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Title: Hamiltonian-Energy Modeling and Control of Fuel Cell/Supercapacitor Hybrid Power Source for DC Microgrid Applications

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Abstract:
Rapid developments in hydrogen fuel cell (FC) hybrid energy source and DC microgrid systems have extended the applications for stabilizing DC bus voltages. The cascade architecture of a power converter in a DC microgrid may cause large oscillations and imbalance given that converters considered as loads have constant power load characteristics. In this work, output DC bus voltage stabilization and current sharing of a multiphase parallel-interleaved-FC boost converter with supercapacitive auxiliary source is presented. The proposed robust controller with added integrator action is based on the Hamiltonian–Lyapunov function. The efficacy and robustness of the designed controller were successfully authenticated by experimental results obtained using a 2.5 kW prototype FC converter and a supercapacitor bank of 160 V, 6 F (via two-phase parallel-interleaved boost converters and the dSPACE MicroLabBox platform. The main source of the FC is based on a fuel reformer engine that converts fuel methanol and water into H_2 gas in a polymer-electrolyte-membrane-FC stack (50 V, 2.5 kW). The simulation using the MATLAB/Simulink program and the experimental results validate that our proposed solution is an excellent control algorithm for highly dynamic power-load cycles.