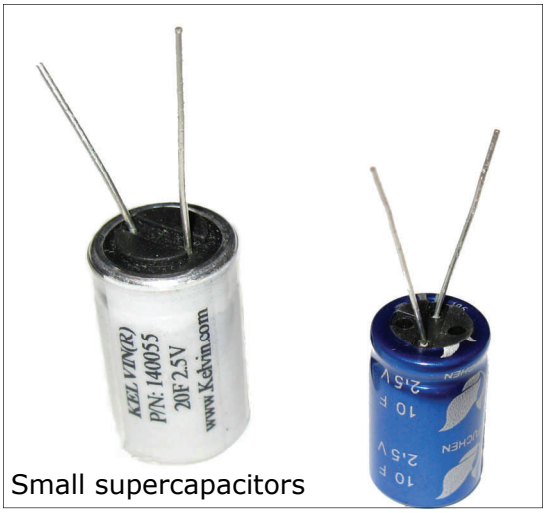
The Kidwind Project:
Using Mini-Supercapacitors to Store Energy



Small supercapacitors

A *capacitor* is similar to a battery because it can store and release electrical energy. But the way that capacitors work is very different from the way batteries work.

Batteries are charged by chemical reactions. Every battery has two terminals. The chemical reactions inside the battery produce electrons on one terminal and absorb electrons on the other terminal. The chemical reaction is reversed to deliver the energy of a battery.

A capacitor does not use chemical reactions at all. Instead, the two terminals connect to two metal plates inside the capacitor. These plates are separated by a non-conductive material, which is called a "*dielectric*." So, when you charge a capacitor (using electricity from wind turbines, solar panels, or batteries) the plate connected to the negative terminal is accepting all of the electrons produced by the source of the electricity (i.e. the battery). At the same time, the plate attached to the positive terminal is losing all of its electrons. The charged capacitor has a concentration of electrons (a charge) on the surface of the negative plate. This charge separation creates a potential (voltage!) between the two plates, which can be used in an external circuit.

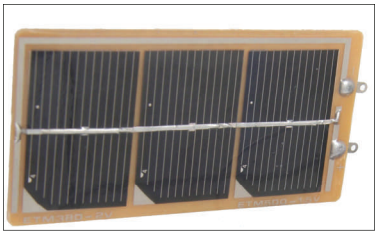
Supercapacitors (also called "ultracapacitors") are different from normal capacitors because they are able to hold a much greater charge. Therefore, the potential is greater, and the total energy stored can be much higher.

Chemical reactions can take some time, but releasing the energy stored in capacitors can be done very fast. For this reason, capacitors are able to release an enormous amount of power in a very short time. However, batteries can release steady voltage for a longer period of time, while most small supercapacitors only store enough energy for a few minutes of voltage.

Larger supercapacitors are used in hybrid-electric vehicles. They are charged when the vehicles brake, and discharged to enhance acceleration.

Charging a Supercapacitor

You can use a renewable energy!

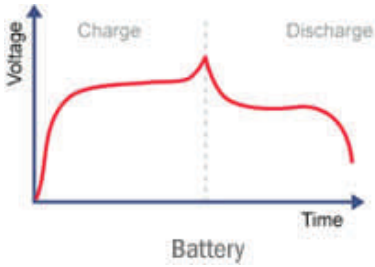


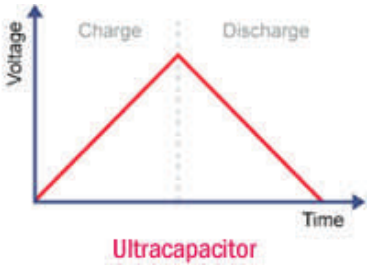
Charging a supercapacitor with renewable energy is very easy, but there are some important steps to follow. Supercapacitors are *polarized*, which means that they have positive and negative terminals. Because of this, you have to properly connect your electricity source (wind turbine, solar cell, etc.) to the supercapacitor. Sometimes the terminals are marked with (+) and (-) signs, but you can always be sure that the longer lead from the supercapacitor is the positive terminal.

To determine the proper polarity of your turbine or solar cell, you will need to connect it to a multimeter. Make sure the wires from the multimeter are correctly installed as shown in the picture (black wire goes in COM port). If your voltage reading is positive, the lead connected to the **red** multimeter wire comes from the positive terminal. If the voltage reading is negative, the lead connected to the **red** multimeter wire comes from the negative terminal. It is a good idea to mark your wires with tape so you know which is positive and which is negative.

