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Voltage equalization circuit for retired batteries for energy storage applications

A.K.M. Ahasan Habib[a,b,*], Mohammad Kamrul Hasan[a,*], Shayla Islam[c,*], Musse Mohamed Ahmed[d], Azana Hafizah Mohd Aman[a], Ashish Bagwari[e], Sheroz Khan[f]

[a] *Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia (UKM), 43600 Bangi, Selangor, Malaysia*
[b] *North Garth Institute of Technology, Bangladesh*
[c] *Institute of Computer Science and Digital Innovation, UCSI University Malaysia, 56000 Kuala Lumpur, Malaysia*
[d] *Department of Electrical and Electronics Engineering, Universiti Malaysia Sarwak (UNIMAS), 94600 Kota Samarahan, Sarawak, Malaysia*
[e] *Departmental of Electronics and Communication Engineering, Women Institute of Technology (State Govt, Engineering Institution) Uttarakhand Technical University, Dehradun, Uttarakhand, India*
[f] *Onizah Engineering College, Saudi Arabia*

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Abstract

In this paper, an active equalization circuit based on resonant converter is presented. This equalization circuit has been proposed to equalize the direct cell-to-cell voltage in a string. All electrochemical energy storage devices are connected in series. Using this equalization circuit energy transfer from higher energy and charge capacitive cell to lower energy and charge cell in the string. All MOSFET switches are operated by complementary Pulse-Width Modulation (PWM) signal. The working principle of this equalization circuit like that of a switches-capacitor equalization circuit. In this circuit, a single Inductor (L) capacitor (C) energy carrier and bidirectional low voltage MOSFET switches are used so that it can recover maximum energy, reduce conduction loss, and improve the switching loss drawback, reduce the equalization time duration between two cells and achieved zero voltage gap. This equalization circuit is bidirectional and operates under the three modes, namely, charging, discharging, and relaxation mode. The proposed circuit details, the working principle, and the mathematical analyzes are presented. The simulation results are validated by the demonstration of an experimental prototype hardware testbed. The experimental results based on lithium-ion, lead–acid, and super-capacitor are presented. This equalization circuit is low cost and occupies little space with efficiencies of 96%, 94.2%, and 84.43% for Li-ion, lead–acid and super-capacitor respectively.

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Keywords: Energy storage device; Cell equalization; Active equalization; Resonant converter; Electric vehicles

* Corresponding authors.
E-mail addresses: ahasan.diu.eee@gmail.com (A.K.M.A. Habib), mkhasan@ukm.edu.my (M.K. Hasan), shayla@ucsiuniversity.edu.my (S. Islam).

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