TELKOMNIKA, Vol. 11, No. 4, April 2013, pp. 2247~2252
ISSN: 2302-4046

The Electric Vehicle Lithium Battery Monitoring System

Lei Lin[1], Yuankai Liu*[2], Wang Ping[3], Fang Hong[4]
[1]School of Electric and Information Engineering of Chengdu University, Chengdu 610106, China
[2]School of Automation Engineering of University of Electronic Science and Technology of China, Chengdu 611731, China
*Corresponding author, e-mail: liuyuankai0303@126.com

Abstract

With the global increase in the number of vehicles, environmental protection and energy issues had become increasingly prominent. People paid more and more attention to the electric vehicle as the future direction of the vehicle, but because the battery technology was relatively backward, it had become the bottleneck in the development of electric vehicles. So in the existing conditions, a perfect battery Monitoring technology had become more and more important. This paper firstly analyzed the characteristics of lithium battery residual capacity and effect factors, then put forward to a set of solutions according to the actual situation. The solution of the lithium battery Monitoring system adopted distributed structure, including detection of voltage, current, temperature and measurement module and the realization of monomer battery equalizer module. Using a single bus device DS2438 produced by DALLAS on the battery voltage, current, temperature, power and other parameters, the system controlled DS2438 by the STC89C52 single-chip in data acquisition. Then it used the algorithm to predict state of charge(SOC) and displayed the battery status in the LCD1602. This solution of the lithium battery Monitoring system was reliable, economy, strong anti-interference ability.

Keywords: *electric vehicle, lithium battery, battery monitor, SOC, equilibration*

1. Introduction

In consideration of large current of lithium battery in quick charge, rapid discharge [1], vibration, extrusion and other heavy conditions, it may cause a fire, explosion safety accident. It is difficult to meet the requirements of "low cost, high volume and high security". For these problems, this paper devotes power electronic technology, single-chip microcomputer technology, intelligent control, optimal algorithm and electrochemical science to the development of high intelligent electric vehicle lithium battery energy monitoring system [2], it can use battery energy more efficiently in complex environment. It not only can do ensure the safe and reliable operation, but can give full play to the life of the battery and charging and discharging ability. So the research of battery monitoring system has played more and more key role in the generalization of the electric vehicle market and improvements of vehicle performance [3].

2. Design of the Electric Vehicle Battery Monitoring System

Electric vehicle battery monitoring system includes the following several parts [4-6].

2.1. Data Collection

Collection of each battery characteristic parameters: terminal voltage, battery's surface temperature, charge and discharge current and total voltage.

2.2. Electrical Control

Charge and discharge control, balance charge and discharge technology.

2.3. Data Communication

The examination of lithium battery dynamic parameters and display, data communication with other modules, establish communications bus for exchanging data with display system, the vehicle controller and chargers to facilitate centralized control.

Received December 8, 2012; Revised March 1, 2013; Accepted March 9, 2013

2.4. Heat Monitoring Ability

Advanced heat monitoring ability can maintain the balance of temperature between battery modules, and control cell temperature in the reasonable scope.

2.5. Display and Recording Part

After getting in the right battery state, proceeding heat monitoring, battery equalization monitoring, charge and discharge monitoring, fault alarm, and show battery parameters.