The positive lead from your wind turbine, solar cell, or battery should be attached to the long (+) lead on the supercapacitor. The negative lead corresponds to the short (-) lead on the supercapacitor.

If you are sure you have the correct polarity, you can start to pump some energy into the supercapacitor! Turn the fan on to start your turbine or shine some light on your solar panel. Then wait about 1 1/2—2 minutes. After this time the supercapacitor should be charged up pretty well. Now you can use this stored energy to power small electrical gadgets!





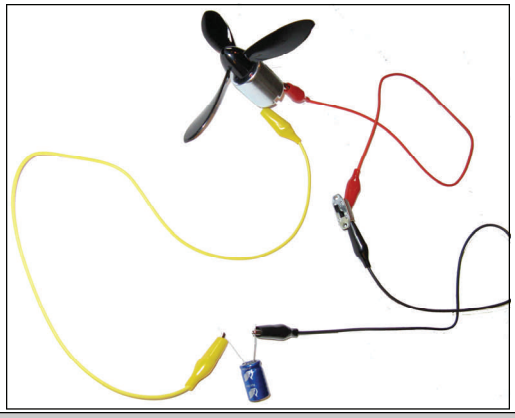
Experiments and Activities with Supercapacitors

Although these are relatively small supercapacitors with low overall power, they can still do a good amount of work after you charge them up!

With the supercapacitor charged up, it will start powering devices as soon as you complete a circuit. Remember that LED and incandescent bulbs are also polarized, so you might have to switch the leads before you can get them to light up.

What Can Kidwind Super-Capacitors Power???

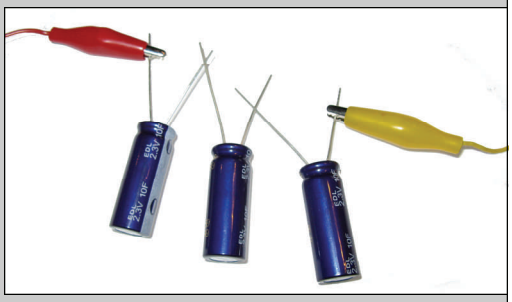
- Light LED bulbs
- Light incandescent bulbs
- Pump water (with KidWind low-voltage water pump)
- Drive motors
  - Cars
  - Boats
  - Planes/props
- Other?



You can also put a switch into your circuit. This will allow you to turn your electrical devices on and off by connecting and disconnecting the circuit. You should connect the supercapacitor, switch, and electrical device in *series* as shown in the picture.

Other Experiments:

- **Wind Turbine Blade testing**: Set a time limit (try 2 minutes), and charge a supercapacitor using one set of blades. Then discharge the capacitor with some kind of load—pump water, run a propeller, or light a bulb. Time how long the charge lasts. The longer you run devices with the capacitor, the more power you have produced with your wind turbine. Then try another set of blades, keeping all other variables constant. Which blades were better?

