Lithium battery charge management storage device based on intelligent detection

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Abstract: In this paper, the long-term storage of lithium batteries is studied, and a lithium battery charge management memory device with charging and intelligent management functions is derived. The store has two selectable modes of operation. It not only can safely charge the lithium battery, but also can intelligently detect the lithium battery power and maintain it for a long time. It solves the problem that after the lithium battery is stored for a long time, the performance of the battery is seriously reduced due to deep discharge, and the battery life is greatly shortened.

1. Introduction
In today's advanced society where science and technology are highly advanced, the application of electronic products has spread all over the world. Lithium batteries are widely used in electronic products in various fields due to their high energy density and flat discharge voltage. We know that when a lithium battery is used as a secondary battery, when overcharging, overdischarging, and high-current charging occur, the phenomenon of lithium deposition on the negative electrode occurs, resulting in severe damage to the battery performance and shortened life. If you want to extend the battery's effective use time, in addition to the quality of the charger must be guaranteed, the correct charging skills are also essential, because the poor quality of the charger or the wrong charging method will affect the battery life and cycle life.

At present, for the overcharge and high-current charging problems, common technical measures include negative voltage increment control, time control, and temperature control. When the negative incremental control method is charging, it can determine whether the battery is full by detecting whether the battery voltage is negatively incremented, thereby changing the charging mode from constant voltage charging to trickle charging; the time control method passes the predetermined charging time when the charging time is reached, the charger stops charging or turns into a trickle charge; the temperature control method measures the temperature change of the battery to determine whether to stop charging, because the battery temperature rises faster when the battery reaches full charge. One of the common disadvantages of these technologies is that the battery can only be protected during the charging process. After the battery is stored for a long time, the battery will run out and the voltage will be too low to make the lithium battery unusable. None of the methods can be solved. In view of the above problems, this paper studies the long-term storage and maintenance technology of lithium batteries, and obtains a charge management memory that can safely charge and store lithium batteries for a long time, and has a high practical value.
2. Structure principle

The register has two modes, one is a charging mode, and the battery can be quickly charged to full power. The other type is the maintenance mode. When the lithium battery is not used, it is connected to the interface of the storage device. The storage device periodically detects the remaining power in the battery and charges the battery in time to maintain the battery power.

When it is necessary to charge the battery, the battery is switched into the memory, the charging mode is selected, and if the battery is stored, the maintenance mode is selected. Or just put the battery into the storage, without any settings, the store will intelligently determine and select the mode. After long-term storage, when you want to use the battery, you can fill the battery by selecting the charging mode.

![Figure 1. Schematic diagram of the structure](image)

The structure of the storage device is shown in Figure 1, which includes a circuit protection module 1, a rectifying and filtering module 2, a transformer module 3, an output circuit module 4, a switch module 5, an interface module 6, a lithium battery storage module 7, a heating module 8, and a sensor module 9 and the controller module 10 is composed.

1. Circuit protection module: It is composed of NTC and fuse, protection circuit to avoid excessive current and current surge, external input 220V AC;
2. Rectification filter module: It is composed of rectifier circuit and filter circuit;
3. Transformer module: It consists of a transformer and a mos tube. These two modules convert 220V AC into DC for battery charging;
4. Output circuit module: It is composed of capacitor and opto-isolator to reduce external interference;
5. Switch module: It is composed of relays and time switches, control circuit on and off;
6. Interface module: It is with several charging connection ports for simultaneous connection of multiple lithium batteries;
7. Lithium battery storage module: It is used to store the battery, connected to the interface module 6;
8. Heating module: It is used to heat the holder when the ambient temperature is too low;
9. Sensor module: It is mainly composed of a fuel gauge c, a current and voltage sensor d, and a temperature sensor e. The fuel gauge c is connected with the lithium battery module to detect the battery voltage, charge and discharge current, battery temperature, etc., and can provide information such as remaining battery capacity, charge status and battery voltage; current and voltage sensor d, detecting current and voltage in the circuit Value; temperature sensor e to monitor the ambient temperature;
10. Control module: consists of a single-chip microcomputer and an auxiliary circuit, which is
connected with the sensor module, the switch module and the heating module, collects the detected data through the sensor module, outputs a control command to switch the switch status of the module, and starts and stops the heating module.

The overall control process is shown in Figure 2.

