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# Research of Power Battery Management System in Electric Vehicle

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***Abstract***

*Power battery management system is a very important part in electric vehicle. Currently, power battery management system is only monitor and control of the power batteries group voltage. This may cause a single battery over-charge and over-discharge, thus affecting cycle life of the power battery. In this paper, for each cell in the batteries group is monitored and controlled to prevent any battery over-charge and over-discharge. Hardware and software of power battery management system has been designed. Experimental results show that power battery management system can accurately monitor the power batteries, thereby ensuring the safety of the power batteries and prolonging the cycle life of the power batteries group.*

***Keywords:*** *$LiFePO_4$, Power Battery Management System, Cycle Life, State of Charge (SOC), Battery monitor*

## 1. Introduction

Power batteries group is an important component of electric vehicles (EV). Supply quality of power batteries directly affects the reliable operation of EV [1]. Used in electric car batteries are mainly lead-acid power batteries, lithium ion batteries, nickel metal hydride batteries and lithium iron phosphate ($LiFePO_4$) batteries and so on. By comparison with several power batteries, $LiFePO_4$ has many advantages, for example, which has long life, the use of safety, high capacity, environmental protection and other unmatched advantages, now widely used in EV [2].

Currently, power battery pack is commonly charged in constant current charge-constant voltage method (CC-CV). Total voltage, total current and temperature of power battery pack are monitored by battery management system in the charge-discharge process, but do not consider voltage changes of the individual cells. Since the production technology and other reasons of $LiFePO_4$ battery, the inconsistency between the batteries can cause different charge-discharge characteristics of the batteries [3]. The use of traditional power battery management system will result in some battery over-charge or over-discharge, thus seriously affecting the cycle life of the battery [4]. Over-charge and over-discharge protection of $LiFePO_4$ battery has been vigorously studied by many scholars at home and abroad, and many good results are obtained [5-6].

The main function of battery management system is various parameters of battery pack have been measured in real time on-line (*e.g.*, voltage, current, temperature, *etc.*). On this basis, the SOC and SOH are estimated on-line in real time, while the corresponding control is performed [7-8]. In this article, $LiFePO_4$ power battery pack is used as the object of the research, power battery management system is studied and designed to ensure the safe of power battery pack and extend the cycle life of battery pack.

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## 2. Hardware Design of Power Battery Management System

Battery management system needs to realize the function of complex; large number of data are collected and processed. According to the function requirements of power battery management system, the overall structure of battery management system is shown in Figure 1.

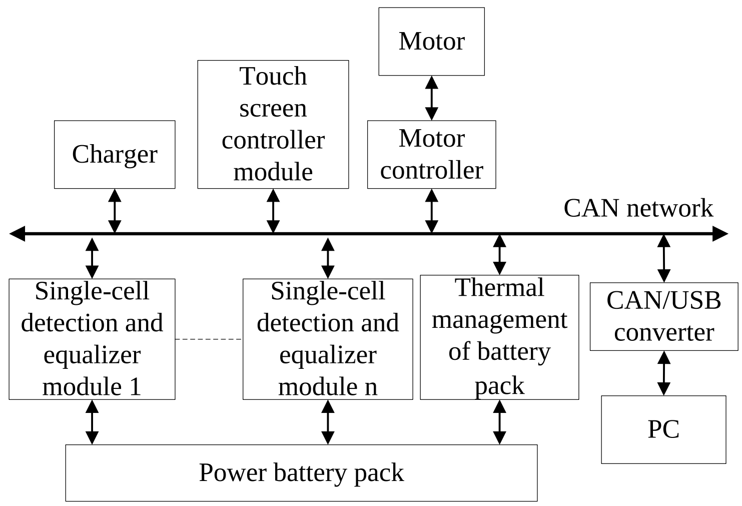


**Figure 1. The Overall Structure Diagram of BMS**

Design of battery management system uses a distributed architecture, consisting of n blocks single-cell detection equalizer modules and a touch screen controller module. The data is transmitted by the CAN network between single-cell detection equalizer modules and the touch screen controller module.

Battery management system mainly consists of four parts: the touch screen controller module main control system, charging machine control system, battery thermal management system and single-cell detection equalization charging system.