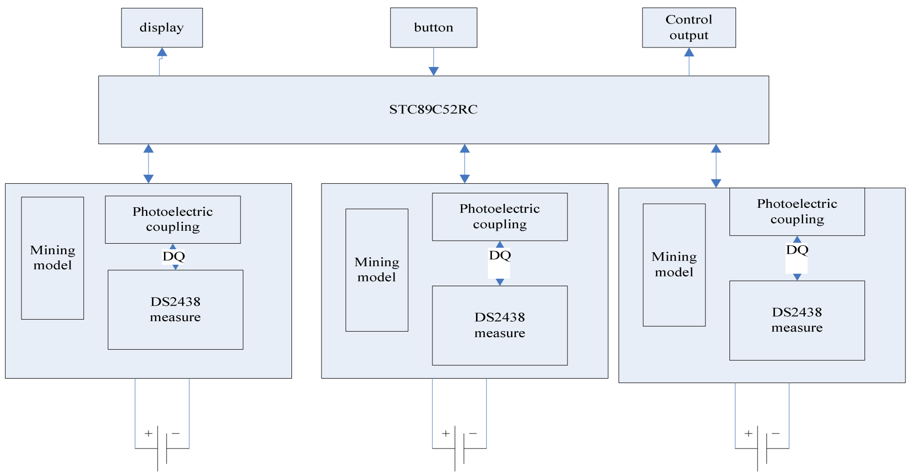

Figure 1. Electric Vehicle Lithium Battery Monitoring System

3. The Prediction of Residual Capacity Battery SOC

In order to characterize residual capacity of the electric vehicle batteries more accurately and scientifically, usually use the battery charge state characterization, namely the SOC (State Of Charge) [7], it is important parameters in the process of battery use. At present, the domestic and international more widely use battery state of charge SOC to reflect the residual capacity, and its numerical value is defined as the rest of the battery power for battery capacity ratio

$$SOC=Qc/Co \quad (1)$$

On the type, for the rest of the battery Qc usable energy, Co for nominal capacity of the battery, in a specified current and temperature in the ideal condition can release energy. Usually the certain temperatures state of battery can't absorb energy is defined 100%, and the state of battery can't release energy is defined electricity state 0%.

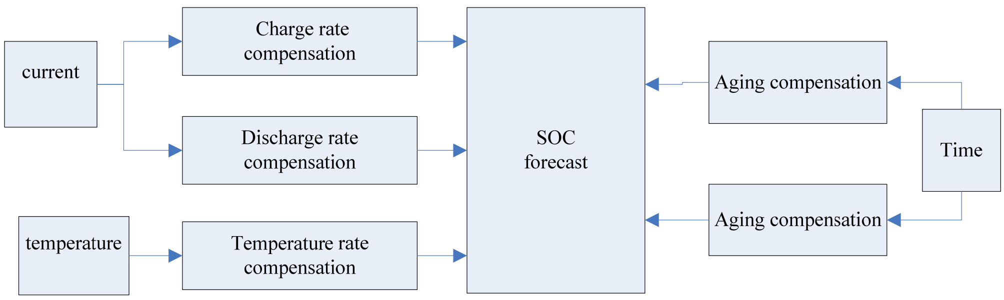

Figure 2. Lithium Battery SOC Estimation

For the lithium battery, the residual capacity is influenced by many factors [8]: the discharge current, the temperature of the battery, the self-discharge rate, cycle times, etc.

On the basis of the analysis of the factors affecting the lithium battery remaining capacity, synthesizing the advantages and disadvantages of existing prediction methods, this paper puts forward a composite residual capacity prediction method: combined with ampere-hour method, open voltage method and the kalman filter method to forecast the actual battery capacity, to accurately predict residual capacity of the battery. First of all, use open voltage method to measure initial capacity, and then use ampere-hour method and the kalman filter approach method [9] to caculate the dynamic residual capacity battery, and compare the results of the two methods to check the actual battery capacity to achieve the purpose of accurate prediction.

4. Battery Parameters Measurement

Single cell measurements of circuit diagram is shown as Figure 4.

