Renewable Energy and Power Quality Journal (RE&PQJ), ISSN 2172-038 X, No.9, 12th May 2011, Reference Paper: 682

European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)	International Conference on Renewable Energies and Power Quality (ICREPQ'11) Las Palmas de Gran Canaria (Spain), 13th to 15th April, 2010

Active balancing circuit for advanced lithium-ion batteries used in photovoltaic application

J.F. Reynaud[1, 2], C. E. Carrejo[1], O. Gantet[1], P. Aloïsi[1], B. Estibals[1, 2], C. Alonso[1, 2]

[1] CNRS ; LAAS ; 7 avenue du colonel Roche, F-31077 Toulouse, France
Phone number: +0033 561336391
E-mail: jfreynau@laas.fr, cecarrej@laas.fr, ogantet@laas.fr, paloisi@laas.fr, bestibal@laas.fr, alonsoc@laas.fr

[2] Université de Toulouse ; UPS, INSA, INP, ISAE ; LAAS ; F-31077 Toulouse, France

Abstract. An approach to the analysis and design of a bidirectional DC power converter for the cell voltage balancing control of a series connected lithium-ion battery string is presented in this paper. The proposed Cell Balancing Circuit (CBC) is designed to transfer the energy from the fully charged battery cell to the weakest one using a switch mode power converter operation. This operation maintains cell batteries at the same State-Of-Charge (SOC) and voltage range. Unlike previous battery balancing circuits, the balancing method uses only one magnetic component, resulting small size system. Simulation and experimental results show that the proposed cell balancing method can not only enhance the bidirectional battery equalization performance, but can also reduce the switching loss during the equalization period. Experiment results are provided to verify the operating principle of the proposed balancing method. Specific conditions of experiments are used to reproduce photovoltaic operations.

Key words

Active balancing, Lithium-ion battery, Bidirectional micro converter, Photovoltaic.

1. Introduction

Because a single battery cell presents low nominal voltage (limited due to the active materials chemistry), battery cells are usually connected in series to be employed in many applications, such as electric vehicles (EV), hybrid electric vehicles (HEV), photovoltaic (PV) systems or telecommunication battery energy systems. Unbalanced cell voltage within a series string can be attributed to the differences in the cell's internal resistance, unbalanced State-Of-Charge (SOC) between cells, degradation and the ambient temperature gradients during charging and discharging [1]-[2]. Voltage monitoring and current diversion equalization circuits and Battery Management Systems (BMS) have been developed to prevent unbalances during charging and discharging in a series connected battery cells [3]. This repeated charge and discharge phenomenon causes a cell mismatch problem because lithium-ion batteries have inevitable differences in chemical and electrical characteristics from manufacturing, and accelerate asymmetrical cell degradation with aging [4]. The problem is that when these imbalanced batteries are left in use without any control, such as cell balancing, the energy storage capacity decreases severely, and in the worst case, there may be an explosion or fire. Lithium-ion batteries require careful management, particularly with regard to overcharge and undercharge problems. Thus, charge equalization for a series connected battery string is necessary to prevent these phenomena and extend the useful lifetime. Numerous charge balancing circuits have been presented and well summarized in [5]. They can be classified into two categories, dissipative and non-dissipative. Example of dissipative balancing method could be based on shunt resistive method. It is the simplest and cheapest cell balancing. This method could be operated continuously on each cell independently but this method presents high energy losses, which reduces the energy efficiency. Example of a non-dissipative method could be based on multiple winding transformers with advantage of being an effective low-cost equalization, but it is difficult to implement multiple windings in a single transformer [6]. In a dedicated DC converter approach, a very low voltage stress can be achieved because the use of a bidirectional DC converter, but there is a high complexity of controlling the bidirectional DC power converter [7]. Another non dissipative method could be based on a switched capacitor applied to every two adjacent cells [8]. This method can balance cells in a short time, but it requires a large number of switches, so lots of energy is dissipated in the switches and capacitor. The main contribution of