# Basic Direct Current (DC) Theory

An Online Continuing Education Course for Engineers

**Course Number: E-4011**

**Credit: 4 Hours / 4 PDH / 4 CPD**

# Basic Direct Current (DC) Theory

## DC SOURCES

*When most people think of DC, they usually think of batteries. In addition to batteries, however, there are other devices that produce DC which are frequently used in modern technology.*

### Batteries

A battery consists of two or more chemical cells connected in series. The combination of materials within a battery is used for the purpose of converting chemical energy into electrical energy. To understand how a battery works, we must first discuss the chemical cell.

The chemical cell is composed of two electrodes made of different types of metal or metallic compounds which are immersed in an electrolyte solution. The chemical actions which result are complicated, and they vary with the type of material used in cell construction. Some knowledge of the basic action of a simple cell will be helpful in understanding the operation of a chemical cell in general.

In the cell, electrolyte ionizes to produce positive and negative ions (Figure 1, Part A). Simultaneously, chemical action causes the atoms within one of the electrodes to ionize.

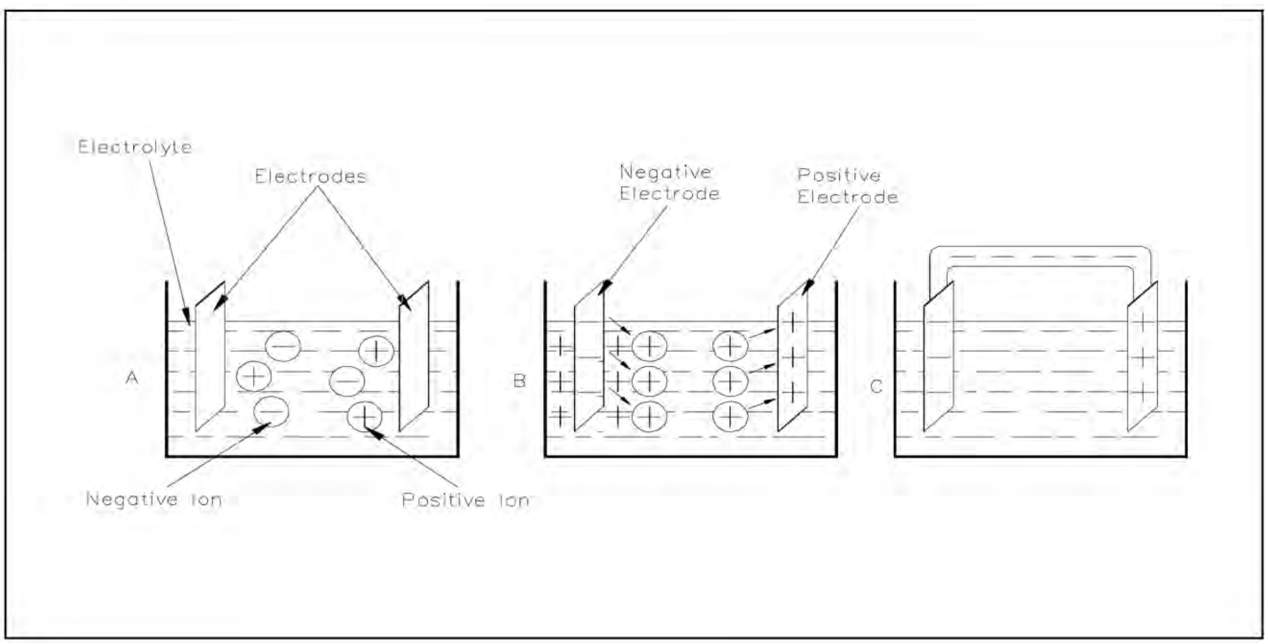


**Figure 1. Basic Chemical Battery**

Due to this action, electrons are deposited on the electrode, and positive ions from the electrode pass into the electrolyte solution (Part B). This causes a negative charge on the electrode and leaves a positive charge in the area near the electrode (Part C).

The positive ions, which were produced by ionization of the electrolyte, are repelled to the other electrode. At this electrode, these ions will combine with the electrons. Because this action causes removal of electrons from the electrode, it becomes positively charged.

## DC Generator

A simple DC generator consists of an armature coil with a single turn of wire. The armature coil cuts across the magnetic field to produce a voltage output. As long as a complete path is present, current will flow through the circuit in the direction shown by the arrows in Figure 2. In this coil position, commutator segment 1 contacts with brush 1, while commutator segment 2 is in contact with brush.

Rotating the armature one-half turn in the clockwise direction causes the contacts between the commutator segments to be reversed. Now segment 1 is contacted by brush 2, and segment 2 is in contact with brush 1.

