Electric Current

A. Electric Current

1. Mechanical Analogy

   a. As in a mechanical system, the rate of water flowing through the system has an analogous concept in the electrical circuit. The rate of flow of electrons through a conductor per unit time is called current (I).

2. Unit of Current

   a. To determine the number of electrons flowing in a given conductor per unit time, it is necessary to adopt a unit of measurement of current flow. Recall that a difference of potential (voltage) is required to create a current. If no voltage exists, electrons drift randomly, resulting in electron flow in one direction canceled by equal electron flow in the opposite direction.

3. Coulomb

   a. The coulomb (C) is a measurement of electrical charge (Q) equivalent to 6.25 x 1018 electrons. The coulomb is to electricity as the gallon is to water.

4. Ampere

   a. The term ampere is the unit of measurement used to define the rate at which current flows (electron flow). The symbol for the ampere is "A". One ampere (amp) is the flow of 6.25 x 1018 electrons (one coulomb) per second past a fixed point in a conductor. Thus, electric charge, in coulombs, moved through a circuit is equal to the product of the current in amperes, I, and the duration of flow in seconds, t. Expressed as an equation.

5. This leads to the equation for current

$$Q = It$$

$$I = \frac{Q}{t}$$

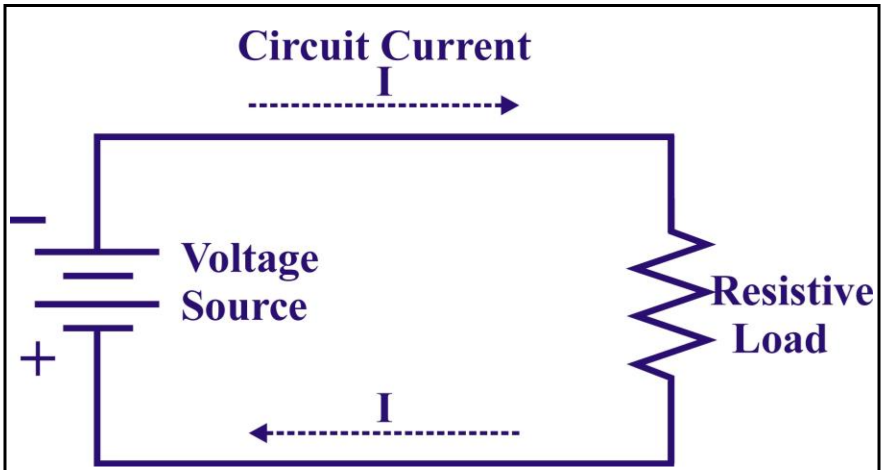
   a. Example

      1) If a current of 2 amperes flows through a circuit for 10 seconds, the quantity of electricity through the circuit is 2 x 10, or 20 coulombs. Conversely, current flow is expressed in terms of coulombs and time in seconds. Thus, if a total of 20 coulombs are moved through a circuit in 10 seconds, the average current flow is 20/10 or 2 amperes. Note that the current flow in amperes implies the rate of flow of coulombs per second without indicating either coulombs or seconds. Thus, a current flow of 2 amperes is equivalent to a rate of flow of 2 coulombs per second.

6. Direction of Current Flow

   a. Two basic methods of describing the direction of current flow are the electron flow theory and the conventional current flow theory.

   b. In the figure below, the direction of electron flow is from the negative side of the battery, through the load resistance (R), and back to the positive terminal at the voltage source. This is the direction of electron flow in the external circuit connected across the output terminals of the voltage source. This is called electron flow.



Picture 1, Direction of Electron Current Flow

c. Inside the battery, electrons move to the negative terminal. This is how the voltage source produces potential difference. Thus, electron flow in the internal circuit is from positive to negative. The battery is doing the work of separating charges, and accumulating electrons at the negative terminal and positive ions at the positive terminal. Potential difference across the two output terminals can do the work of moving electrons around the external circuit. In the circuit outside the voltage source, however, the direction of electron flow is from a point of negative potential to a point of positive potential.

d. The direction of moving positive charges, opposite from electron flow, is considered the conventional direction of current. The reason is based on the fact that, by positive definitions of force and work, positive potential is considered above a negative potential. So conventional current is a motion of positive charges (lack of electrons) "falling downhill" from a positive to a negative potential. This theory of current flow was proposed by Benjamin Franklin, and is called the conventional theory of current flow.

e. An example of positive charges moving in the direction of conventional current is hole current in P-type semiconductors. Also, a current of positive ions in liquids and gases moves in the opposite direction from electron flow. For instance, current through the electrolyte inside a battery is ion current.

f. Actually, either a positive or a negative potential of the same value can do the same amount of work in moving charges. Any circuit can be analyzed either with electron flow or by conventional current flow in the opposite direction. In this book, current is considered as electron flow in applications where electrons are the moving charges.

PRACTICE:

1 What is the measure of electrical charge?

2. What is the measure of electron flow?