



Analysis and Design of Storage Battery Charge/Discharge Equalization Management

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Abstract

This article introduces the design of storage battery charge/discharge equalization system of the electrical cars based on HT46R47. Because it becomes into one difficulty in the development of electrical cars that the characters of the battery decides the equalization of the battery electric quantity, so this system adopts the equalization management to the storage battery charge/discharge, adjusts the unsuited batteries (over charge/over discharge) in the initial adjustment process, and implements equalization in the later charge process. The system makes the use capacity and the cycle life of the storage battery fully enhance. At the same time, this charger adopts the SCM as the main control component, which has many advantages such as simple and credible circuit, short charge time, low power consumption, low use trouble rate and so on.

Keywords: Storage battery, Embedded system, Equalization charging

1. Introduction

With rapid development of global economy, human living level is changing quickly. Human living is more and more convenient and comfortable, but the follow environment pollution also puzzles human beings. Hundred years history of the flourish develop of auto industry records the brilliant course of human civilization. However, the continual increase of car quantity also put the problem of energy and environment to the increasingly serious situation when it promotes the rapid development of global economy. The electrical car is one important measure to solve the problem of energy and environment in the 21st century.

At present, the electrical cars mainly include three types, battery electrical vehicle (BEV), hybrid electrical vehicle (HEV), and fuel-cell electrical vehicle (FCEV). Based on various reasons, this system mainly aims at the study of hybrid electrical drive mode. This mode concurrently possesses the advantages of electrical cars and gas engine cars. HEV has two types including series-wound type and shunt-wound type. For the series-wound electrical cars, the gas engine drives the generator, and the generator charges to the battery, and the battery supplies power to the electromotor and the electromotor directly drives the car. The shunt-wound gas engine and electromotor all can directly drive the car. The specific work mode of the electrical car has many special requirements for the power battery, which includes good charge receptivity (regeneration braking, complementary charge), high power density and proportion power, high cycle efficiency and low interior resistance (power equalization), good coherence and so on.

2. Equalization management of storage battery pile

The power supply management technology that takes the single battery as the power source such as mobile phone has been very perfect, but in the battery pile, the difference among single battery is always existent. In the cycle charge/discharge process of electrical car, because of the difference of the chemic component of various storage batteries and the difference of running history of the storage battery, the variance of various batteries will be further enlarged, which will induce the difference of charge/discharge final voltage of the storage battery under same charge/discharge condition. If the battery system runs under that situation and without management, the use life and system reliability of the storage battery will be influenced. To extend the use life of the battery pile, we must make all single storage batteries keep same discharge depth and adopt the method of equalization charge to solve this problem.

The battery equalization is to adopt difference current to different batteries (or battery piles) in the series-wound battery group. The current of every battery in the series-wound battery is generally same, so we must add extra components and circuits to realize battery equalization. When all batteries in the battery group fulfill following two conditions, they will realize battery equalization. First, if the capabilities of all batteries are same, they will realize battery equalization when they are in the relative charge state. The state of charge (SOC) is generally represented by the percent of current capability and rating capability, so the open circuit voltage (OCV) can be taken as a measurement standard of SOC. If all batteries in an inequality battery pile can achieve full capability (the equalization point) through difference charge,

they can be implemented normal charge/discharge and need not any extra adjustment, and this sort of adjustment is one-off generally. Second, if the capabilities of various batteries are different, when SOC is same, they are thought as equalization. But SOC is a relative value, and the absolute value of every battery capability is different. To make SOC of the batteries with different capabilities same, the difference current must be used when implementing charge/discharge to the series-wound batteries every time.

The concrete scheme design includes following aspects.

(1) Shunt: The shunt doesn't cut the work loop of the battery, and it is to add a bypass setting for every battery just like battery partner, and both combined characters is equal to the character of the single battery which has the mean quality in the battery pile.

(2) Feedback: The feedback transfers the warp energy among single batteries to the battery pile or some single batteries in the pile through the energy convertor. Theoretically speaking, the feedback doesn't consume energy and can realize dynamic equalization. Because the battery pile on the electrical care has large powers and the instantaneous current can achieve hundreds ampere and present double polarities change, so this equalizer adopts the method of shunt feedback under considering many factors such as feasibility, quality-price ratio, practicability and reliability.

(3) Dynamic: The dynamic equalization can realize the equalization of single voltage in the pile and timely keep close load degrees through the method of energy transform under the charge state, discharge state or the float state.

(4) Double directions: The double direction convertor is selected according to the possible current direction of the equalizer treatment energy, which can implement dynamic adjustment of the input and output direction.

