How Capacitors Work

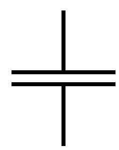
In a way, a capacitor is a little like a battery. Although they work in completely different ways, capacitors and batteries both **store electrical energy**. If you have read How Batteries Work, then you know that a battery has two terminals. Inside the battery, chemical reactions produce electrons on one terminal and absorb electrons at the other terminal.

A capacitor is a much simpler device, and it cannot produce new electrons -- it only stores them. In this article, you'll learn exactly what a capacitor is and how it's used in electronics.

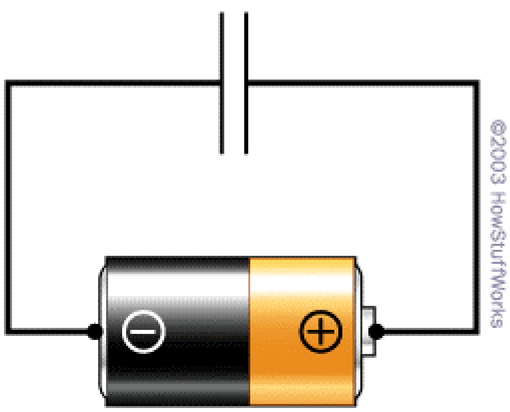
The Basics

Like a battery, a capacitor has two terminals. Inside the capacitor, the terminals connect to two metal **plates** separated by a **dielectric**. The dielectric can be air, paper, plastic or anything else that does not conduct electricity and keeps the plates from touching each other. You can easily make a capacitor from two pieces of aluminum foil and a piece of paper. It won't be a particularly good capacitor in terms of its storage capacity, but it will work.

In an **electronic circuit**, a capacitor is shown like this:

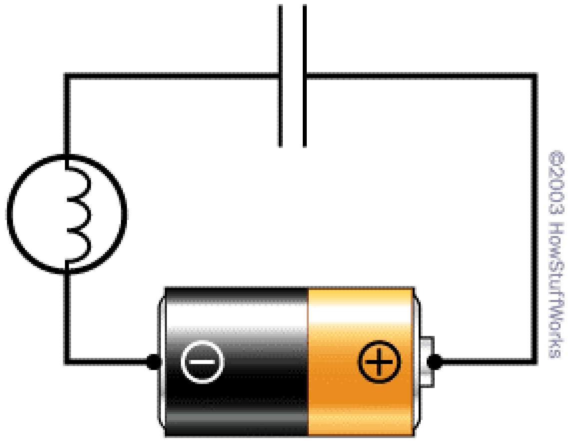


When you **connect a capacitor to a battery**, here's what happens:



- The plate on the capacitor that attaches to the negative terminal of the battery accepts electrons that the battery is producing.
- The plate on the capacitor that attaches to the positive terminal of the battery loses electrons to the battery.

Once it's charged, the capacitor has the same voltage as the battery (1.5 volts on the battery means 1.5 volts on the capacitor). For a small capacitor, the capacity is small. But large capacitors can hold quite a bit of charge. You can find capacitors as big as soda cans, for example that hold enough charge to light a flashlight bulb for a minute or more. When you see lightning in the sky, what you are seeing is a huge capacitor where one plate is the cloud and the other plate is the ground, and the lightning is the charge releasing between these two "plates." Obviously, in a capacitor that large, you can hold a huge amount of charge! Let's say you hook up a capacitor like this:



Here you have a battery, a light bulb and a capacitor. If the capacitor is pretty big, what you would notice is that, when you connected the battery, the light bulb would light up as current flows from the battery to the capacitor to charge it up. The bulb would get progressively dimmer and finally go out once the capacitor reached its capacity. Then you could remove the battery and replace it with a wire. Current would flow from one plate of the capacitor to the other. The light bulb would light and then get dimmer and dimmer; finally going out once the capacitor had completely discharged (the same number of electrons on both plates).

Like a Water Tower

One way to visualize the action of a capacitor is to imagine it as a water tower hooked to a pipe. A water tower "stores" water pressure -- when the water system pumps produce more water than a town needs, the excess is stored in the water tower. Then, at times of high demand, the excess water flows out of the tower to keep the pressure up. A capacitor stores electrons in the same way, and can then release them later.

Farad

The unit of capacitance is a **farad**. A 1-farad capacitor can store one coulomb (coo-Lomb) of charge at 1 volt. A coulomb is 6.25e18 (6.25 * 10^18, or 6.25 billion billion) electrons. One **amp** represents a rate of electron flow of 1 coulomb of electrons per second, so a 1-farad capacitor can hold 1 amp-second of electrons at 1 volt.

A 1-farad capacitor would typically be pretty big. It might be as big as a can of tuna or a 1-liter soda bottle, depending on the voltage it can handle. So you typically see capacitors measured in microfarads (millionths of a farad).

To get some perspective on how big a farad is, think about this:

- A typical alkaline AA battery holds about 2.8 amp-hours.
- That means that a AA battery can produce 2.8 amps for an hour at 1.5 volts (about 4.2 watt-hours -- a AA battery can light a 4-watt bulb for a little more than an hour).
- Let's call it 1 volt to make the math easier. To store one AA battery's energy in a capacitor, you would need 3,600 * 2.8 = 10,080 farads to hold it, because an amp-hour is 3,600 amp-seconds.

If it takes something the size of a can of tuna to hold a farad, then 10,080 farads is going to take up a LOT more space than a single AA battery! Obviously, it is impractical to use capacitors to store any significant amount of power unless you do it at a high voltage.

Applications

The difference between a capacitor and a battery is that a capacitor can dump its entire charge in a tiny fraction of a second, where a battery would take minutes to completely discharge itself. That's why the electronic flash on a camera uses a capacitor -- the battery charges up the flash's capacitor over several seconds, and then the capacitor dumps the full charge into the flash tube almost instantly. This can make a large, charged capacitor extremely dangerous -- flash units and TVs have warnings about opening them up for this reason. They contain big capacitors that can, potentially, kill you with the charge they contain.

Capacitors are used in several different ways in electronic circuits:

- Sometimes, capacitors are used to **store charge for high-speed use**. That's what a flash does. Big lasers use this technique as well to get very bright, instantaneous flashes.
- Capacitors can also **eliminate ripples**. If a line carrying DC voltage has ripples or spikes in it, a big capacitor can even out the voltage by absorbing the peaks and filling in the valleys.
- A capacitor can **block DC voltage**. If you hook a small capacitor to a battery, then no current will flow between the poles of the battery once the capacitor charges (which is instantaneous if the capacitor is small). However, any alternating current (AC) signal flows through a capacitor unimpeded. That's because the capacitor will charge and discharge as the alternating current fluctuates, making it appear that the alternating current is flowing.