Ultracapacitors

Like the name implies, an ultracapacitors functions much like a standard capacitor only with much higher capacitance that in effect offers numerous advantages over its conventional counterparts. In both ultracapacitors and electrolytic capacitors, an applied charge creates an electric field within the device (between plates in the case of traditional capacitors) and energy is stored within that field. Capacitance measures the ability of a capacitor to store a charge, the magnitude of which is proportional to the area of the plates and inversely so to the distance between them. Electrolytic capacitors are designed in a layered fashion with the electrodes and dielectric forming a “sandwich.” Ultracapacitors contain innovations that increase the surface area within the capacitor and reduce the distance between the charges. These factors dramatically increase the capacitance, with available devices measured at up to 5000 farads.

Researchers at Standard Oil in 1966 coated electrodes with etched carbon, greatly increasing the surface area of the electrodes. The use of the porous carbon also reduced the distance between the charges, to “about 0.3 to 0.5 nm, instead of 10 to 100 nm in [electrolytic capacitors].” At the time, standard capacitors had a capacitance much less than one farad, but the ultracapacitor design resulted in a multifarad device. However this activated carbon design does have limits as far as the electrical potential and new research into the use of carbon nanotubes offers higher voltage and power supply.

Ultracapacitors are often compared to batteries and although it is in this capacity that ultracapacitors have probably the most significant applications, there are substantial differences between the two. Conventional batteries are driven by relatively slow electrochemical reactions while ultracapacitors are quickly charged from an external source. Batteries discharge slowly at a more or less steady voltage while ultracapacitors discharge rapidly with an exponential drop in voltage; and unlike batteries with a limit of hundreds or thousands of charge cycles, ultracapacitors
have cycles numbering in the millions. In addition, ultracapacitors are smaller and less massive than batteries and are more reliable at lower operating temperatures. Used together, the advantages are the, “power performance of the [ultracapacitor] and the greater energy storage capability of the [battery]… [which] can extend the life of a battery, save on replacement and maintenance costs, and enable a battery to be downsized. At the same time, it can increase available energy by providing high peak power whenever necessary.”

Present and future uses for ultracapacitors include those in the areas of consumer electronics, transportation and industry. The ability to store and provide a large amount of power quickly and endure repetitive charge cycles is useful in many consumer level electronics such as digital cameras and computers. Smaller ultracapacitors can be used on vehicle climate control, steering and entertainment systems but the main application is in the drive train itself. Unlike standard rechargeable vehicle batteries, “ultracapacitors can capture and store large amounts of electrical energy (generated by braking) and release it quickly for reacceleration, greatly [improving] fuel efficiency under stop-and-go urban driving conditions.” Ultracapacitors alone cannot power a vehicle yet, but adding them in tandem with existing vehicle batteries offers improved efficiency and lower environmental impact given their long life and smaller size. The storage capability of ultracapacitors also has use in green energy. “Electric power grids could be 10 percent more efficient if there could be simple, inexpensive ways to store energy locally at the point of use.” As the development of ultracapacitors continues, its unique characteristics will improve the delivery and function of electricity in many areas from personal devices to transportation to power distribution.
Notes

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