# New ultracapacitor delivers a jolt of energy at a constant voltage

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Chemical batteries power many different mobile electronic devices, but repeated charging and discharging cycles can wear them out. An alternative energy storage device called an ultracapacitor can be recharged hundreds of thousands of times without degrading, but ultracapacitors have their own disadvantages, including a voltage output that drops precipitously as the device is discharged. Now a researcher from the University of West Florida has designed an ultracapacitor that maintains a near steady voltage. The novel constant-voltage design, which may one day help ultracapacitors find new uses in low-voltage electric vehicle circuits and handheld electronics, is described in the American Institute of Physics' *Journal of Renewable and Sustainable Energy*.

Standard capacitors store energy in an electric field created when opposite electrical charges collect on two plates separated by a thin insulating material. In ultracapacitors the surface area of the plates is increased with a coating of porous activated carbon, which is packed with tiny holes and cracks that can capture charged particles. The space between the plates is filled with an electrolyte solution containing positive and negative ions. As charge accumulates on the plates, they attract ions, creating a double-layer of stored energy.

In both standard capacitors and ultracapacitors, the voltage drops as the stored charge is released. Most electronic devices, however, require constant voltage to operate. An electronic circuit called a DC-DC converter can change the dropping voltage of the capacitor into a constant voltage output, but the converters experience problems below one volt.

"A significant portion of the energy of the ultracapacitor is held below one volt," notes Ezzat Bakhoum, a professor of electrical engineering at the University of West Florida. "Operation in that region is very difficult because the DC-DC converter cannot function at such low voltage. Applications where the use of an ultracapacitor is precluded because of this problem include low-voltage systems in electric vehicles, hand-held power tools, toys, and cameras, just to name a few."

So Bakhoum has designed an ultracapacitor that maintains a near-constant voltage without a DC-DC converter. The ultracapacitor is fitted with an electromechanical system that can slowly lift the core of the device out of the electrolyte solution as the stored charged is released. As the electrolyte drains away, the device can hold less charge, thus lowering, its capacitance. Since the voltage of the capacitor is related to the ratio of the stored charge to the capacitance, the system maintains a steady voltage as charge is siphoned off.

Bakhoum built and tested a prototype of the new ultracapacitor. After attaching a 35-watt load to the device, he found he could successfully program the voltage to stay within a 4.9 to 4.6 volt range. Testing also showed that the constant-voltage mechanism operates with a 99 percent efficiency or higher. The lifetime of the electromechanical motor is expected to be about the same as the lifetime of the ultracapacitor's core, Bakhoum writes.

"The ultracapacitor is a wonderful new energy storage device that has many advantages by comparison with batteries," says Bakhoum. In addition to their near limitless ability to be recharged, ultracapacitors can release a jolt of energy much more quickly than batteries. One current disadvantage of commercially available ultracapacitors, that they store only a fraction of the energy per unit mass that batteries store, is a challenge that is still being researched. Some groups have experimented, for example, with changing the structure of the electrode to increase surface area, and thus the amount of charge that can be stored.

For Bakhoum, future research steps include modifying the design of the constant-voltage ultracapacitor system so that it can be installed at any angle. He may also explore whether the same type of constant-voltage approach is suitable for new, high-energy-density ultracapacitors.

**More information:** "Constant Voltage Ultracapacitor" *Journal of Renewable and Sustainable Energy*, jrse.aip.org/resource/1/jrsebh/v4/i3/p033116_s1

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