(5) Class connection: Several single batteries are spaced between high voltage single battery and low voltage single battery in the pile, and many class connected convertors need working simultaneously when the energy is transferred from high voltage single battery to the low voltage single battery.

(6) Efficiency and safety: For the dynamic equalization, especially in the use discharge process, the heat consumption of the convertor comes from the energy of the battery pile, and because the single battery has low voltage, so the efficiency of the convertor is a design difficulty, which must adopt and refer new design technology of present power supply and circuit, and many general inspection functions such as parameter excessive warning and heat protection are necessary. Because the environment in the car is in the bump and shaking state, so the line matching technology and durance structure must be designed carefully, and the short circuit induced by the lead abrasion may produce hidden fire trouble independent of battery performance.

3. Design of equalization circuit

This equipment is composed by a set of four charging series-wound battery pile, four measurement control and equalization modules and Holtek SCM HT47R47.

Figure 1 is the circuit frame of the battery module composed by a battery and its corresponding measurement control and equalization modules.

3.1 Voltage measurement

For several series-wound storage batteries (four), in the problems measuring the voltage needed to be solved, the main problem is the voltage sharing the ground. Because the anode of the upper battery connects with the cathode of the lower battery, various batteries don't share the ground when measuring. We can adopt the method of resistance sharing voltage to solve that problem. The principle of the method is seen in Figure 2. The method is to transform the voltage of B1 to U1, and transform the voltage of B1+B2 to U2, and transform the voltage of B1+B2+B3 to U3, and so on. So the U1, U2 and U3 produced by this method are signals sharing the ground, and the measurement is convenient.

3.2 Equalization process

The equalization circuit is composed by one switch pipe Q, one diode D and one inductance L (the measurement control and equalization module 4 has not his component). The connection mode is that after Q and D is parallel connected, they are connected with L in series, and then respectively connected with the anode and the cathode of the battery, where, the cathode of D connects the anode of the battery and L connects the cathode of the battery. In the automatic equalization equipment of series-wound storage battery pile, various equalization circuits are series-wound. When the battery voltage in the X'th module is the highest voltage, connect Q and cut other switches, and here, the inductance L_{x-1} and L_x charge and L_{x-1} receives the forward voltage L_x , and L_x receives the reverse voltage. When Q is cut, the inductance L_{x-1} charges to the batteries of various modules through $D_{x-1}, D_{x-2}, \dots, D_1$, and in the same way L_x charges to the corresponding batteries though $D_{x+1}, D_{x+2}, \dots, D_4$. When the difference of single battery voltage is less than certain value, all switch pipes will be cut and the equalization process stops.

The equalization equipment is composed by four lithium batteries in series, and the mean voltage of the battery pile is 4V, and the maximum voltage of single battery is 4.1V. Whether the battery pile is in the charge state, discharge state or

float state, the voltage signals of various single batteries are collected by the voltage inspection circuit in time, and analyzed by the SCM HT46R47. Through the comparison of these voltage signals, we will find one circuit which can fulfill the condition, which voltage is the highest one, and exceeds the mean voltage value to 0.02V, and we suppose it is the second circuit. So HT46R47 sends instruction to other circuits, orders their corresponding switch pipe Q close and transfer a pulse signal with 20KHz and 50% void occupation ratio. But when the circuit with highest voltage is the first circuit or the fourth circuit, i.e. the circuit is in the port of the equalization circuit, so the void occupation ratio is less than 1/2, and under other situations, this value is less than 2/3. Q_2 is connected or cut under the control of the pulse, and the energy is transferred from the battery with higher voltage to other batteries through the inductance. When the difference of the voltage of the second circuit battery with the mean voltage is less than 0.02V, Q_2 cuts. If other circuit fulfills the condition here, it will control the switch pipe connect or close in this circuit, or else, cut all switch pipes, and the equalization circuit of the storage battery is in the awaiting state. The selection condition of the control switch is the voltage value is the highest voltage and exceeds the mean voltage value 0.02V, which can avoid energy consumption and low life of switch pipe because of repeated switching actions under the situation that the voltage value difference is very small. Figure 3 is the principle of charge/discharge.

The discharge process is similar with the charge process, and the HT46R47 deals with the collected voltage signals, and finds out the circuit which voltage is the highest one and exceeds the mean voltage 0.02V, and we suppose it is the third circuit, lead the switch Q_3 , and charge to L_2 and L_1 , and make various batteries discharge under the situation keeping voltage close, and when the voltage can not fulfill the condition, Q_3 cuts.

