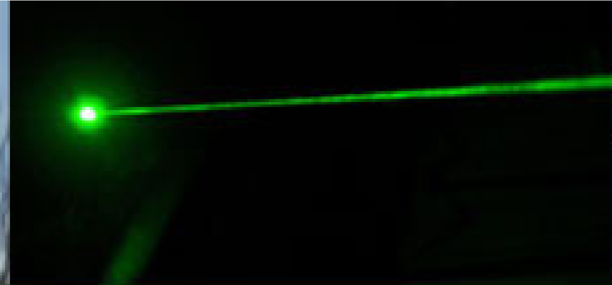
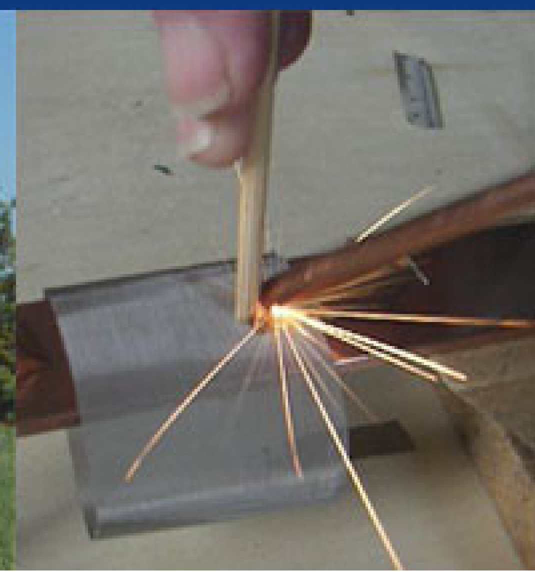




SOLAR SUPERCAPACITOR APPLICATIONS

by Phillip Hurley





Solar Supercapacitor Applications

by Phillip Hurley

ISBN-10: 0-9710125-8-X

ISBN-13: 978-0-9710125-8-5

Wheelock Mountain Publications
is an imprint of
Good Idea Creative Services
Wheelock VT
USA

How to use this e-book

View

If you wish to use “full screen view”, hit the keys “control-L” (Windows) or “command-L” (Mac). To return to your normal desk-top view, hit the “esc” key.

If a watermark is visible when viewing the pages on screen, be sure that you are viewing the e-book with Adobe Acrobat 6.0 or newer, and not a different PDF reader such as Preview for Mac OSX. If the watermark is very dark when pages are printed, try adjusting your printer settings to a different resolution, or color instead of black and white.

Text links

Click on maroon colored text to go to a link within the e-book.

Click on **blue colored text** to go to an external link on the internet. The link will automatically open your browser. You must be connected to the internet to view the externally linked pages.

Buttons

The **TOC** button will take you to the first page of the Table of Contents.

The left pointing triangle will take you to the previous page.
The right pointing triangle will take you to the next page.

Table of Contents

Table of contents continued on the next page

Table of contents continued on the next page

Table of contents, continued

Modified biomass camping stove

Solar supercap powered wireless rocket ignition system

Supercaps and the home PV system

Table of contents continued on the next page

TOC

Table of contents, continued

Solar supercapacitor power supplies

Supercapacitor basics

Supercapacitors, also known as ultracapacitors, are similar to conventional capacitors in that they are energy storage devices. They store energy in an electric field during charging from a direct current (DC) power source such as a PV panel. However, they differ from conventional capacitors in that they have much higher capacitance capabilities.

Capacitance is defined in terms of charge storage and is designated in units called farads. Charge storage is affected by three basic factors in a capacitor. These are plate/electrode area, plate/electrode spacing, and the dielectric material used for separators. “Super” or “ultra” capacitance is attained, for the most part, by using electrode materials with much larger surface area per volume than conventional capacitors, although electrode spacing and separator material also play a role.