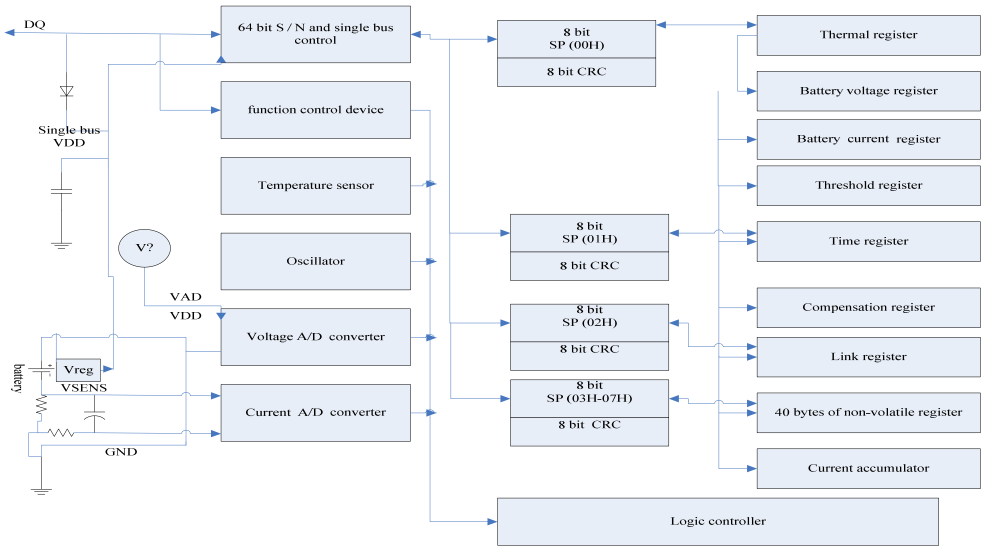

Figure 3. Battery Parameter Detection Circuit

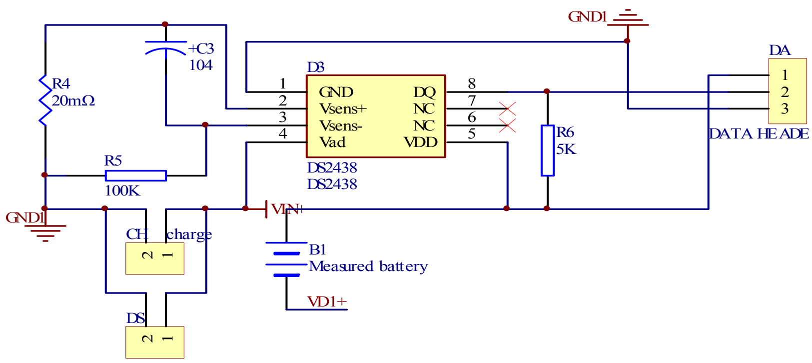

Figure 4. DS2438 Measurement Circuit Diagram

For the design of single lithium battery series group, the system uses a detecting chip DS2438 [10] which can support multiple batteries cascade control and communicate without common earth under high voltage. The shape of battery group can be design flexibly and placed distributedly, which meets the requirements of large capacity, high power according to the different applications. Each battery is configured a data acquisition boards to gather every single battery parameters, lithium battery supply power for DS2438 at the same time. If the battery measured is made up of several monomer series and share a DS2438, voltage will be more than DS2438 working voltage, we can use precise resistance to divide, then lower voltage supply chips work. Measuring principle diagram is shown as Figure 3.

5. The Balance of Battery Body

Based on the synthesis of the advantages and disadvantages of the existing equilibrium methods, adopting the switch of capacitance equilibrium method through the program to control cell in the stationary state, through the switch to balance different monomers independently, and shortening the discharge levels. This scheme is simple and reliable, its biggest advantage is to balance the unit cell in the charge and discharge process, and not to consume lithium battery energy. Disadvantage is capacitance discharge only in the adjacent batteries, so it need to pay attention to control the capacitance charging time to prevent capacitor filling explosion.

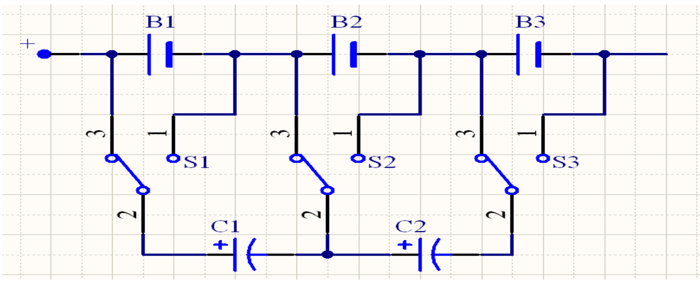

Figure 5. Switched Capacitor Equilibrium

6. The Software Realization of Electric Vehicle Lithium Battery Monitoring System

The software is realized by the corresponding hardware circuit, by using a single bus device DS2438, which samples main parameters such as battery voltage, current, temperature, and power. The data is processed by the single-chip microcomputer STC89C52. Then the processed data is combined with the present value, and the battery normal state is displayed on the LCD1602. The sysytem will alarm when there is a fault .The main program process chart is shown as follow.

