Design and Research of Power Lithium Battery Management System

Zhonglin YUAN\textsuperscript{1,a}, Haichuan ZHANG\textsuperscript{2,b} and Yueling NIU\textsuperscript{3,c}

\textsuperscript{1}Dalian Polytechnic University, China
\textsuperscript{2}Dalian Polytechnic University, China
\textsuperscript{3}Dalian Polytechnic University, China
\textsuperscript{a}757959876@qq.com, \textsuperscript{b}zhanghc@dlpu.edu.cn

Keyword: battery management system; low power consumption; BQ76925

Abstract: Due to the problems of overcharge, over discharge, internal and external short circuit and thermal runaway in the use of lithium battery, a low-power lithium battery management system was designed for these problems. This system takes MSP430 as the core, using BQ76925 chip of TI company as the front-end acquisition chip can detect 3 to 6 string lithium battery with voltage, current, temperature and other information collection, overcharge and over discharge protection, balance management and other functions. The test shows that the system is good for the management of lithium battery and has good accuracy and stability.

1. Introduction

As the lithium battery with high energy, long life, small size, no memory, green and other advantages, it is widely used. At the same time, the lithium battery performance parameters with significant non-linear, high charge and discharge requirements, therefore, in order to protect the safe use of lithium batteries to extend the life of lithium batteries, cost savings, design a suitable lithium battery management system is very important\cite{1,2}.

The Battery Management System (BMS) is the main task is monitor and manage the battery pack, through real-time monitoring of single cell voltage, current, temperature and other parameters to prevent the battery overcharge, over discharge and other factors affect the battery life, the balance between the battery cells has a great impact on the life of the battery pack, so the battery management system to balance the battery management to prevent the imbalance between the battery to reduce the battery life \cite{3,4}.

Aiming at the particularity of lithium battery, this paper presents a low power lithium battery management system based on TI battery management chip BQ76925 and MSP430F2618. It can measure the voltage, current and temperature of battery in real time and monitor the working status of battery pack and maintain the battery voltage consistency, to achieve the intelligent management and protection of lithium batteries.

2. System overall design

The system mainly consists of the control module, the drive module and the display module. The drive module also includes the data detection circuit, the protection circuit, the wake-up circuit and the pre-charge control circuit. The overall block diagram of the system is shown in Fig. 1. The master chip uses MSP430F2618, which has the characteristics of fast operation, strong processing power, ultra low power consumption and other characteristics \cite{5}, so it is used in the need for battery-powered portable instrumentation. MSP430F2618 real-time monitoring of the battery parameters to ensure that the battery normal operation, then transfer parameters to the host computer, the host computer through the transmission of data to estimate the battery charge state (SOC), and display on the display module.
3. **System hardware design**

**Drive module.** The drive module includes voltage sensing circuit, detection circuit, protection circuit and wake-up circuit.

Detection circuit selected by TI's BQ76925 chip, the chip is mainly designed for power tools, it cannot be used alone and must be combined with the microcontroller to collect the battery voltage, current, temperature and other information. This paper chooses the MSP430F2618 and BQ76925 to realize the information collection of the battery, converts the collected information into an accurate analog signal through the analog voltage, and then transmits the signal to the microcontroller. The AD conversion can make the system recognize all the battery parameters, at the same time, the internal control software controls the charge and discharge control MOS tube so as to achieve the purpose of safety control.

Battery voltage sensing circuit shown in Fig. 2, RIN and CIN filter circuit can reduce the input noise, improve the accuracy of the battery voltage sensing and balance the voltage difference between the battery. R1-1 and R1-2 control the need to detect the number of batteries, if you need 5 batteries R1-1 welding, R1-2 not welding, if you need 4 batteries R1-1 welding, R1-2 welding. When the short-circuit current occurs, the battery current will rise to several hundred amperes, short-circuit current protection circuit there will be a large peak voltage, the chip may exceed the maximum input voltage, so access to the circuit D23 can effectively avoid this happens to protect the chip.

**Figure 2.** Battery voltage sensing circuit.

Fig. 3 circuit, BQ76925 converts the measured data into an analog signal and send the signal to the input of the microcontroller, realize the real-time monitoring of battery parameters. While the capacitors C8, C14 can filter some noise to improve accuracy. At the same time BQ76925 contains
a dynamically selectable threshold comparator used to monitor the current value, the comparator is
driven by an open-drain output, when the current value exceeds the set value, the comparator sends
an alarm signal to the microcontroller alarm, the microcontroller into the interrupt to protect circuit.
BQ76925 ALERT pin connected with the microcontroller, you can wake up the BQ76925 from
sleep mode. The wake-up circuit shown in Fig. 4.