3.3 MCU main control module

The MCU main control module based on HT46R47 microprocessor is the control core. HT46R47 is the SCM with 8 digital high performance simply instruction set, and specially designed for the product which needs implementing A/D transformation. The clock of the system is produced by the crystal oscillator. This clock is divided into four clock cycles without superposition in the interior of the chip. One instruction cycle includes four system clock cycles. The reading and implementation of the instruction is completed through the assembly line mode which can implement instruction operation in one instruction cycle. Therefore, most instructions can be performed completely in one cycle. Figure 4 is the principle of HT46R47 oscillating circuit.

4. Conclusions

In this article, we design a sort of equalization manager, which can be used with charge management and discharge management at the same time, and they are independent each other, and the equalization manager can be started in any stage of charge/discharge. The equalization voltage management of charge/discharge enhances the coherence of the single battery, reduces the accumulated influences of disequilibrium factors, and better solves the problem of a great lot of battery discarding induced by hybrid series-wound batteries with differences in the electrical cars.

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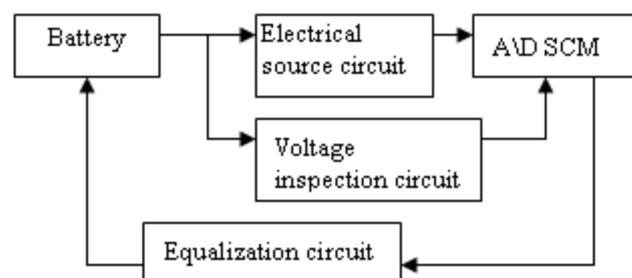


Figure 1. Circuit Frame of Battery Module

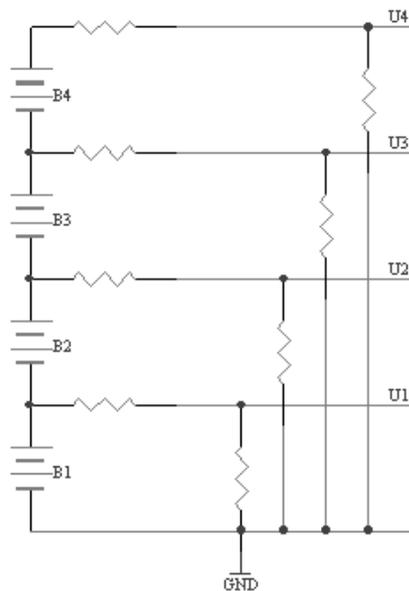


Figure 2. Principle of Voltage Measurement

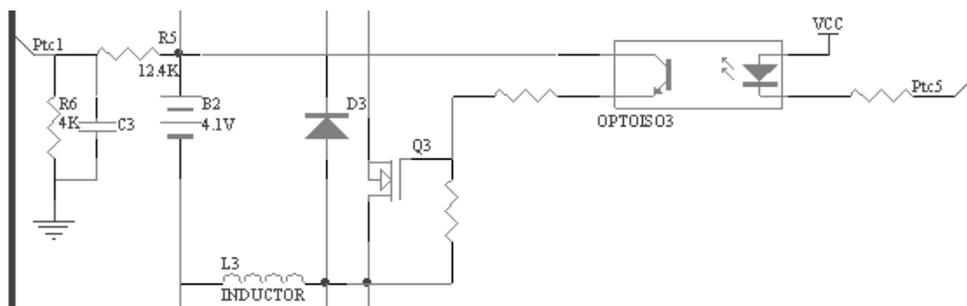


Figure 3. Principle of Charge/Discharge

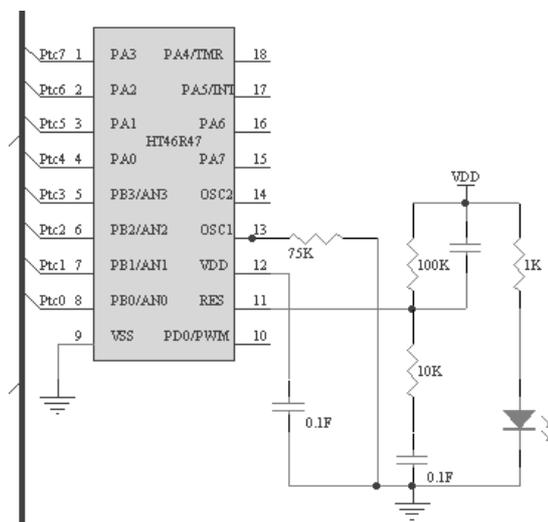


Figure 4. Principle of Oscillating Circuit