### 2.1 The Touch Screen Controller Module Main Control System

Touch screen controller module main control system is the core of BMS. Touch screen controller module uses a microcontroller PIC32MX460F512L, detect the total current and total voltage of battery pack, receive the information of single-cell voltage and temperature by CAN bus and displayed on the touch screen. Touch screen controller module also communicates with the charger and motor controller by CAN bus, the charging and discharging of battery pack is monitored and controlled by touch screen controller. During charging, the touch screen controller module settings charge mode of the charger through CAN communication, and receives the charging parameters of the charger. Received parameters of the batteries are processed by touch screen controller, and SOC, the maximum charge-discharge power and driving range of electric vehicles have been estimated, while the state of health (SOH) has been evaluated.

Touch screen controller module also monitors SOC of all batteries, and controls equalization charging process of battery pack. Touch screen controller module detects the temperature of the battery pack, touch screen controller module also exchange data with the host computer, and thus the parameters of the batteries are recorded and analyzed by the host computer.

 

### 2.2. Charging Machine Control System

Charger is designed and developed by lab members; the charging current is 0-300A. When battery pack needs charging, the touch screen controller module selects fast charging or normal charge. If it is fast charging, you must enter the parameters of the charge current and charge cut-off voltage by the touch screen controller module. When the current size of the setup is complete, the touch screen controller module will send charge commands to the charger through the CAN bus, and send the size of the charging current. Then the charger starts charging. When the battery voltage reaches the charge cut-off voltage, the touch screen controller module instructs the end of charging, charge termination command is received by the charger, and it begins to flow down, until no current output.

### 2.3. Battery Thermal Management System

Due to the different battery charge-discharge characteristics at different temperatures and the battery temperature will affect the cycle life of the battery, and therefore the temperature of battery pack need been detected and controlled. In the high power discharge and high temperature conditions, thermal management of the power battery pack is important. In the battery pack thermal management system, cooling of the battery pack has been widely studied. However, at low temperatures, battery energy storage will be reduced, and therefore, heating of the battery pack has also been studied for low temperature to protect the battery safety in low temperature environment.

In short, the purpose of the battery pack thermal management is to keep the temperature of each cell is consistent and controlled within an appropriate range; so that each cell has substantially the same charge-discharge characteristics, so as to effectively use the battery pack, extend cycle life of the battery pack.

### 2.4. Single-cell Detection Equalization Charging System

Single-cell detection equalizing system consists of a single battery detection system and a balanced system. Single-cell detection system includes four functions: battery voltage detection, battery temperature detection, wire connections detection between the batteries, equalization charging system work control and CAN communications. Single-cell detection system uses free scale chips MC9S08DZ16 as processing chip. This chip has 12 AD sampling, you can make a single battery voltage sampling accuracy 1mV, the battery voltage and temperature can be detected with high accuracy. The chip uses an external 10M crystal clock signal.

## 3. Software Design of Power Battery Management System

The main function of electric vehicle battery management system software architecture needs to be done include: receiving voltage, temperature and SOC information of n batteries by CAN bus, and processing data; timing acquisition total voltage and total current of power battery pack, and sends battery current information to single-cell detection module; through the voltage, current, temperature and other information, the SOC value of a single battery or battery pack has been estimated by using a certain algorithm; battery SOH estimation; maximum charge and discharge power estimation of the battery pack; equalizing charge of the battery pack.

The software architecture of battery management system is shown in Figure 2.