![Figure 3. Data detection protection circuit.](image)

![Figure 4. Wake-up circuit.](image)

**Control module.** The main controller is the core of the control module. According to the
requirements of the system, this paper chooses the MSP430F2618, which collects and processes the
transmitted data, communicates with the drive module through the internal CAN bus, it receives and
sends the data, and then the data analysis, processing and storage, by controlling the external circuit
real-time monitoring of the state of the battery, at the same time through the serial port and the host
computer communication, and the information transmitted to the display module, in order to real-
time monitoring of the battery charge state (SOC). Therefore, the control module is responsible for
implementing the battery management system preset various functions. The main control module
circuit shown in Fig. 5.
4. **Display module**

Display module is mainly composed of four-in-one digital tube, it is responsible for the data transmitted by the microcontroller displayed on the digital tube, to achieve real-time monitoring of the battery SOC. The circuit diagram is shown in Fig. 6.

5. **Software design**

Lithium battery management system hardware is completed, the system control and a variety of fault protection and SOC estimation are completed through the microcomputer software. System software flow chart shown in Fig. 7, the system initialization including BQ76925 initialization, I²C initialization, microcontroller and peripheral module initialization. Data detection control part through the microcomputer to complete the data processing, determine the state of the battery, deal
with the corresponding problems and determine whether the alarm signal generation. If the detected data exceeds the set value, take the appropriate protection method to protect the circuit.

6. Experimental test

Experimental study shows that the lithium battery management system can achieve the battery voltage, current and temperature and other information real-time monitoring, the monomer voltage error is less than 10mV, while the single cell voltage between 3.5V-3.8V, indicating that the battery voltage between the single has a good balance. The experimental data for voltage detection are shown in Table 1. Current and temperature detection data as shown in Table 2 and Table 3, the current and temperature data error is less than 5mV, indicating that the system has a good accuracy.

Table 1. Voltage detection data.

<table>
<thead>
<tr>
<th>Battery</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated voltage (mV)</td>
<td>3632.5</td>
<td>3633.5</td>
<td>3631.7</td>
<td>3636.7</td>
<td>3603.5</td>
<td>3645.7</td>
</tr>
<tr>
<td>Measuring voltage (mV)</td>
<td>3636.5</td>
<td>3638.3</td>
<td>3631.9</td>
<td>3640.5</td>
<td>3605.7</td>
<td>3650.2</td>
</tr>
<tr>
<td>Difference (mV)</td>
<td>4.0</td>
<td>-4.8</td>
<td>2.2</td>
<td>3.8</td>
<td>2.2</td>
<td>4.5</td>
</tr>
</tbody>
</table>
Table 2. Current detection data.

<table>
<thead>
<tr>
<th>Estimated value(mV)</th>
<th>Measured value(mV)</th>
<th>Difference(mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.85</td>
<td>14.65</td>
<td>0.80</td>
</tr>
<tr>
<td>45.78</td>
<td>46.16</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Table 3. Temperature measurement data.

<table>
<thead>
<tr>
<th>ADC value(mV)</th>
<th>Measurement value(mV)</th>
<th>Difference(mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1068.2</td>
<td>1065.4</td>
<td>~2.8</td>
</tr>
</tbody>
</table>

When the system charging current is greater than the set threshold and the duration exceeds the set value, the CHG pin of the microcontroller is turned off, the charging overcurrent protection circuit is turned on, the current value is normal after 4 seconds, and the CHG pin of the microcontroller is turned on. When the discharge current is too large, the microcontroller DSG pin is turned off and the overcurrent protection circuit is on. If the load is removed during overcurrent protection, the microcontroller DSG will turn on again. When the battery voltage is detected greater than the critical value and the duration exceeds the set value, the CHG pin of the microcontroller is turned off, the overvoltage protection is on, the battery voltage returns to normal, the CHG pin is off, and when the system is in the discharge state, Feet CHG open, otherwise, it is closed. When the battery voltage is less than the set value, the microcontroller chip DSG pin off, under-voltage protection circuit is turned on, the battery voltage back to normal, DSG pin is off, when the system is in the state of charge the microcontroller DSG open, on the contrary, it is closed. Experiments show that the system has a good over-current over-voltage protection, real-time to complete the protection of the battery pack.

7. Conclusion

This paper designs a lithium battery management system based on front-end acquisition chip BQ76925, MSP430F2618 as the core processor, to achieve the lithium battery balance management, over-current over-voltage management, under-voltage management, short circuit management and over-temperature protection, at the same time draw the system hardware design and software flow chart, the experiment proved to meet the expected requirements. Although the lithium battery management system to extend the battery life, however, there is still some error in estimating SOC with Kalman filter algorithm, which needs to be improved.

References