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BATTERY STORAGE AND DIRECT CURRENT

Direct current (DC) is often provided by a battery source and, in some traffic applications, the battery source is recharged via solar energy. A common example of this is a solar powered flashing beacon associated with a school speed limit sign. To understand the dynamics of how such a system works, the following discussion is provided.

A solar power system is best visualized using the hydrological analogy provided in Figure 1. The battery is like a reservoir, the solar panels are like rain clouds, and the end equipment is like a sprinkler system.

In our hydrological example, water is provided to the reservoir via rain at the rate of 4 gallons/hour when it is storming, 1 gallon/hour when it is drizzling, and 0 gallons/hour when the storm stops. When the amount of rain exceeds the draw of the sprinkler system (2 gallons per hour), the level of the reservoir rises and the foot-pounds (ft-lbs) of pressure exerted by the reservoir on the sprinkler system increases. However, when the intensity of the rain is less than the draw of the sprinkler system, the level of the reservoir drops and the foot-pounds (ft-lbs) of pressure exerted by the reservoir on the sprinkler system decreases.

In the example shown, the reservoir is capable of storing 400 gallons of water and, when it is full, it exerts 120 ft-lbs of pressure on the sprinkler system. With a full reservoir there is plenty of pressure to operate the sprinkler system, which requires a minimum of 90 ft-lbs of pressure to work properly. As shown in Figure 1, a full reservoir must be drawn down by 100 gallons for the water pressure to fall to less than the required 90 ft-lbs.

It is interesting to note that, if the level of the reservoir falls so low that the amount of water pressure is less than 90 ft-lbs of pressure then the sprinkler system will quit working, even though there are 300 gallons of water left in the reservoir!

Using the above scenario, we can now describe the same situation in electrical terms (see Figure 2). Energy is provided to the battery via converted sunshine at the rate of 4 coulombs/hour (or amps) when it is sunny, 1 amp when it is cloudy, and 0 amps at night. When the amount of solar energy entering the battery exceeds the current draw of the electrical device (2 amps), the level of energy in the battery rises and its voltage (V) increases. However, when the amount of solar energy entering the battery is less than the draw of the electrical device, the level of energy in the battery drops and its voltage (V) decreases.

In the example shown, the battery is capable of storing 400 coulombs (or 400 amp-hours) of energy and, when it is full, the battery has a voltage of 12 volts. With a full battery there is plenty of voltage to operate the electrical device since, in this example, only 9 volts are required for the device to work properly. As shown in Figure 2, a full battery must be drawn down more than 100 coulombs (or amp-hours) for the voltage to fall to less than the required 9 volts.

It is interesting to note that, if the voltage of the battery falls below 9 volts then the electrical device will quit working, even though there are 300 coulombs of charge left in the battery!

Having a bigger battery will provide a greater reserve of energy and having more solar cells will charge the battery faster, both of which will reduce the probability of the voltage in the battery falling to unacceptably low levels. In addition, using end equipment that draws less current and operates on a lower voltage further reduces the probability of encountering power problems. However, even with a large battery, a large solar array, and low-power end equipment, there is still a chance that a long run of cloudy days could cause a problem.

Keeping the above discussion in mind, we can ask the right questions when selecting components for a battery-operated system:

- When selecting a battery, the total charge that the battery can hold (400 amp-hours in our example) is of little interest. What is of more interest is the amount of charge that the battery can supply before it reaches a specified "terminal" voltage (100 amp-hours for a terminal voltage of 9 volts in our example). Carefully read the manufacturer's literature to determine these values.

- When evaluating electrical devices we are not only concerned with how much current they draw but we are also concerned with the lowest voltage at which they will successfully operate. Although 2 devices may have the same current draw, if one of the devices can operate successfully down to 8 volts instead of 9 volts, then it can be powered longer by the same battery. In our example 100 amp-hours were available down to a terminal voltage of 9 volts, but more charge would have been available (let's say, 20 more amp-hours) if the electrical device would have worked on only 8 volts. Again, carefully read the manufacturer's literature.

The above discussion is equally valid for a non-solar powered system. Batteries that are charged by AC power, or regular dry-cell batteries that are not charged at all but are simply replaced when they lose charge and their voltage becomes so low that they can no longer power the end use device, follow the same basic principles of operation.