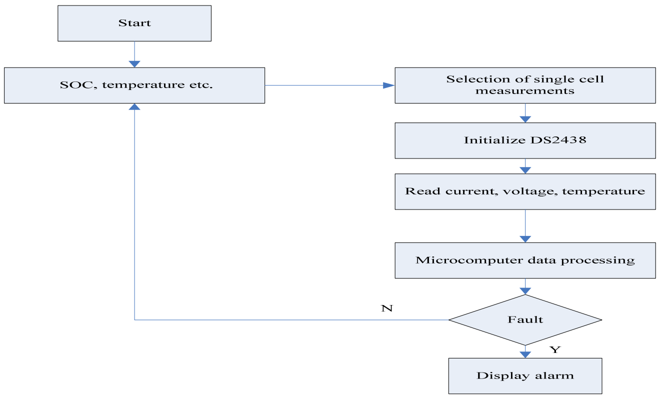

Figure 6. Flow Chart of Main Program

7. The Simulation Results and Analysis

In order to validate the actual effect of the composite residual capacity prediction method, conduct the charging and discharging test at room temperature, and use MATLAB/SIMULINK software to simulate battery SOC estimated algorithm modeling [10]. The results are shown as Figure 7 and Figure 8.

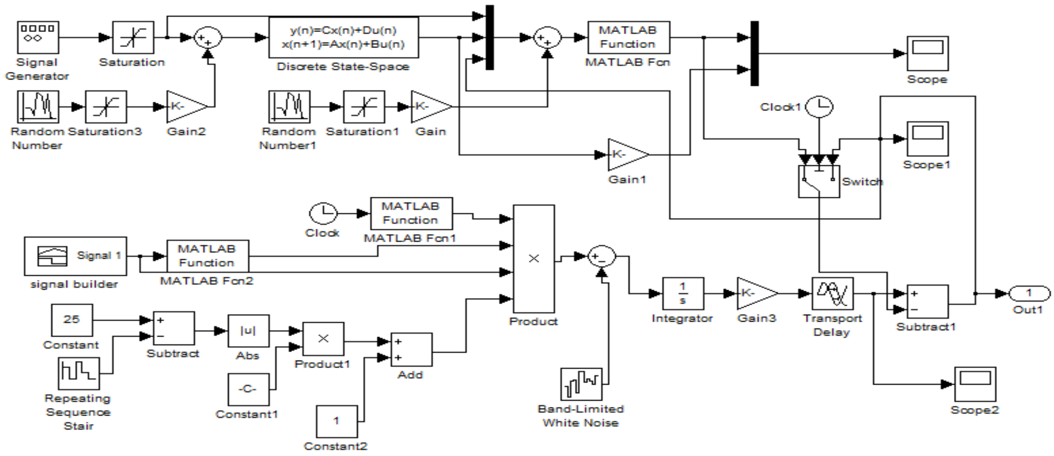

Figure 7. MATLAB Simulation Plans

According to the simulation results, in the later discharge, because of error accumulation, the precision of kalman filtering method is higher than ampere-hour method's.