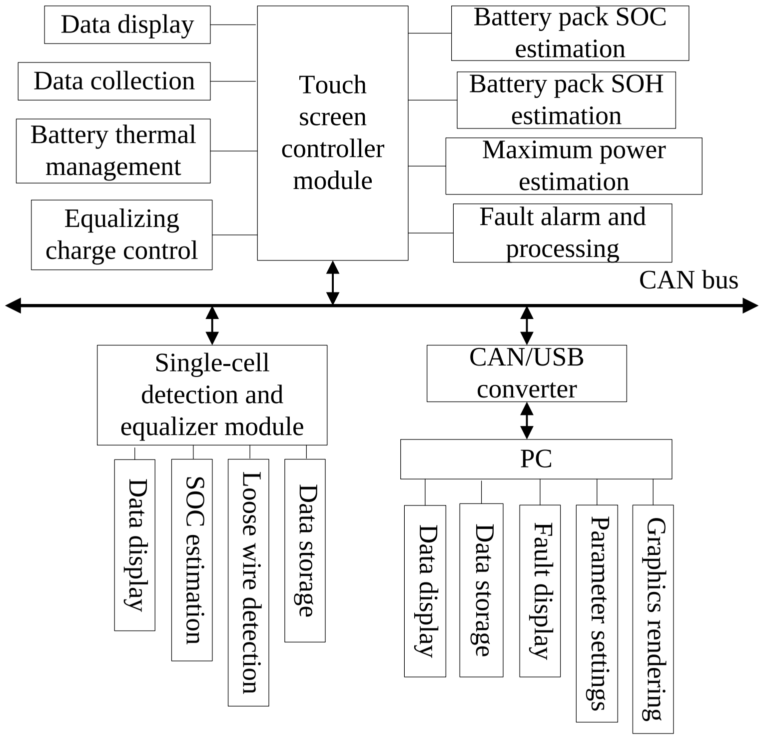


**Figure 2. Software System Structure of BMS**

### 3.1. The Touch Screen Controller Module Software Design

As can be seen from Figure 2, the touch screen controller software design module comprises eight modules: data display module, data acquisition module, the battery thermal management module, equalization charging control module, the battery SOC estimation module, the battery SOH estimation module, the battery fault alarm and diagnostic module and the maximum charge-discharge power estimation module.

1) Data display module. Acquisition parameters and calculated parameters obtained were subjected to display on the touch screen.

2) The data acquisition module. The battery voltage, current and other parameters are collected and stored.

3) The battery pack thermal management module. The battery temperature is controlled so that the temperatures of the battery pack is maintained substantially the same and controlled within an appropriate range.

4) The battery pack SOC estimation module. According to SOC of each battery, SOC of battery pack is estimated, to avoid battery overcharge and over discharge, thereby effectively use battery power, increase the mileage of electric cars.

5) Battery pack SOH estimation module. SOH is state of health of the battery; the standard case is defined as the percentage of available battery capacity representing the standard capacity. In the entire life cycle of power battery, SOH of the battery will gradually decline until complete failure. SOH can provide the appropriate information to the vehicle, such as the current health status of the battery, cycle life of the battery, available capacity of the battery. Because the relevant parameters are difficult to measure in the SOH, therefore, SOH is estimated according to the internal resistance and SOC value of the battery.

 

6) Equalizing charge control module. Equalizing charge can effectively improve the consistency of power battery pack, to improve the performance of the battery pack. Paper presents the SOC of each battery as input of a balanced charge control. The difference of SOC of each battery and mean SOC of all batteries is used as the basis for a balanced charge. Through the new equilibrium charging method can effectively utilize the power of battery capacity, increase the mileage of electric cars.

7) Battery fault alarm and diagnostic module. Battery fault alarm and diagnostic are calculated according to the current battery voltage, current, temperature and SOC values. The module through a comparative analysis of the input parameters to determine the cause of battery failure, fault type, and then displayed fault state on the touch screen to remind user.

8) The maximum charge-discharge power Pmax estimation module. Pmax is the current maximum charge and discharge power of battery pack provide, which is basis of the energy allocation strategy of vehicle controller. Maximum charge power estimation of battery pack can provide the basis for rapid charging of battery pack. Maximum discharge power estimation of battery pack can provide the basis for motor controllers control strategy.

### 3.2. Single-cell Detection and Equalizer Module Software Design

As can be seen from Figure 2, single-cell detection and equalizer module software design consists of four modules: data acquisition module, data storage module, SOC estimation module and wire connection loose detection module.

1) Data acquisition module. Freescale produced MC9S08DZ16 chip as data acquisition chip. Single cell voltage and temperature are detected by the chip.

2) The data storage module. The battery voltage, current, temperature, *etc.*, are stored by chip.

3) SOC estimation module. Battery SOC estimation is the most critical part in power battery management system, which indicates capacity of battery power remaining. SOC of all single battery is estimated in the battery pack, in order to effectively and safely use power battery, extending cycle life of the battery.

