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Fuzzy Logic Control of a Hybrid Energy Storage Module for Naval Pulsed Power Applications Using a Hardware-in-the-Loop Testbed

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As the Navy transitions to a more electrical fleet, the electrical architectures must adapt to the changing load profiles. With the introduction of electrical propulsion, new types of electrical energy based weapons, and energy storage backups for these devices, load profiles have become higher power and more transient than ever seen before –especially during directed energy weapon operation. One issue that has become apparent with the introduction of these transient loads is the ability of traditional generation sources, such as fossil fuel generators, to power them. Although generators are stiff sources of power, they suffer efficiency losses when they deviate from operating at a constant maximum load. Previous research has shown that it is possible to integrate hybrid energy storage modules (HESMs) in order effectively filter out the power transients seen by the generators while preserving the lifetimes of the energy storage devices used in the module. Although the topology has been verified, there still exists some concern about the method of controlling the system level power flow in order to meet the unique demands of this naval application while preserving energy storage device lifetimes. This paper proposes to utilize fuzzy logic control in order to intelligently govern the flow of power throughout the system. A small-scale testbed has been constructed using a custom designed power converter capable of bi-directional power flow between a battery and supercapacitor to feed a dynamic pulsed power load through several operational scenarios. The system utilizes a PC104 running Simulink RTOS to impose fuzzy logic control on the system. This testbed will demonstrate the effectiveness of fuzzy logic control to act as a system level controller for a HESM in naval pulsed power applications.

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