When the battery is connected, the working mode is selected manually. Mode=1, for charging mode; Mode=2, for maintenance mode;

When the battery is connected and no mode is selected, when the SOC value is less than 1, the register enters the charging mode; when the SOC value is equal to 1, the register enters the maintenance mode;

After the charge mode is completed, the battery is not removed after t1, the memory is switched to maintenance mode.

3. Control rules

3.1 Charging mode
When Mode=1, the storage device enters the charging mode. At this time, the ambient temperature, the charging current, and the voltage are all within the safe range during the entire process. The battery temperature is maintained at 0°C or more, and charging is performed by using the quick charging method. Charging mode control process is shown in Figure 3.
Figure 3. charging mode control flow chart

1. When the battery voltage is less than the voltage lower limit (Voltage_LO), the charge switch is turned on (On). At this time, the trickle charge is performed, that is, the battery with a deep discharge depth is recharged. The trickle charge current is one tenth of the constant current charge current, i.e., 0.1C. For example, if the constant charge current is 1A, the trickle charge current is 100mA;

2. When the battery voltage value is greater than the voltage lower limit (Voltage_LO) and less than the voltage upper limit (Voltage_HI), the charging switch is turned on (On). At this time, constant current charging is performed, that is, when the battery voltage rises above the threshold of the trickle charging voltage, the charging current is increased. Constant current charging. The constant current charging current is between 0.2C and 1.0C;

3. When the battery voltage value is greater than the voltage limit (Voltage_HI), the charge switch is on (On) at this time for constant voltage charging, that is, when the power is nearly full, the constant current charge ends and the constant voltage charging phase begins. According to the saturation of the battery, the charging current gradually decreases from the maximum value as the charging process continues;

4. When the SOC value of the battery reaches 1, the charge switch is turned off (Off), and the
charging is completed.

3.2. Maintenance Mode

Studies have shown that the battery’s remaining power is controlled in a semi-electric state, which is about 40% of the power, which is conducive to the long-term storage of the battery. When Mode = 2, the register enters maintenance mode and the battery is maintained for maintenance. The maintenance mode control process is shown in Figure 4.

![Maintenance Mode Control Flow Chart](image)

Figure 4. Maintenance mode control flow chart

When the battery SOC value is less than or equal to the SOC lower limit (SOC_LO), the battery is charged and turned on (On) battery trickle charge; in the maintenance mode, due to not pursuing fast charge in a short time, the trickle charging method is adopted, This is also the least charging method for battery damage;

When the battery SOC value is greater than or equal to the SOC upper limit (SOC_HI), the charge closes the switch (Off) to end the charge.

In the maintenance mode, the selection of the upper and lower limits of the battery SOC value has a great influence on the battery life. As the lithium battery has an irrecoverable capacity loss during storage, this loss is large at the early stage of storage and gradually decreases at the later stage. At the beginning of storage, the upper and lower limits of the SOC are slightly larger. Taking into account the ambient temperature, and different periods of lithium battery irreversible capacity loss is different, the battery maintenance mode SOC value of the upper and lower limits of the calculation, based on SOC_LO0, SOC_HI0, multiplied by the temperature coefficient λ1, multiplied by the life factor λ2. SOC_LO0, SOC_HI0 are the experimentally measured values or the battery SOC value upper limit referenced in the lithium battery specification.

If the standard temperature is 20°C and the total charge-discharge cycle is 500 times, the current temperature is set to a, and the number of charged and discharged times is b.
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\lambda_1 = (1 - \frac{|a - 20|}{63}), \quad \lambda_2 = 1.1 \times (1 - \frac{b}{500})
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SOC_LO = \lambda_1 \lambda_2 \times SOC_{LO0}, \quad SOC_HI = \lambda_1 \lambda_2 \times SOC_{HI0}

When the temperature of the lithium battery drops below 0°C, the battery's charging ability also rapidly drops, and even the battery cannot be charged. Therefore, the SOC's upper and lower limit values are slightly higher at low temperatures.

4. Conclusion
The lithium battery storage device studied in this paper solves the problem that after the long-term storage of the lithium battery, the battery performance is seriously degraded due to deep discharge, and the battery life is greatly shortened. Its innovation lies in that by regularly detecting the remaining battery power, it is possible to charge the battery before it is deeply discharged, maintain its internal power, avoid over-discharge of the battery, and fully consider the charging characteristics of the lithium battery. Over-charging, high-current charging, and low-temperature charging greatly extend the life of lithium batteries. This study meets the needs of today's era of low-carbon, energy-saving and environmental protection and has strong practical value.

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