2022-01-1132 Published 30 Aug 2022

SAE INTERNATIONAL

# A Layered Active Balance System for Lithium-ion Power Battery Based on Auxiliary Power

Longyu Fan, Yuxi Liu, Xinwen Gao, Ronbin Yan, and Haotian Zhu Wuhan University of Technology

*Citation:* Fan, L., Liu, Y., Gao, X., Yan, R. et al., "A Layered Active Balance System for Lithium-ion Power Battery Based on Auxiliary Power," SAE Technical Paper 2022-01-1132, 2022, doi:10.4271/2022-01-1132.

Received: 13 Apr 2022 Revised: 04 Jun 2022 Accepted: 22 Jun 2022

## Abstract

In this paper, a high-efficiency and low-cost lithium-ion battery pack active balance system is designed. It adopts a distributed structure and consists of three parts: auxiliary power module, one-way isolated DC/DC conversion module, and a battery group. The battery single cells in the battery pack are layered and divided into ***m*** battery groups in total, and each battery group is composed of ***n*** battery single cells. Each battery group is connected to an isolated DC/DC conversion module, and all the conversion modules are connected in parallel with the auxiliary power. Taking the SOC average value of the all-single cells in one battery group as the balancing variable, the auxiliary power is controlled to charge the battery group with the lower SOC average value, so that the difference of the SOC average value of all battery groups is within the set threshold range, so as to realize the active balance of each battery group. For the single cells in the same battery group, by controlling the closing and opening of the bypass switch, the charging and resting of each single cell is realized, and finally the balance of the SOC of the single cells in the same group is realized.

This design adopts a layered and modular active balance topology, which is beneficial to improve the stability of the balance system and simplify the system structure. Multi-channel charging through the auxiliary power can balance multiple battery groups at the same time, reducing the loss of energy transmission and speeding up the active balance speed. Compared with the existing active balance topology, this design improves both economy and balance efficiency.

## Introduction

With the rapid development of new energy vehicles in the world, lithium-ion batteries with high energy density, long cycle life, low natural discharge rate, and no memory effect are more widely used [1]. Due to the low voltage and small capacity of lithium-ion battery single cell in electric vehicles, lithium-ion batteries work by connecting multiple cells in series and parallel to form a battery pack to meet the requirements of output voltage and capacity. The electric vehicle power battery pack is shown in Figure 1. However, lithium-ion batteries are affected by factors such as production process and raw material differences in the production process. Even if the batteries are produced in the same batch, there will be inconsistencies in voltage, capacity, SOC, and other indicators between each single cell [2]. At the same time, many complex working states and working environments will be encountered during using, and the internal and external influences on the battery will exacerbate the inconsistency between single cells [3]. The formation process of battery pack inconsistency is shown in Figure 2. The inconsistency of the battery single cells will cause the actual usable capacity to decrease, overcharge and over discharge will occur, and the battery pack life will be shortened. This will cause permanent damage to the lithium-ion battery for a long time, and even lead to the occurrence of fire, which seriously threatens the safety of electric vehicles.

**FIGURE 1** Electric vehicle battery pack

In view of the inconsistency of the battery pack, in addition to improving the process level to reduce the differences in battery single cells during the production process of the battery, it is also necessary to take corresponding balance

**TABLE 3** Charge balance record parameters

| Battery serial number | Auxiliary Power | Battery Control | Battery1 | Battery2 | Battery3 | Battery4 |
|---|---|---|---|---|---|---|
| Initial SOC | 100% | 90% | 89% | 88% | 87% | 86% |
| Final SOC | 99.45% | 90% | 89.99% | 89.99% | 89.99% | 89.99% |
| Duty cycle | | | 0.4 | 0.48 | 0.50 | 0.58 |
| Charge current | | | 3.2A | 4.9A | 7.8A | 10.0A |
| Balance time | | | 69.4s | 69.6s | 65.8s | 68.7s |

# Conclusions

In this paper, a hierarchical active charge balance system based on auxiliary power and flyback converter is designed. Taking SOC as the balance variable, the input duty cycle of the flyback converter is controlled by the SOC difference, so as to perform constant current charging for different output currents of each battery group. In this way, the high-speed adaptive balance of the SOC of each battery group is realized, and the damage to the battery is also reduced, and the service life of the battery is prolonged. Transformer charging is carried out through the flyback converter, and its electrical isolation feature improves the safety of the battery pack, and its large-scale transformation ratio provides conditions for the flexible selection of charging parameters. The high efficiency and low energy consumption of the system are confirmed by Simulink simulation, which provides a development direction for the balance management system of electric vehicle power battery pack.

The balance topology designed in this paper still has the following shortcomings:

1. The system involves a large number of MOSFET and switches, resulting in a huge control system. In the future, we will continue to study the simplification and control of the switching circuit. At the same time, we will try to design proper controllers and use a battery model with a certain parameters deviation for validation.
2. The simulation model is relatively simple, the scale and parameters of the battery pack are far from the real-life power battery pack. In the follow-up, we will consider building a physical model according to the balance topology for verification. Calculate the cost-effectiveness of this design and compare it to the advantages and disadvantages of other existing active balancing design systems.
3. Compared with the common balance topology, this design adds an auxiliary power module, which will increase the volume and weight of the balance system. The capacity, volume, and arrangement of the auxiliary power module will be further optimized in the future.

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