4) Wires loose detection module. The inter-connecting wires loose of power battery pack has been detected by wires loose detection module, in order to improve the reliability of battery-powered and to ensure reliable and efficient work, avoid high-temperature and spontaneous combustion of the battery.

## 4. Experiments and Analysis

In the experiment platform, charging and discharging experiments of 16 series 200Ah/3.2V $LiFePO_4$ battery have been done by BMS of the paper designed.

Power battery pack is charged by battery charger with CAN communication, charging current and charging cut-off voltage are set by touch screen, charging current is 25A. When the voltage of any battery reaches cut-off voltage, charge current begins to decrease, so that each cell voltage of battery pack does not exceed the cut-off voltage. When the charger output current is less than 1A, the charger stops charging, charging is completed.

The charging experimental curve of power battery pack is shown in Figure 3.

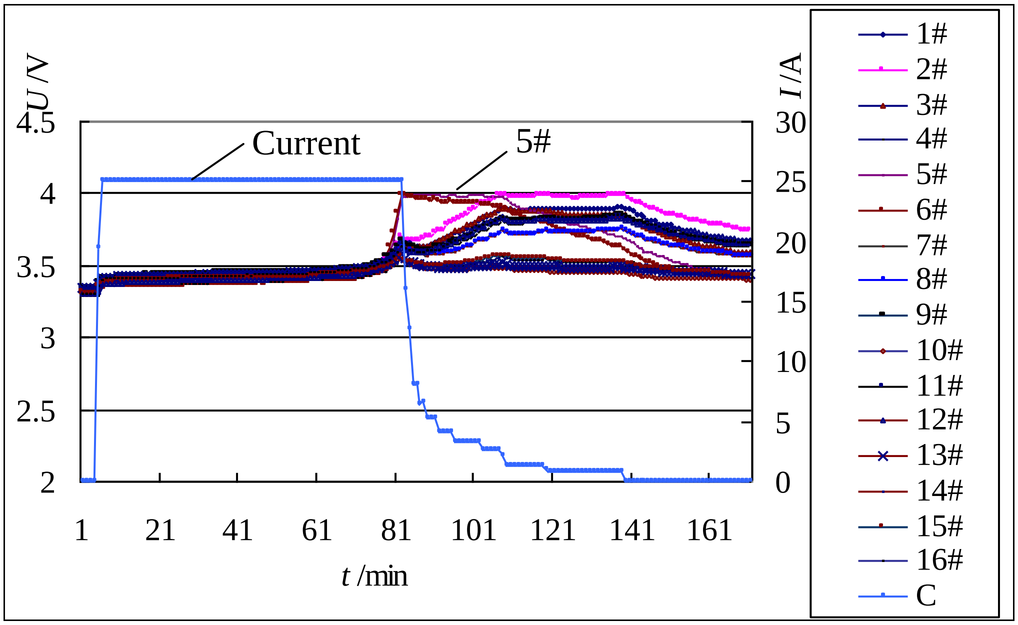


**Figure 3. Charge Experiments of Power Battery Pack**

The Discharging Experimental Curve of Power Battery Pack is shown in Figure 4.

