Maintaining a Constant Charging Duration Independent of Battery Capacity for Battery Pack by Designing a Fast DC Charger

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ABSTRACT

This article proposes a novel strategy for developing a new structure for a lithium-ion battery pack fast charger which aims to achieve fast DC charging, based on the topology of a boost converter. The proposed charger has been designed considering using fewer electronic components at lower cost. Varying initial charging percentage of the Li-ion cells has not been addressed in this article, an equal initial charging percentage of each Li-ion cell is assumed. Performance of the proposed structure of the charger has been tested using a simulation environment. This strategy has shown that this structure ensures scalability of this charger, while using the utility grid (220V, 50Hz) as a main power source for this charger has ensured practical usage flexibility. The results of this research are presented and discussed. These results have shown the outstanding performance and response of this charger.

KEYWORDS

AGV, Boost PFC converter, DC-DC converter, Electric Vehicle, Fast Charger, High voltage DC-DC converter, Li-ion batteries

INTRODUCTION

Batteries are essential components of most electrical and even mechanical devices (Maheshwari et al., 2014). The importance of batteries in equipment and devices has emerged from its core function of storing power (Yilmaz et al., 2012). The importance of this function has been demonstrated recently in the technological revolution of the early 20th century (Wang et al., 2014). Batteries have emerged as an essential element in the manufacture of most mobile devices such as mobile phones, laptops and recently modern electric cars, which first appeared in the mid-19th century (Alhelou & Golshan, 2016). Today, the batteries are divided into two main categories: non-rechargeable primary batteries and rechargeable secondary batteries (Yilmaz et al., 2012). There is a great variety of materials that make up the batteries, including acid batteries, alkaline, galvanic, aluminum ions and last but not least lithium ion batteries (Alhelou, Golshan & Askari-Marnani, 2018). Recently, Li-ion batteries have been very popular in rechargeable battery industries, because of the superior features that are unique to them (Sul, 1995). These types of batteries have a deep discharge depth of up to 100% of the total battery capacity and have a discharge cycle of between 300 and 700 cycles (Whitaker, 2014).

However, with the global trend to use these batteries in different electrical devices and equipment, the focus has been on the charging time required for batteries, the shorter this time is the more it becomes a positive factor in different areas of use and application (Fini, Yousefi & Alhelou, 2016). Less charging time of batteries is desirable by the consumer and the plant to satisfy and meet the
needs of the growing commercial and industrial market. Recently, different methods and advanced technologies have been introduced to achieve the rapid charging feature of Li-ion batteries, which is the subject of this research.

OBJECTIVE

The importance of this research is to find a way to achieve the fast charging technique of a Li-ion cell or multiple cells which have the same charging period of one cell. This method should ensure that the Li-ion cell can be charged with a specific capacity over a certain period and that multiple Li-ion cells of the same type can be charged over the same period required to charge a single cell, while ensuring that this period is as short as possible.

The aim of this research is to design a 16.6624 kW charger for a 5 kW Li-ion battery pack. The most important specification of this charger is the voltage and current regulation within the required values of the battery pack. This charger will be able to charge a set of Li-ion cells located in a special assortment of serial and serial connections. This charger ensures the proper voltage and charging current for each branch of the Li-ion group cells. Each branch contains several serially connected cells.

METHODOLOGY

The LG18650HB6 Li-ion cell with a nominal capacity of 1500mAh and a nominal voltage of 3.65 volts and a maximum charge current of 4000mA was chosen for this research Figure 1. In addition, a Boost Charging System was designed to generate electrical power from the 220V AC system. This regulator provides a continuous output voltage of 598.6 V and a maximum charging current of 28 A, and a microprocessor was used to control the charging algorithm and Monitoring and data collection.

Modeling was done using the Matlab / Simulink 2016 software package. A practical experiment was conducted for charging and discharging on a single Li-ion cell. The same experiment was performed under the same test conditions on 4 Li-ion cells connected in series, an equal duration of the charging process was achieved in both experiments.
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