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# Multi-Objective Component Sizing for a Battery-Supercapacitor Power Supply Considering the Use of a Power Converter

Li Sun, Paul Walker, Kaiwu Feng, and Nong Zhang

1 *Abstract--* Owing to a lack of power density of conventional batteries, the onboard energy storage systems of an electric vehicle has  
 2 to be oversized to compensate worst-case load condition, which is sub-optimal as it induces a heavy penalty on overall system weight  
 3 and cost. One solution to overcome this limitation is to hybridize it with supercapacitors in order to boost its power performance via a  
 4 power converter. This paper presents a multi-objective optimization problem over the parameters of such hybrid energy storage  
 5 systems, with the aims to solve two conflicting objectives – cost and total stored energy in the hybrid energy storage system, under a set  
 6 of pre-defined design constraints. An algorithm is first developed to find all feasible solutions to the problem. Two popular design  
 7 examples are then tested differentiating Lithium Iron Phosphate based batteries from Lithium Manganese Oxide / Nickel-Cobalt-  
 8 Manganese based batteries. A Pareto frontier is recreated for each example and an  $\xi$ -constraint method is finally adopted to choose the  
 9 best member for comparison. This is so far, according to the authors' knowledge, the first reported multi-objective optimal sizing  
 10 method for an active hybrid energy storage system considering the effect of the power converter to gain a clearer understanding of its  
 11 impact over various design choices.

12 **Keywords—**Li-ion batteries; Supercapacitors; DC-DC converters; Load leveling; Multi-objective optimization

## 13 NOMENCLATURE

14 BP	Battery Pack
15 HCR	Hybridized Cost Ratio
16 HESS	Hybrid Energy Storage System
17 LiFePO <sub>4</sub>	Lithium Iron Phosphate
18 LMO	Lithium Manganese Oxide
19 MOOP	Multi-Objective Optimization Problem
20 NCM	Nickel-Cobalt-Manganese
21 P2W	Power-to-Weight (Ratio)
22 PC	Power Converter

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