In the sysytem, Ampere-hour method calculation formula is shown as follow:

$$SOC=SOC_0-\int_0^t I(t)dt \tag{2}$$

Discrete system kalman filter formulas are as follow:

$$X(k+1)=A(k)X(k)+B(k)U(k)+W(k) \tag{3}$$

$$Y(k)=C(k)X(k)+V(k) \tag{4}$$

$$X(k|k-1)=A(k-1)X(k-1)+B(k-1)U(k-1) \tag{5}$$

$$X(k)=X(k|k-1)+K(k)[Y(k)-Y(k)] \tag{6}$$

$$P(k|k-1)= A(k-1)P(k-1)A^T \tag{7}$$

$$K(k)= P(k|k-1)C^T(k)[C(k)P(k|k-1) C^T(k)+R]^{-1} \tag{8}$$

$$P(k)=[I-K(k)C(k)]P(k|k-1) \tag{9}$$

In the above formula, X(k) is state vector, U(k) is control vector, Y(k) is observation vector, W(k) and V(k) is noise vector, A(k), B(k) and C(k) are coefficient matrix, P(k|k-1) and P(k) are state variables predicted error and the error of filter variance array, Q and R respectively is the variance array of noise W(k) and V(k).

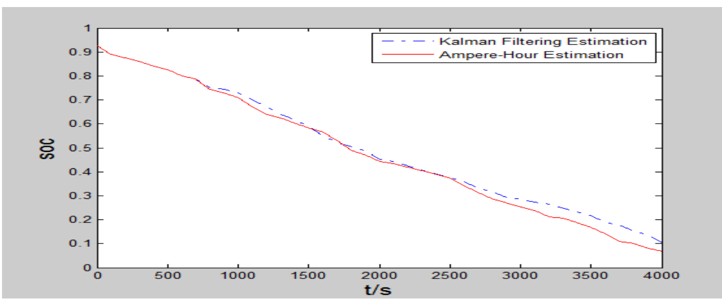

Figure 8. SOC Simulation Curve

8. Conclusion

The paper offers a solution of lithium battery monitoring system based on Single Chip Microcomputer(SCM) and DS2438, this system can more accurately measure battery voltage, current and temperature data. After the system test, SOC arithmetic is reliable, the judge of battery state is accurate, sending the battery state message to the central processing system is fast, the anti-interference ability is strong and displaying through the liquid crystal is real-time. At the same, the equilibration function solves unbalanced voltage of the monomer battery caused by the overcharge. This solution reaches the expected design requirements and provides a new reference for the further study of electric vehicle lithium battery monitoring system.

Aknowledgement

This project is supported by science and technology support plan of Sichuan province (2011GZ0194), China.

References

[1] Wu Tiezhou, Cao Quan, Liu Lunan, Xiao Qing, Wang Xieyang. Research on the fast charging of VRLA. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2012; 10(7): 1660-1666.
[2] Ye Zunzhong. *Monomer electric vehicle battery management system*. Zhejiang University. 2004; 3.
[3] Jia Xuping. The United States A123 company new lithium battery electric vehicle. 2009; 12.
[4] ZHANG Wei, YANG Jian-wu. Design of accumulator inspect system based on 1-wire technology. *Microcomputer Information*. 2009; 25.
[5] YU Neng-shun, XU Xin. Lithium Battery Protection Circuit Design for Electric Vehicle Based on ATmega16L Single-chip. *Journal of Chongqing Institute of Technology (Natural Science)*. 2009; 10.
[6] ZENG Wei, TANG Hai-bo. Performance testing system for electric vehicles power battery. *Chinese Journal of Power Sources.* 2011; 25: 35-39.
[7] Zhao Jian. *The research of estimate method of residual capacity on battery for electric vehicle*. Dalian University of Technology. 2006; 1201.
[8] Huang Wenhua, Han Xiao-dong. A Study on SOC Estimation Algorithm and Battery monitoring System for Electric Vehicle. *Automotive Engineering*. 2007; 29: 198-202.
[9] Wu Hongbin, Sun Hui. New improved prediction algorithm for state of charge of battery. *Journal of Electronic Measurement and Instrument.* 2010; 11.
[10] Tiezhou Wu, Lunan Liu, Qing Xiao, Quan Cao, Xieyang Wang. Research on SOC estimation based on second-order RC model. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2012; 10(7): 1667-1672.