Technically, supercapacitors are known as electrochemical double layer capacitors, or EDLCs. The electric double layer differs from a conventional capacitor in that the dielectric is nanometers thin, which also contributes to creating high capacitance. The nature of the structure of the double layer, however, limits the voltage to 2.5 or 2.7 volts. At higher voltages the electric double layer breaks down, causing capacitor failure. At the present time researchers are working to resolve the voltage limitation barrier.

In summary, electrochemical double layer supercapacitors consist of porous, high surface area positive and negative electrodes, a nanometers thin separator with all three being immersed in a liquid electrolyte which is usually composed of acetonitrile and ionic salts. The materials which give supercapacitor electrodes their unique capabilities are currently either carbon aerogels, activated carbon, carbon nanotubes, or conductive polymers with extremely high surface area characteristics.

Supercapacitors vs batteries

In comparison with batteries, supercapacitors have lower energy densities but their power density is greater. Power density is a combination of the energy density and the speed that the energy can be drawn out of the battery or supercapacitor.

Batteries have much slower charge and discharge times. Supercapacitors have a time constant of between one and two seconds. This means that you can charge a supercapacitor to 63.5% of its capacity in 1-2 seconds. A capacitor is considered fully charged after five time constants. Thus, you can fully charge a supercapacitor within five to ten seconds, and fully discharge a capacitor within the same amount of time if that is what you want to do.

Supercapacitor charge and discharge times are only limited by the heating of the electrodes, whereas batteries depend on the slower movement of charge carriers in the electrolyte. That being said, supercapacitors lose voltage quickly while in use, whereas batteries will maintain voltage for a longer period of time. Unlike batteries, supercapacitors can be totally discharged to 0 volts with no harm.

Supercapacitors also have much better temperature tolerance than batteries and will operate well from -40°C to +65°C.

Supercapacitors have a much longer life cycle than batteries. Life cycles vary by brand from 100,000 to 1,000,000 cycles of charge and discharge.

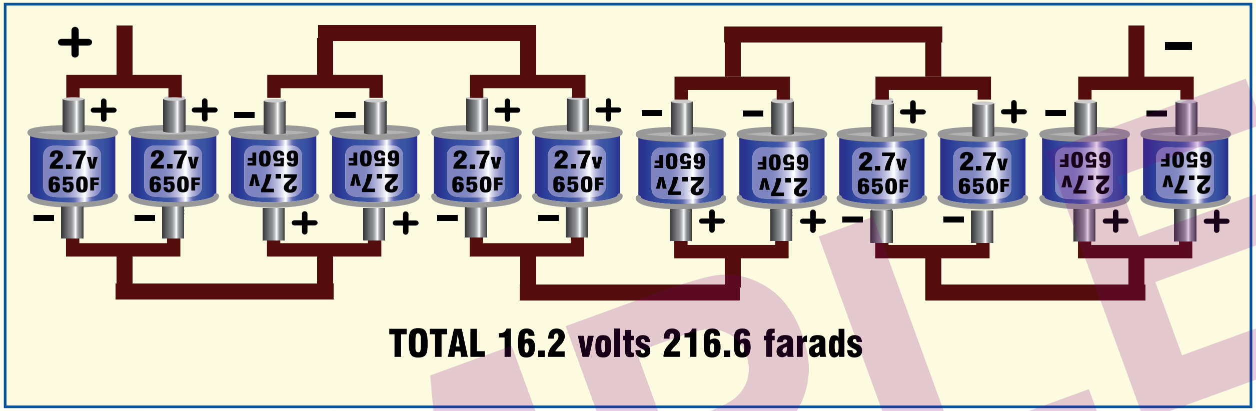
TOC

Suitable applications

Basically supercapacitors are best suited for short duration, pulse power, or longer duration, low current draw situations.

Devices that can operate within a wide voltage range are best suited to being powered by supercapacitors. For instance, a 2.5 volt supercapacitor will be able to provide about 75% of its stored energy if the load can operate in a voltage range of 2.5 volts to 1.5 volts.

