

## **Adaptive Energy Management Strategy for Hybrid Energy Storage System Made of Battery/Supercapacitor Applied in Electric Vehicles**

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**Abstract :** The complementary feature of batteries and supercapacitors (SC) in terms of energy density and power density makes the battery-supercapacitor hybrid energy storage system (HESS) an effective energy storage solution in application scenarios requiring a high power density and high energy density as it is for electric vehicle (EV). An appropriate topology and energy management strategy (EMS) for HESS is required to coordinate the power distribution among different power sources. Currently, commercial carbon-based supercapacitors are usually applied in HESS. However, the energy density of such supercapacitors is too low. On the other hand, new types of electrochemical capacitors, like hybrid supercapacitors, were reported to have increased energy density. This could lead to an improvement in the energy efficiency of a HESS. Thus, this study aims to build an adaptive EMS for battery/supercapacitor considering these new types of capacitors to increase the performance of the system. Effects of electrochemical capacitor model parameters on efficiency are studied after obtaining the model through parameter characterization of experimental data. Also, the charging mechanism's effect on energy efficiency is studied in this project. Firstly, a rule-based EMS with the aim of considering battery as a primary energy storage system is proposed. Then, dynamic programming (DP) is used with the purpose of minimizing the energy losses in the system, thereby improving energy efficiency. The DP optimization algorithm was chosen for our work to reach optimal global results. Since this optimization method can be used to refine rule-based methods or be considered as a tool to prepare training datasets for further usage in data-based EMSs, it will be used to refine the rule-based method for our case, which is a promising solution for real-time implementation.

**Keywords :** energy management strategy, hybrid energy storage system, battery, supercapacitor

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