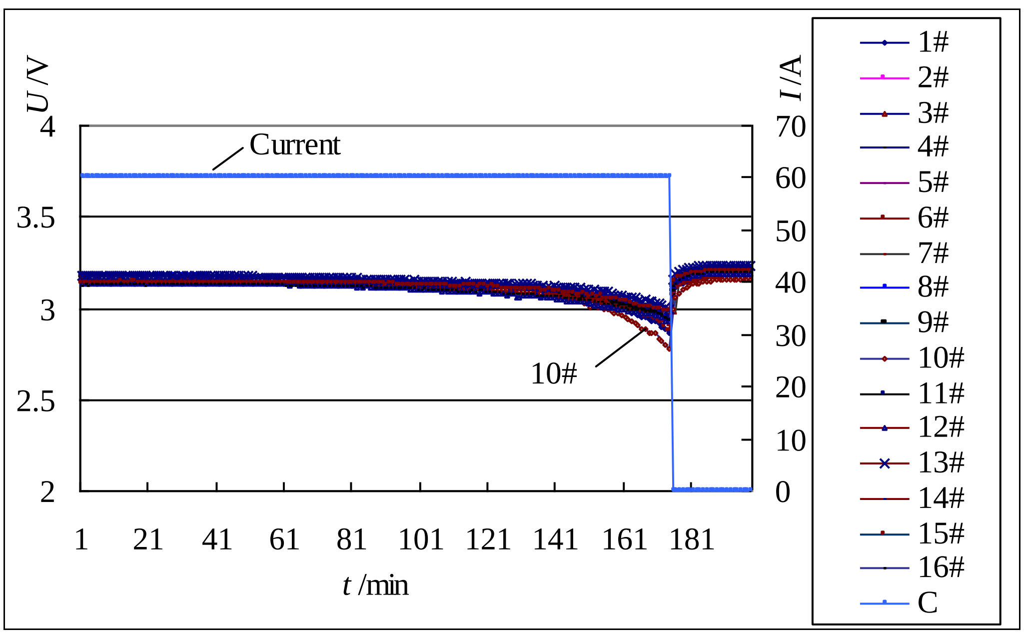


**Figure 4. Discharge Experiments of Power Battery Pack**

Figure 3 can be seen in the experiment, the voltage and temperature of all batteries have been monitored and charging process of battery pack has been controlled by BMS. Over-charge phenomenon of any battery did not happen during charging process. But there are also some problems, is in one of the batteries voltage reaches the charging cut-off voltage, other battery voltage rises in stages, has not reached the cut-off voltage, which is not yet fully charged.

Figure 4 can be seen in the experiment, the voltage and temperature of all batteries have been monitored and discharging process of battery pack has been controlled by BMS. When the voltage of any battery is lower than discharge cut-off voltage, stop the discharge, so it avoids over-discharge of the battery. But here there are some problems, that is, in which one cell voltage reaches the discharge cut-off voltage, the other battery voltage is still in slow decline stage, which is also part capacity of the battery has not discharged.

In addition, Figure 3 and Figure 4 can be seen in the experiment, the voltage of the 5th battery first reaches charge cut-off voltage during charging process, the voltage of the 10th battery first reaches discharge cut-off voltage during discharging process. It indicates that the capacity of the 10th battery has been a big difference compared with other batteries.

## 5. Conclusion

In this paper, $LiFePO_4$ power battery pack is used as the object of study; power battery management system is analyzed and studied. The voltage and temperature of each battery are detected by BMS, and detection data has been transmitted to the touch screen microprocessor by CAN communication. The charge and discharge process of battery pack have been monitored and controlled by BMS. In the charging process, charging parameters and charging mode are set by BMS, in the discharging process, the voltage and SOC information of battery pack are transmitted to motor controller.

Through charge and discharge experiments of power battery pack, the feasibility and effectiveness of the power battery management system design has been demonstrated.

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## References

[1] L. Damen, J. Hassoun, M. Mastragostino and B. Scrosati. J. of Pow. Sour, vol. 19, **(2010),** pp. 6902-6904.
[2] B. Jin and H. B. Gu, Solid. Stat. Ionics., vol. 178, **(2008),** pp. 1907-1914.
[3] T. Takeuchi, M. Tabuchi, A. Nakashima, J. Pow. Sour., vol. 146, **(2005),** pp. 575-579.
[4] S. F. Yang, Y. N. Song, P. Y. Zavalij, Elec. Comm., vol. 4, **(2002),** pp. 239-244.
[5] L. M. Moshurchak, C. Buhrmester, R. L. Wang and J. R. Dahn, Elec. Acta., vol. 52, **(2007),** pp. 3779-3784.
[6] Q. Zhang and R. E. White, J. of Pow. Sour., vol. 179, **(2008),** pp. 793-798.
[7] X. W. Zhao, G. Y. Zhang, L. Yang, J. X. Qiang and Z. Q. Chen, J. of Ther. Analy. and Calo., vol. 2, **(2011),** pp. 561-567 **(2011)**.
[8] Y. Q. Hu, H. P. Liu, Y. Zhang and K. F. Liu, J. of Wuhan. Univ. of Tech. vol. 9, **(2011),** pp. 130-134.

 