

# The Design of Battery Protection Circuit and Its Application in Solar Street Lamp

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**Key words:** solar street lamp, battery, protection circuit design

**Abstract:** Solar panels convert solar energy into electrical energy stored in the battery and provide power for the solar street lamp. The voltage of solar panel power supplying is not stable, resulting in the problem of over charge and over discharge for battery in the use process of solar street lamp. The above problems lead to the battery life is reduced, and the service life of the solar street lamp is directly affected. In order to solve the above problems, the protective circuit of the battery was designed in this paper, including charging circuit design, discharging circuit design, voltage detection circuit design and current detection circuit design.

## 1. Introduction

The battery is reserve energy equipment and key component of the solar energy street lamp, which directly affects the service life of the solar street lamp. During the day, the solar battery charge the battery, at night the system and the load of the electricity used by the battery to provide, rainy days of power supply also rely on the battery to complete. A large number of research results show that the battery charging and discharging mode determines the battery life, the incorrect charging and discharging mode will not only reduce the battery energy storage capacity, but also shorten the battery life. A large number of experiments show that the battery voltage is always maintained between the 23.5V-25V, and the protection of charged and over discharge for batter can effectively extend the life of the battery. The experiment shows that the frequent charging and discharging of the battery will greatly reduce the life of the battery. The 95% of premature battery is the overcharge and over discharge caused, and the battery life of no overcharge and over discharge protection circuit is only 1 to 2 years; the battery life can reach more than 3 years if taken over charge and over discharge protection measures.

## 2. The charging circuit design

The battery charging circuit diagram was shown in figure 1. After the solar panel voltage by R2 and R1, sent to the microcontroller A/D conversion port AD1 detection to determine the intensity of light. In the daytime, the light is sufficient, so the battery is charged by the solar panel. Used continuously detecting battery terminal voltage as a method to control the degree of charge. Set the

conversion of the battery terminal voltage to control each stage of the automatic conversion and stop charging.

To extend battery life and improve the charging efficiency, the controller charged the battery based on the float and charging combination way. In Fig.1, constantly detected the battery voltage, the R3, R4 and 10K potentiometer W1 voltage was sent to the MCU AD2. After A/D conversion, the continuous change of voltage signal was converted to discrete digital signal. The microcontroller I/O port issued a high and low level signal to control the transistor T2 on and off and T1 tube IRFZ44N off and on, so as to control the battery charging status. In the battery charging early, T2 conduction, T1 shutdown, solar panels by Schottky diode D1 to T1 sustained in charge until the end voltage of the battery charging to the float point. Then by the microcontroller /O I port issued PWM signal, fast controlled the on and off of T2and T1, to realize the battery pulse charging. When the battery voltage is charged to the charging point, the microcontroller I/O port issued a low level signal to T2 shutdown and T1conduction, solar battery and T1 tube formed circuit, stop charging the battery, to form the battery over charge protection. When the battery voltage drops to float voltage and recovery voltage, separately carried on the pulse charge and full charge.

### 3. The discharging circuit design

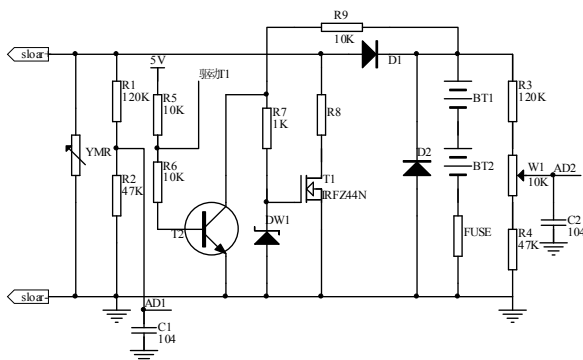


Fig. 1 The charging circuit diagram

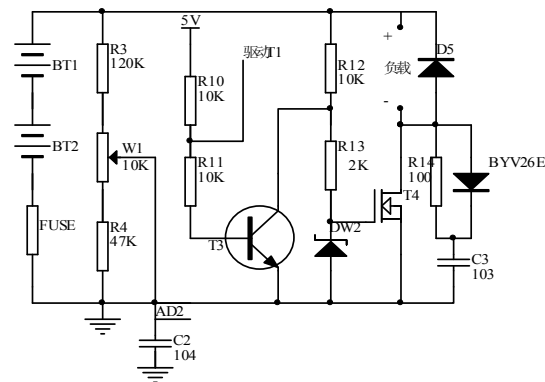


Fig. 2 The discharging circuit diagram

When the discharging circuit detected the solar panel voltage is less than 1V, turn on the control circuit, delay 1 minutes later, LED power supply by the battery, LED lights lit. The Fig. 2 is the discharging circuit, the battery voltage is very large as full of power generally in the 24.6 ~ 25.6V. The optimal driving current of a single white LED is 15 ~ 20mA and the driving voltage is 3 ~ 3.2V. According to this calculation, the current flowing through the LED is 26.7 ~ 31.5mA, beyond the acceptable 15 ~ 20mA. In order to solve this problem, when the battery voltage changed between 24 ~ 26V, used PWM (pulse width modulation) technology to rapidly control the transistor T3 and MOSFET tube T4 turn off and on. Adjust duty cycle, the load voltage at both ends was stability at 24V to achieve the LED constant current, so as to achieve the purpose of prolonging the service life of LED. When the battery voltage was lower than the over discharge protection voltage 23.5V, the microcontroller I/O issued a high level signal, so that T3 conduction, T4 shutdown, the battery was no longer to supply load power. When the battery voltage recovery to the over discharge voltage 24V, the signal was sent out by the I/O, which made the T3 shutdown and the T4 conduction, the battery continued to supply the load power. When the voltage is changed from 25.6V to 24.6V, the load is PWM power supply. In Fig. 2, the shutdown buffer circuit was designed