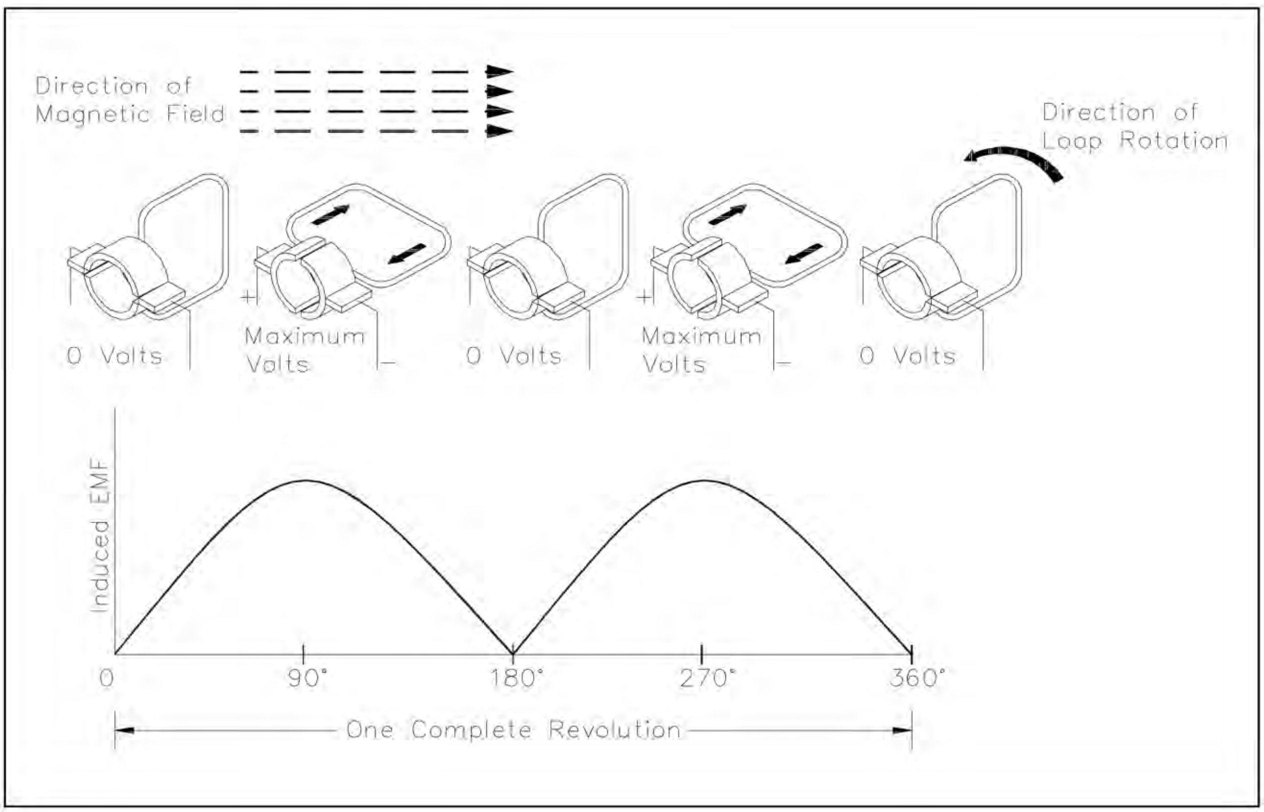


**Figure 2. Basic DC Generator**

Due to this commutator action, that side of the armature coil which is in contact with either of the brushes is always cutting the magnetic field in the same direction. Brushes 1 and 2 have a constant polarity, and pulsating DC is delivered to the load circuit.

## Thermocouples

A thermocouple is a device used to convert heat energy into a voltage output. The thermocouple consists of two different types of metal joined at a junction (Figure 3).

