Unit 6

Section One: Reading Comprehension

Relationship Between Voltage and Current

This is a long and interesting story. It is the heart of electronics. Crudely speaking, the name of the game is to make and use gadgets that have interesting and useful *I* versus *V* characteristics. Resistors (*I* simply propor tional to *V*), capacitors (*I* proportional to rate of change of *V*), diodes (*I* only flows in one direction), thermistors (temperature-dependent resistor), photoresistors (light-dependent resistor), strain gauges (strain-dependent resistor), etc., are examples. We will gradually get into some of these exotic devices; for now, we will start with the most mundane and most widely used circuit element, the resistor (Figure 6-1).


Figure 6-1.

It is an interesting fact that the current through a metallic conductor (or other partially conducting material) is proportional to the voltage across it. (In the case of wire conductors used in circuits, we usually choose a thick enough gauge of wire so that these Voltage drops' will be negligible.) This is by no means a universal law for all objects. For instance, the current through a neon bulb is a highly nonlinear function of the applied voltage (it is zero up to a critical voltage, at which point it rises dramatically). The same goes for a variety of interesting special devices-diodes, transistors, light bulbs, etc.

A resistor is made out of some conducting stuff (carbon, or a thin metal or carbon film, or wire of poor conductivity), with a wire coming out each end. It is characterized by its resistance:

$$R = \frac{V}{I}$$

R is in ohms for V in volts and *I* in amps. This is known as Ohm's law. Typical resistors of the most frequently used type (carbon composition) come in values from 1 ohm (1Ω) to about 22 megohms (22 MΩ). Resistors are also characterized by how much power they can safely dissipate (the most commonly used ones are rated at ¼ or ½ watt and by other parameters such as tolerance (accuracy), temperature coefficient, noise, voltage coefficient (the extent to which *R* depends on applied *V*), stability with time, inductance, etc. Capacitors (Figure 6-2) are devices that might be considered simply frequency-dependent resistors. They allow you to make frequency-dependent voltage dividers, for instance. For some applications (bypass, coupling) this is almost all you need to know, but for other applications (filtering, energy storage, resonant circuits) a deeper understanding is needed. For example, capacitors cannot dissipate power, even though current can flow through them, because the voltage and current are 90° out of phase.

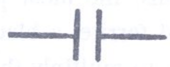

Figure 6-2.

A capacitor (the old-fashioned name was *condenser)* is a device that has two wires sticking out of it and has the property

$$Q = CV$$

A capacitor of *C* farads with *V* volts across its terminals will contain *Q* coulombs of stored charge.

Taking the derivative, you get

$$I = C\frac{dV}{dt}$$

Capacitors come in an amazing variety of shapes and sizes. The basic construction is simply two conductors near each other; in fact, the simplest capacitors are just that. For greater capacitance, you need more area and closer spacing; the usual approach is to plate some conductor onto a thin insulating material (called a dielectric), for instance, aluminized Mylar film rolled up into a small cylindrical configuration. Other popular types are thin ceramic wafers, metal foils with oxide insulators (electrolytics), and metallized mica. Each of these types has unique properties. In general, ceramic and Mylar types are used for most noncritical circuit applications; tantalum capacitors are used where greater capacitance is needed, and electrolytics are used for power supply filtering.

Inductors (Figure 6-3) are closely related to capacitors; the rate of current change in an inductor depends on the voltage applie across it, whereas the rate of voltage change in a capacitor depends on the current through it. The

Figure 6-3.