including T21, resistance R14, fast recovery diode BYV26E and capacitor C3, also called du/dt suppression circuit. As the T4 shutdown, the load current through the C3 to the BYV26E discharge, reduced the burden of T4, inhibited the du/dt and over voltage, reduced the shutdown loss. In the design of the buffer circuit, the selection of the buffer capacitor, the absorption resistance and the fast recovery diode should be considered. The diode generally used fast recovery diode, and its rated current should be not less than the main circuit device 1/10, considered the maximum discharge current was 8A, the selected fast recovery diode rated current should not be less than 0.8A. The fast recovery diode BYV26E was selected as 1A, which satisfied the selection principle. The value of the buffer capacity and the absorption resistance can be determined by the experimental method, and can also refer to the relevant engineering manual. According to the experimental results, selected R14=100Ω、C3=103.

#### 4. The voltage detection circuit design

The solar street lamp voltage detection requires sampling battery voltage and solar battery voltage, and the zero potential point entire of system is the same point, so chosen the negative electrode for solar battery.

The voltage detection circuit was mainly used to collect the voltage at both ends of the battery, as shown in Fig. 3. The voltage of 0 ~ 26V was converted to 0 ~ 3.3V by using 2 resistances, and the input data of A/D was used to read the data, which was converted into digital signal, and then the digital signal was converted into analog signal. The main components were resistance, operational amplifier and voltage regulator diode in this detection circuit. LM358 was a single supply dual operational amplifier, which was made into a voltage follower to improve the driving ability of the circuit.

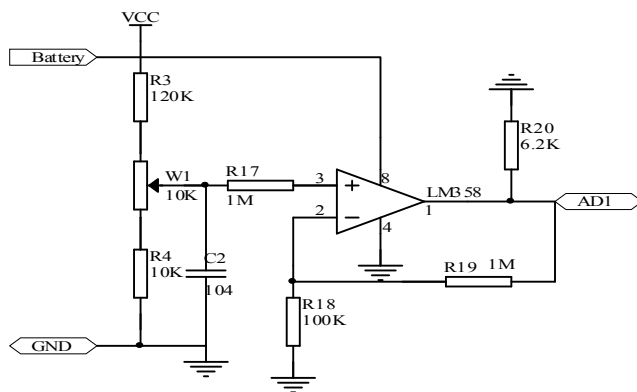


Fig.3 The voltage detection circuit

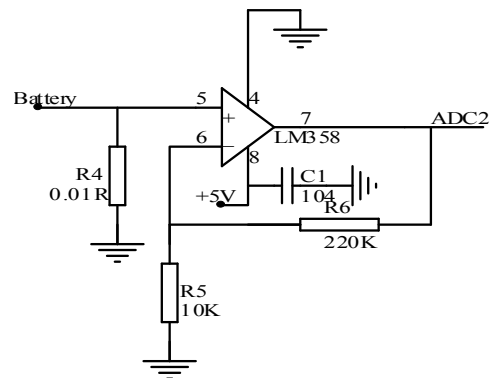


Fig.4 The current detection circuit

#### 5. The current detection circuit design

The battery current sampling circuit was mainly using small resistance sampling, and the small resistance at both ends of the sampling voltage was amplified by the operational amplifier. At noon the sun is relatively sufficient condition, so the maximum charge current can reach 6A, in the morning and evening when the charge current is less than 1A, after several experiments found that the battery charging current fluctuates in the range of 0-6A. The sampling resistance of 0.01 ohm was selected, and the voltage sampled value was sent to the operational amplifier to amplify, and the inverse proportion was amplified, as shown in Fig. 4. The magnification was 23 times and the

output was controlled in 0-3.3V, then the amplified signal was sent to the I/O port of the microcontroller. After A/D, the final was converted to analog signals and displayed on the terminal. The experimental data obtained from the current sampling was stored on a regular basis and the data can be analyzed in the end. The relationship of the charge current, time and season for the battery was obtained, which provided a lot of scientific data for the later analysis of the battery characteristics.

## 6. Conclusion

The power voltage of solar panels supplied was instability caused problem of battery overcharge and over discharge, so designed the charging circuit, discharging circuit, voltage detection circuit and current detection circuit to solve the problem. Designed the protection circuit to effectively protected the battery used in the solar street lamp. The life and performance of the battery were improved, and the service life of the solar street lamp was prolonged.

## 7. References

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