Design of digital charger based on AVR microcontroller

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Abstract. Most of the rechargeable batteries in the equipment can only use a dedicated charger, and it is impossible to determine the charging parameters and the remaining charging time. In order to solve this problem, we design a digital charger, single-chip microcomputer control as the core, to real time control of rechargeable batteries, can real time collection and rechargeable battery voltage, current, the rest of the parameters such as charging time, can also by serial port and PC communication, and through the display device according to the necessary information to users.

1. Introduction
In contemporary times, mobile phones, digital products, laptop computers, electric bicycles and other commonly use rechargeable batteries as power supply, the use of rechargeable batteries is very extensive. However, most of the rechargeable batteries in the devices can only use a dedicated charger, and most of the general chargers take a long time to charge, and it is impossible to judge their charging parameters and the remaining charging time.

This paper introduces the design of a universal digital charger based on AVR microcontroller. The charger of the battery charging process in intelligent control, real-time acquisition of battery voltage, current parameters, calculate the battery has power and the rest of the charging time, can also through the serial port and PC communication, and through the display part shows the necessary information to users, it can also change according to user needs charging parameter, to adapt to the different types of battery charging\textsuperscript{[1]}.

2. Hardware structure of digital charger
The hardware design structure diagram of digital charger is shown in figure 1. The main components include power circuit, microcontroller chip, battery pack, RS232 communication interface, etc., forming a microcontroller control system. The following is a brief description of several parts of the hardware architecture\textsuperscript{[2]}.
2.1. Power circuit
The power circuit is composed of power transformer, rectifier circuit, filter circuit and voltage regulator circuit. The working power supply of the single-chip control system is DC4.5V~5.5V. Therefore, the task of the power circuit is to convert AC220V voltage to ABOUT DC5V by using the above circuit part.

2.2. Microcontroller control circuit
The CHIP adopts AVR series of chip microcomputer ATmega16. The MCU has an 8-channel 10-bit A/D converter, four PWM channels, four 8-bit bidirectional parallel ports, three timers, three external interrupts and one USART serial port resource. The task of the MCU is to collect the charging state of the battery in real time through the internal A/D converter, determine the charging current in the next stage through calculation, and then output instructions to control the charging current. The MCU can store data and display the current battery status in real time by communicating with the host computer (PC) through serial port[3].

2.2.1. Sampling of battery voltage and current
Voltage and current are sampled using an eight-channel, 10-bit A/D converter inside the ATmega16. The AVCC power supply of the converter shall be connected to the VCC power supply of the single chip microcomputer through a low-pass filter. The charging current is converted to 0~5V voltage by DBC0.1/O DC small current current sensor. The voltage value of the current sampling and the battery voltage value are converted respectively through the analog input channel of A/D converter. The results are filtered by the single chip microcomputer and then sent to the corresponding storage unit. The data can be sent to the upper computer (PC) through the RS-232C communication interface through the serial port.

2.2.2. PWM output
The charger controls the charging current by changing the duty ratio of PWM. PWM generator adopts the PWM output function of ATmega16 internal timer/counter 1, and adjusts the duty ratio, period and phase of PWM signals by changing the control register (TCCR1A) and OCR1A values of the timer/counter. Duty ratio \( D = \frac{OCR1A}{1023} \), average voltage \( V = D \times 5 = \frac{5 \times OCR1A}{1023} \).

2.3. RS-232 communication interface
The UART of ATmega16 chip is used to establish simple RS-232 communication with PC COM. The communication principle diagram of ATmega16 and PC is shown in figure 2.
3. Digital charger software design

3.1. Sampling of battery voltage and current

Signal conditioning circuit collects and conditions the electrical signals, and transmits them MCU controller. Optimization of circuit design is directly related to positioning accuracy and stability of the system. In this paper, signal conditioning circuit adopts LTC1569 general filter, which is high precision filter and can recuperate the sensor output signal. Compared with the ordinary active filter, LTC1569 filter has the advantages of low external components, simple structure, convenient parameter adjustment and good stability [4].

During the battery voltage and current sampling, the voltage value and battery voltage value of the current sampling are converted respectively through the analog input channel of A/D converter, and the conversion results are sent to the DATA register (ADCL and ADCH) of ATmega16. When reading the results, the high and low bits should be read separately, and then the high and low bits should be combined for data. The charging time and the remaining charging time are calculated by single chip microcomputer. The remaining charging time is equal to the difference between the preset charging time and the charged time. The preset time can be obtained in advance according to the type of battery.

3.2. Charging control program of digital charger

To charge different types of batteries, MCU needs to set different charging parameters and choose different charging schemes. So charging control during initialization program, the user will be rechargeable battery of model parameters, including the types of rechargeable batteries (nickel cadmium (Ni-Cd), nickel metal hydride (Ni-MH) and lithium (Li-ion)), the capacity of rechargeable batteries (unit for mAh), and other information via the keyboard microcontroller, depending on the input information, SCM can set different charging parameters, can also be set or modified by the upper machine charging parameters.

In addition, the full degree of the battery should be intelligently judged according to the voltage or voltage change rate during the charging process, so that the battery can be fully charged without less charging or overcharging, and the battery can be protected to the maximum extent. The program also requires the forced termination of charging under abnormal conditions such as overcurrent and overvoltage of the battery. Depending on the type of battery, the following criteria are used to finish the charge: 1. Peak voltage detected by PVD (for nickel-cadmium, nickel-hydrogen batteries). 2. Minimum charge current detection (for lithium-ion batteries). 3. Maximum temperature detection. 4. Maximum charging time detection.

In the process of controlling constant current and constant voltage, proportional control is adopted, that is, if the charging current is greater than the set current, the duty ratio of PWM will be reduced in proportion. Conversely, increase the duty ratio of PWM in proportion. SCM also needs to constantly
detect and receive the command sent by the upper computer, and according to the requirements of the upper computer data real-time communication to the upper computer.

3.3. Upper computer (PC) user interface
Upper computer (PC) program written by Visual Basic. Its main task is to send a query command to the serial port every time interval, read the information sent back by the single chip microcomputer, and extract the parameters such as charging current, charging voltage and working state[5]. After data processing and transformation, the parameters are displayed in THE VB interface, where the current working state of the battery and the remaining charging time can be conveniently observed.

4. Charging performance test of digital charger
SONY lithium ion battery model US18650 is selected here, with rated capacity of 1800mAh; After measuring, at around 4.2 V battery internal resistance of about 0.3 Ω. Take the constant current charging current 1/3C= 0.6a, cut-off voltage of 4.2V, and mark current at the end of charging as 0.06a to conduct charging test. Figure 3 shows the curves of voltage, current and capacitance during charging[5].

![Figure 3. Charge performance test of lithium ion battery.](image)

The charging time is about 230 minutes. If the charging time needs to be further shortened, just set a higher charging current at the initial time.

5. Conclusions
This digital charger can charge different types of batteries, SCM set different charging parameters according to the battery type, choose different charging schemes. The battery can be judged intelligently according to voltage or voltage change rate during charging Full degree, make the battery charging full, neither less charge nor overcharge, maximum protection of the battery. The hardware composition and software design of the charger are reliable, with strong portability, and can be easily applied to different applications.

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