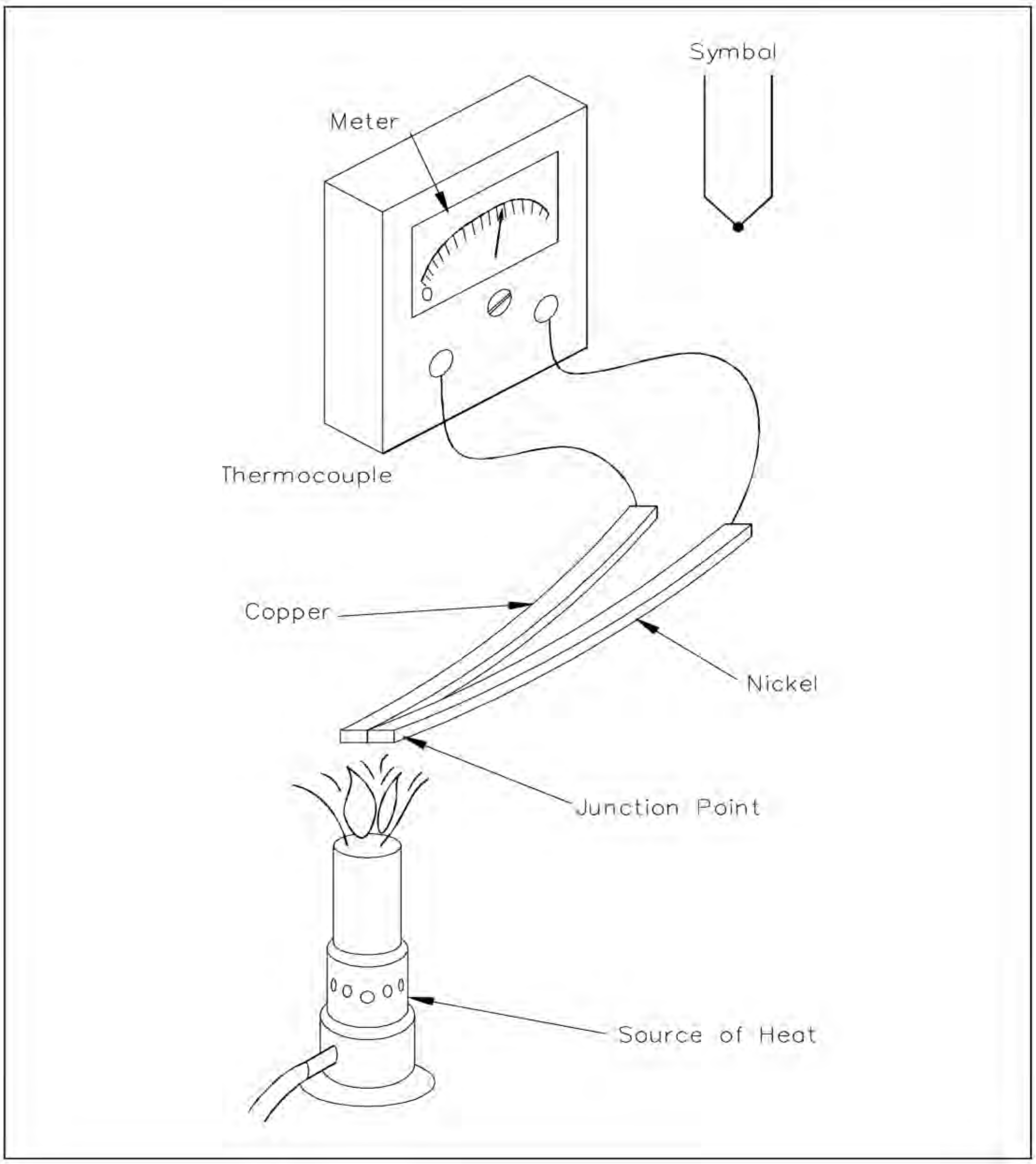


**Figure 3. Production of a DC Voltage Using a Thermocouple**

As the junction is heated, the electrons in one of the metals gain enough energy to become free electrons. The free electrons will then migrate across the junction and into the other metal. This displacement of electrons produces a voltage across the terminals of the thermocouple. The combinations used in the makeup of a thermocouple include: iron and constantan; copper and constantan; antimony and bismuth; and chromel and alumel.

Thermocouples are normally used to measure temperature. The voltage produced causes a current to flow through a meter, which is calibrated to indicate temperature.

## Rectifiers

Most electrical power generating stations produce alternating current. The major reason for generating AC is that it can be transferred over long distances with fewer losses than DC; however, many of the devices which are used today operate only, or more efficiently, with DC. For example, transistors, electron tubes, and certain electronic control devices require DC for operation. If we are to operate these devices from ordinary AC outlet receptacles, they must be equipped with rectifier units to convert AC to DC. In order to accomplish this conversion, we use diodes in rectifier circuits. The purpose of a rectifier circuit is to convert AC power to DC.

The most common type of solid state diode rectifier is made of silicon. The diode acts as a gate, which allows current to pass in one direction and blocks current in the other direction. The polarity of the applied voltage determines if the diode will conduct. The two polarities are known as forward bias and reverse bias.

