Basic Definitions and Terms

Before we begin our analysis of electric circuits, we must define terms that we will employ. We will simply refer to an *electric circuit* as an interconnection of electrical components, each of which we will describe with a mathematical model. The most elementary quantity in an analysis of electric circuits is the electric *charge*. Our interest in electric charge is centered around its motion, since charge in motion results in energy transfer. An electric circuit is essentially a pipeline that facilitates the transfer of charge from one point to another. The time rate of change of charge constitutes an electric *current*. The basic unit of current is the ampere (A), and 1 ampere is 1 coulomb per second. Although we know that current flow in metallic conductors results from electron motion, the conventional current flow, which is universally adopted, represents the movement of positive charges. It is important that the reader thinks of current flow as the movement of positive charge regardless of the physical phenomena that take place. Therefore, it is important to specify not only the magnitude of the variable representing the current but also its direction.

The term *direct current* or DC is used to describe current that flows in only one direction. Direct current moves only one way, from positive to negative. A battery is a common direct-current device. A DC source will always try to move current in the same direction. One thing to note is that the current coming out of the source always needs to get back to the source somehow. The ground connection on the schematic should be thought of as a label that connects the signal back to the source. If the signal does not get back to the source, then there is no current flow. AC or *alternating current* came about as the interaction of magnets and electricity were discovered. This type of current most commonly comes from big AC generators at your local hydroelectric dam. When you move a coil of wire past a magnet, the current first climbs as the strength of the field increases, then as the field decreases and switches polarity, the current also decreases and switches polarity. The voltage and current change in a sinusoidal fashion naturally as the coil passes by the magnets. As long as you keep moving the coil, AC power will continue to be generated.

We have indicated that charges in motion yield energy transfer. Now we define the *voltage* (also called the *electromotive force*, or *potential*) between two points in a circuit as the difference in energy level of a unit charge located at each of the two points. Charges in motion represent a current. The motion of charges in an electric circuit will be resisted as well. We will introduce the concept of resistance later to describe this effect.

Energy is measured in joules (J). Hence, voltage is measured in volts (V) and 1 volt is 1 joule per coulomb. If a unit positive charge is moved between two points, the energy required to move it is the difference in energy level between the two points and is defined voltage.

Energy is yet another important term of basic significance. Let's investigate the voltage–current relationships for energy transfer using the flashlight. The basic elements of a flashlight are a battery, a switch, a light bulb, and connecting wires. Assuming a good battery, we all know that the light bulb will glow when the switch is closed. A current now flows in this closed circuit as charges flow out of the positive terminal of the battery through the switch and light bulb and back into the negative terminal of the battery. The current heats up the filament in the bulb, causing it to glow and emit light. An energy conversion process occurs in the flashlight as the chemical energy in the battery is converted to electrical energy, it is converted to thermal energy in the light bulb.

Ohm's law is named for the German physicist Georg Simon Ohm, who is credited with establishing the voltage–current relationship for resistance. As a result of his pioneering work, the unit of resistance bears his name. *Ohm's law states that the voltage across a resistance is directly proportional to the current flowing through it*. Some important parameters that are used to specify resistors are the resistor's value, tolerance, and power rating. The tolerance specifications for resistors are typically 5% and 10%. The power rating for a resistor specifies the maximum power that can be dissipated by the resistor. Some typical power ratings for resistors are 0.25 W, 0.5 W, 1 W, and 2 W and so forth, up to very high values for high-power applications. Thus, in selecting a resistor for some application, one important selection criterion is the expected power dissipation.

We now need to consider Kirchhoff's laws, named after German scientist Gustav Robert Kirchhoff. These two laws are quite simple but extremely important. The first law is Kirchhoff's current law (KCL), which states that *the algebraic sum of the currents entering any node is zero*. There are alternative forms of Kirchhoff's current law that *the algebraic sum of the currents leaving a node is zero*, or that *the sum of the currents entering a node is equal to the sum of the currents leaving the node*. Kirchhoff's second law, called *Kirchhoff's voltage law* (KVL), states that *the algebraic sum of the voltages around any loop is zero*.