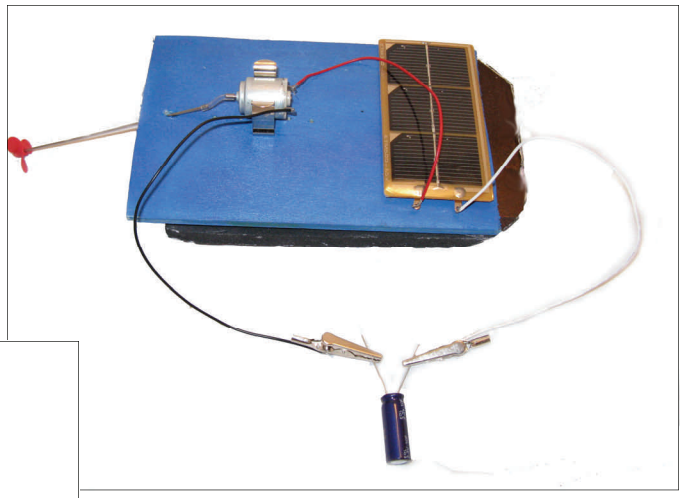


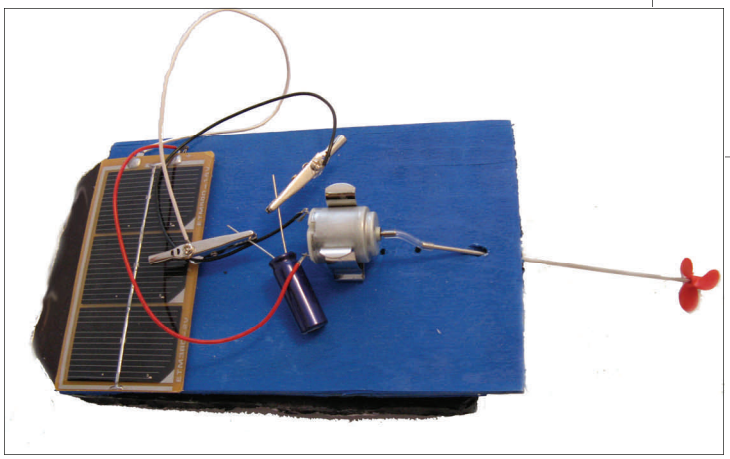
- **Connect Multiple Supercapacitors**: What happens when you power a device using the power of more than one capacitor? Remember—always connect leads positive to negative. Can you pump more water? Light more bulbs?

- **Series vs. Parallel**: Try connecting the supercapacitor in a parallel circuit instead of in series. Does this change the output? This gets more interesting if you are using multiple supercapacitors.

Supercapacitors and Solar Boats:

It is a really cool idea to connect a supercapacitor to your solar boat setup. That way, if the sun goes behind the cloud for a minute or two, you can use the stored energy from the supercapacitor to keep your boat zooming along until the sun shines again!

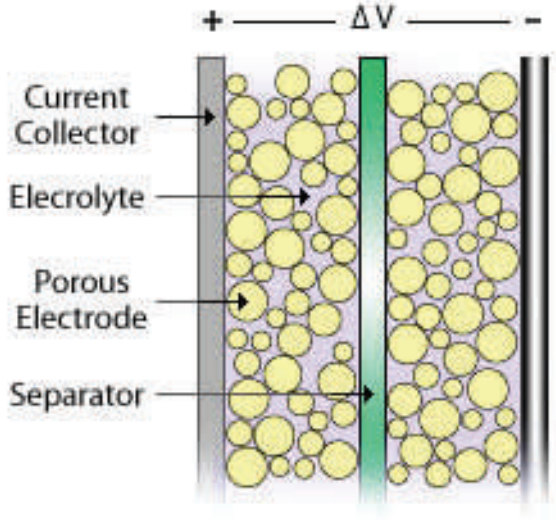




Just connect the supercapacitor in series between the solar panel and the electric motor on your boat (make sure you've connected the right leads). When the panel activates in the sun, part of the electricity created will trickle into the supercapacitor, and part will go straight to your electric motor. You may find that the motor does not spin quite as fast while the supercapacitor is charging up. Though it might slow you down at first, this could really pay off later if the sun hides!

Don't get stuck out of luck when the sun hides behind a cloud! Use a supercapacitor to store extra energy!

More Information About Supercapacitors



An ultracapacitor can be viewed as two nonreactive porous plates, or collectors, suspended within an electrolyte, with a voltage potential applied across the collectors. In an individual ultracapacitor cell, the applied potential on the positive electrode attracts the negative ions in the electrolyte, while the potential on the negative electrode attracts the positive ions. A dielectric separator between the two electrodes prevents the charge from moving between the two electrodes. (NREL)

Supercapacitors:

- Can be charged and discharged almost an unlimited number of times
- Can discharge in matters of milliseconds or as long as tens of seconds or several minutes
- Can be charged in seconds to minutes
- High power density
- Do not release any thermal heat during discharge
- There is no danger of overcharging; when fully charged the ultracapacitor simply quits accepting a charge
- Are not affected by deep discharges as are chemical batteries
- Have a long lifetime, which reduces maintenance costs; anecdotal evidence suggests that they lose about 80% of their storage capacity after 10 years, with a lifetime estimated to be 20 years
- The DC-DC round-trip efficiency is 80%-95% in most applications
- Operating temperature range as great as between -50C and 85C, capacity increases as temperature decreases below the rating temperature
- They do not release any hazardous substances that can damage the en-

What is Capacitance?

Capacitance is a measure of the amount of electric charge stored for a given electric potential. If the charges on the two plates are +Q and –Q, and V gives the voltage difference between the plates, then the capacitance is given by:

$$C = \frac{Q}{V}$$