Active Cell Balancing Control Method for Series-Connected Lithium-Ion Battery

Ohirul Qays, Yonis Buswig, Martin Anyi

Abstract*: Power conveyance potentiality for series and parallel allied battery-packages are constrained by the wickedest cell of the string. Every cell contains marginally dissimilar capability and terminal voltage because of industrialized acceptances and functional situations. During charging or discharging progression, the charge status of the cell strings become imbalanced and incline to loss equalization. Therefore, the enthusiasm of this paper is to design an active charge balancing system for Lithium-ion battery pack with the help of online state of charge (SOC) estimation technique. A Battery Management System (BMS) is modeled by means of controlling the SOC of the cells to upsurge the efficacy of rechargeable batteries. The capacity of each cell is calculated by dint of SOC function estimated as a result of Backpropagation Neural Network (BPNN) algorithm through four switched DC/DC Buck-Boost converter. The simulation results confirm that the designed BMS can synchronize the cell equalization via curtailing the SOC estimation error (RMSE 1.20%) productively.

Index Terms*: Active Cell balancing, Battery Management System, Battery modeling, SOC estimation.

I. INTRODUCTION

Smart grids and Electric vehicles (EVs) are turning out to be widely held owing to the increment of atmospheric apprehensions and deficiency of fossil fuels. As a perilous condition of the energy involving machineries, battery energy storage system (BESS) performs an indispensable role to provide power source and enhance the stowage strength [1]. Nevertheless, the BESS struggles with the variation of cell-to-cell parameter inconsistencies as well as these factors affect the battery cells life-time undesirability. To fix this delinquencies, BMS is entitled as the intellect of a battery pack that can monitor the battery voltage, current, temperature, SOC et al. in an attempt to retain cells in the interior of safe operational ranges. The leading purpose of BMS is to protect the cells from over-charging or deep-discharging to lengthen the battery life cycle [2],[3]. Generally, cells which are existent in series connection with different SOC levels, limits the battery-pack efficiency during charging and discharging conditions. As demonstrated in Fig.1, cells with the highest and lowest labeled SOC becomes over-charge and deep-discharge firstly neglecting others at charging and discharging period respectively[4].

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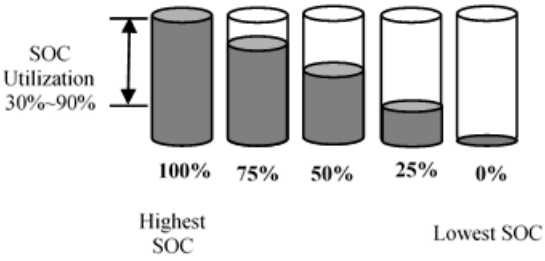

Fig. 1 Diagram of the cells with unbalanced state-of-charge.

To achieve reckless equalization efficiency for series-connected Lithium-ion batteries, Chen et al. [5] hired Multi-winding transformer to moderate the driving circuit quantities. Knap et al. [6] classified the charge equilibrium techniques into two main classifications: Passive and active charge equalization. The passive method disperses energy from overcharged cells by attaching a resistor. On the other hand, active cell balancing method agree to collect or allocate energy from higher ones to lower ones. Consequently, active charge balancing method can decline the power losses and battery cooling necessities [7],[8]. Typically, Open circuit voltage (OCV), terminal voltage and SOC are chosen as a parameter of charge equalization technique. But the instability of OCV and terminal voltage marks the system-inefficiency enormously comparing to SOC function. Furthermore, the use of SOC variable can be governed by the accuracy of SOC estimation method for every single cell. Among the SOC estimation techniques, adaptive method especially Artificial Neural Network (ANN) is the most popular and accurate method because of its self-processing characteristics [9]. BMS observes the battery condition by estimating SOC for each cell and transfers the directions via DC/DC converter according to its requirements [10],[11]. In this paper, an active cell balancing topology based on SOC estimation is accomplished standing on BPNN algorithm as well as a DC/DC buck-boost converter is engaged for each cell to observe the charge equilibrium scheme. The remainder of this paper is structured as follows: The previous related work is presented in section 2. In section 3, the proposed methodology is explained descriptively. Numerical simulation and a brief discussion for the proposed method is demonstrated in section 4. In the last section 5, the conclusion of this paper is drawn.