## Forward Bias

A diode is forward biased when the positive terminal of a voltage source is connected to its anode, and the negative terminal is connected to the cathode (Figure 4A). The power source's positive side will tend to repel the holes in the p-type material toward the p-n junction by the negative side. A hole is a vacancy in the electron structure of a material. Holes behave as positive charges. As the holes and the electrons reach the p-n junction, some of them break through it (Figure 4B). Holes combine with electrons in the n-type material, and electrons combine with holes in the p-type material.

When a hole combines with an electron, or an electron combines with a hole near the p-n junction, an electron from an electron-pair bond in the p-type material breaks its bond and enters the positive side of the source. Simultaneously, an electron from the negative side of the source enters the n-type material (Figure 4C). This produces a flow of electrons in the circuit.

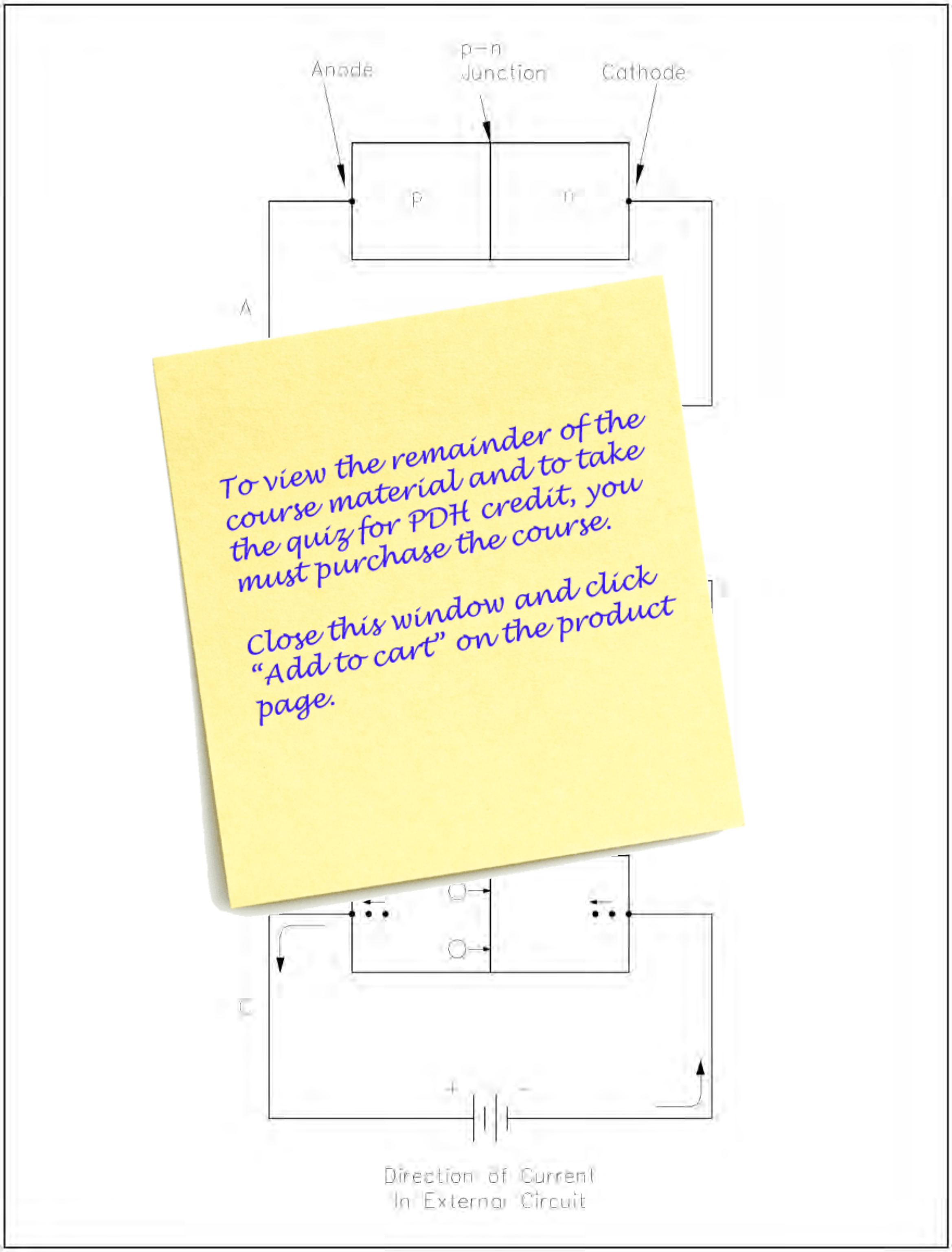


**Figure 4. Forward-Biased Diode**