Design options are available to suit most power needs. In most instances, the photovoltaic panels are always connected to the supercapacitors and constantly charging during daylight conditions. In this manner a more or less steady application of voltage and current can be maintained. For nocturnal applications, the supercapacitor bank has to be designed with enough capacitance to meet power requirements until daylight. Beyond this, a system could be designed to integrate rechargeable batteries so that the system can ride through a number of limiting conditions.



Parallel connected pairs of supercapacitors connected in series

For some applications this loss of capacitance is not of importance. However, for other applications, more capacitance may be required at these higher voltages. In that case you can use a parallel series arrangement which connects two or more cells in parallel and then connects these parallel connected capacitors to a similar parallel connected string in series. For example, if you connected twelve 650 farad, 2.7 volt supercapacitors in parallel-series as in the illustration, you would get 16.2 volts, at around 216.6 farad capacity.

You can, of course add more capacitors in your parallel string to augment capacity but it begins to get expensive. There are other less expensive ways to increase voltage using DC to DC converters with a parallel string.

TOC

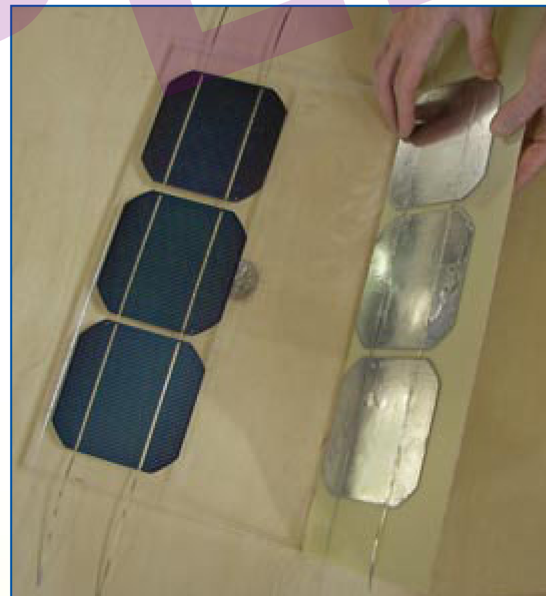
Supercapacitors are presently available in two voltage ratings, 2.5, and 2.7 volts per cell. A bank of six series connected 2.5 volt supercapacitors will give you a total voltage of 15 volts. A bank of six series connected 2.7 volt supercapacitors will give you a total voltage of 16.2 volts. At first glance it would seem that you need to use the 2.7 volt bank at 16.2 volts to cover the 15.5 volts needed for the system. This would be a good choice; however, you can also use the 2.5 volt supercapacitors as they have a overcharge margin of about .1 per cell. This would allow you about 15.6 volts for charging. This is just within the range of general charging and equalization voltage needed.

Parallel connected
2.0 volt hybrid system

To prepare to connect the cells, align three cells in a straight row with 1/8" space between the cells. You can draw a template to align the cells.

To solder the cells together, lay three of them face (negative) side down, on the template. One of the cells with extra leads should be included in each group of three cells.

When the cells are lined up, roll the soldering iron over the tabs to join the cells. Use a flat square wooden stick to hold the tab ribbon in place while soldering, but do not apply too much pressure because the cells can easily crack.



TOC

Universal solar supercapacitor power supply

As an experimenter, I need a power supply that is flexible and portable. Sometimes I need AC and sometimes I need DC electricity. Sometimes I need high voltage, sometimes I need a specific low voltage. Sometimes I need the equipment in the laboratory and sometimes I need it in the field.

Of course everything has its limitations, but I have found that a dual 2.5 volt/15 volt solar supercapacitor supply with a few attachments is quite useful for a variety of situations and applications. The supply is simple in that it contains one parallel connected supercapacitor bank, and one series connected supercapacitor bank. The 15 volt bank is charged by a 12 volt system PV panel and the 2.5 volt bank is powered by a 2.5 volt system panel. The power supply can be used while connected to the panels, or disconnected from the panels when the supercapacitors are charged up.

Always turn receiver off before checking for malfunctions.

