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## **Energy Storage System using an Ultracapacitor with a Switched Battery/Circuit with a Switch for Charging a Battery in a Battery Capacitor Circuit**

The University of Toledo is seeking a company interested in employing technology relating to combined battery/ultracapacitor energy storage systems and the battery chargers associated with these systems. These systems are especially useful for Hybrid Electric Vehicles, which require the extended storage capacity of a battery but often demand brief high current surges from their power system. This invention provides both of these elements. First, it combines an ultracapacitor with a battery to optimally power both high current surges and more constant demands. The ultracapacitor provides the high current power, thereby insulating the battery from such uses. Additionally, this technology introduces a circuit with a switch and control device to monitor the current load on the system and regulate the battery charging cycle accordingly. This allows the ultracapacitor to protect the battery even during a charging cycle while keeping a nearly full charge on the battery at all times. As a result, battery life is improved and inexpensive lead acid batteries may be used in this demanding application.

### **Application:**

Hybrid Electric Vehicles can benefit from an energy storage system consisting of an ultracapacitor combined with a battery. The ultracapacitor can deliver energy during periods of high current surge, such as engine start, acceleration, and regeneration. This allows the battery to be used only for long duration loads, optimizing its energy storage and increasing its life. A battery charging control circuit will assist such systems by allowing the ultracapacitor to work during periods of battery charging and continuously keeping the battery at near 100% charge.

### **Advantages:**

1. Battery life is increased because this circuit allows a battery to be optimized for energy storage, rather than having to respond to high current surges
2. The energy storage optimization allows inexpensive lead acid batteries to be used in systems that experience these surges, rather than costly nickel-metal-hydrate or lithium-ion batteries
3. Battery life is further increased because this circuit keeps the battery in a state of nearly full charge at all times
4. The use of an ultracapacitor provides fast, high current response to demands for engine start, acceleration, and regeneration power.

**This invention is protected by two pending patents**

## **Contact**

The University of Toledo  
Office of Research Development  
MS 1034  
3000 Arlington Avenue  
Toledo, Ohio 43614

Phone: 419-383-6963

E-mail: [stephen.snider@utoledo.edu](mailto:stephen.snider@utoledo.edu)

