly exceeds the circuit response time. In this case, the circuit has ample time to be driven from the zero state to a new steady-state condition. The step function is used to model the long pulse input, and the resulting *step response* is studied in Section 11–4.

The impuse response is of great importance because it contains all of the information needed to calculate the response due to any other input. The step response is important because it describes how a circuit response transitions from one state to another. The signal transition requirements for circuits and systems are often stated in terms of the step response using partial waveform descriptors such as rise time, fall time, propagation delay, and overshoot.

The unique properties of the sinusoid make it a useful input for characterizing the signal-processing capabilities of linear circuits and systems. When a stable linear circuit is driven by a sinusoidal input, the steady-state output is a sinusoid with the same frequency, but with a different phase angle and amplitude. The frequency-dependent relationship between the sinusoidal input and the steady-state output is called *frequency response*, a signal-processing description that is often used to specify the performance of circuits and systems. The relationship between network functions and the sinusoidal steady-state response is studied in Sec. 11–5.

11–2 NETWORK FUNCTIONS OF ONE- AND TWO-PORT CIRCUITS

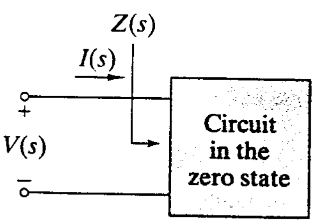

FIGURE 11–2 *A one-port circuit.*

The two major types of network functions are driving-point impedance and transfer functions. A **driving-point impedance** relates the voltage and current at a pair of terminals called a port. The driving-point impedance $Z(s)$ of the one-port circuit in Figure 11–2 is defined as

$$Z(s) = \frac{V(s)}{I(s)} \qquad (11\text{–}$$