This system is reliable, simple, and works quite well. We have used it for many launches. It will work forever without ever needing a battery and there is no need to string long lengths of snarly wire to and from the igniter and controller.

The system works well with Estes igniters, but other igniters can be used or made to suit your needs. They would, of course, have to be tested with the system for compatibility and tweaked.

For making igniters from Nichrome resistance wire, we have found that #30 wire works well. You can, of course, try other gauges to suit your needs.

TOC

The supercapacitor bank is slipped into the enclosure and the ring terminals connected to the positive and negative output terminals. With the integration kit you get the choice of using battery type terminals or hex nuts. We chose to use the battery type terminals for a variety of reasons but you can use either to secure your ring terminals.

The next step was to place the six screws to hold the bottom and top portions of the box securely together.

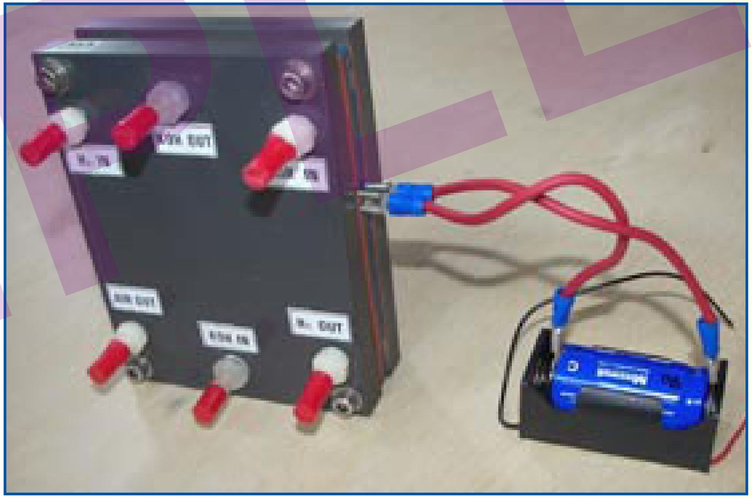
One laser experiment was a solar supercapacitor setup for distance ignition of black powder. Black powder has an ignition temperature of around 630°F, depending on the exact composition of the powder. We tested the ignition capability of a 200 milliwatt red diode laser set in the V block and powered by a solar supercapacitor supply with an attached Recoton. The ignition photos are time lapse taken from video. The distance was about 16 feet from the laser head.

A good source for information about building and using high voltage power supplies is Gordon McComb's book *Gadgeteers Goldmine*. There are plenty of plans and information about high voltage supplies to be found on the internet. High voltage supplies are available from **Fair Radio Sales**, **Surplus Sales Of Nebraska**, **Information Unlimited**, **Science First**, **Ramsey Electronics** and many others.

Solar hydrogen fuel cell systems

Supercapacitors can be used in parallel connection with electrolyzers and/or fuel cells to aid in a smoother delivery of either gas output or voltage generated from the fuel cells.

Solar powered electrolyzers reduce output with quickly changing cloud transits. A supercapacitor allows smoother, more consistent gas production.



Supercapacitor connected in parallel with fuel cell

Coupled in parallel with fuel cells, supercapacitors provide a buffer for a fuel cell or fuel cell bank when current surges are needed to start electromagnetic devices such as motors.

Other e-book titles available from

Wheelock Mountain Publications:

Build Your Own Solar Panel by Phillip Hurley

Solar II by Phillip Hurley

Build a Solar Hydrogen Fuel Cell System by Phillip Hurley

Practical Hydrogen Systems by Phillip Hurley

Build Your Own Fuel Cells by Phillip Hurley

The Battery Builder's Guide by Phillip Hurley

Solar Hydrogen Chronicles edited by Walt Pyle

Tesla: the Lost Inventions by George Trinkaus

Tesla Coil by George Trinkaus

Radio Tesla by George Trinkaus

TOC

Wheelock Mountain Publications
is an imprint of

Good Idea Creative Services
324 Minister Hill Road
Wheelock VT 05851