ACTIVE CONTROL OF A HYBRID FUEL CELL – BATTERY SYSTEM

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In the ongoing Solar Hydrogen Project at the Illinois Institute of Technology (IIT), Chicago, modeling and optimization of a stand-alone distributed power generation system is performed. In this project, solar energy is the main power contributor to charge a secondary battery bank and power a light emitting diode (LED) billboard sign, as well as to generate hydrogen from electrolysis to feed a fuel cell.

As part of the project, an active controller for a fuel cell – battery hybrid system was designed. The sharp changes in the fuel cell output power demand will cause severe electrochemical and thermal non-uniformities. These non-uniformities increase the degradation rate of the construction material; thus, reduce the expected life span of the fuel cell. Due to these transient response limitations of fuel cells, this hybrid system is designed in such a manner that sudden changes in the load will be absorbed by the battery, giving sufficient time for the fuel cell to respond.

To achieve the objective of this project, characteristics of fuel cells and batteries are studied individually. Fuel cell and batteries are tested for sudden changes in load to determine the time constants. This was done using data acquisition boards, specifically designed Labview program (National Instruments, Austin, TX) and an electronic load (Model HP 6060B). Collected data is used to simulate the control system. The required control logic circuitry and DC/DC converters are being built.

The proposed fuel cell – battery hybrid system is shown in Fig 1. Output power of the fuel cell is controlled by a DC/DC converter. A bi-directional DC/DC converter is used to control the output power, charging and discharging, of the battery. An optional DC/AC inverter is added, for cases when the load requires AC power.

An active control system is being simulated using Matlab/Simulink®, a sample result is shown in Fig 2. For a sudden change in load power requirement, battery responds immediately and supplies the total power. When the fuel cell slowly catches up to the load power, battery power drops down and settles down to zero. In cases when the fuel cell generates more power than required by the load, batteries will be charged using the extra power through a bi-directional converter.

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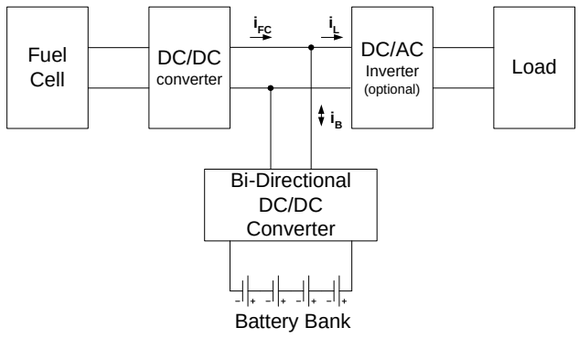

Fig 1. Block diagram of the hybrid fuel cell- battery system

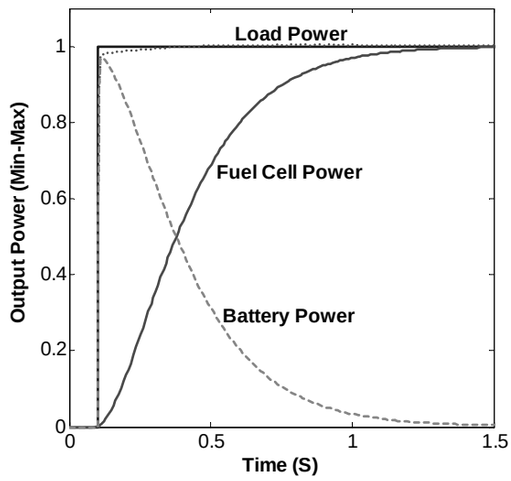

Fig 2. Simulation results of the proposed hybrid fuel cell – battery system

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