Design of a Lead-Acid Battery Charging and Protecting IC in Photovoltaic System

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1.Introduction

Solar energy as an inexhaustible, inexhaustible source of energy more and more attention. Solar power has become popular in many countries and regions, solar lighting has also been put into use in many cities in China. As a key part of the solar lighting, battery charging and protection is particularly important. Sealed maintenance-free lead-acid battery has a sealed, leak-free, pollution-free, maintenance-free, low-cost, reliable power supply during the entire life of the battery voltage is stable and no maintenance, the need for uninterrupted for the various types of has wide application in power electronic equipment, and portable instrumentation. Appropriate float voltage, in normal use (to prevent over-discharge, overcharge, over-current), maintenance-free lead-acid battery float life of up to 12 ~ 16 years float voltage deviation of 5% shorten the life of 1/2. Thus, the charge has a major impact on this type of battery life. Photovoltaic, battery does not need regular maintenance, the correct charge and reasonable protection, can effectively extend battery life. Charging and protection IC is the separation of the occupied area and the peripheral circuit complexity. Currently, the market has not yet real, charged with the protection function is integrated on a single chip. For this problem, design a set of battery charging and protection functions in one IC is very necessary.

2.System design and considerations

The system mainly includes two parts: the battery charger module and the protection module. Of great significance for the battery as standby power use of the occasion, It can ensure that the external power supply to the battery-powered, but also in the battery overcharge, over-current and an external power supply is disconnected the battery is to put the state to provide protection, the charge and protection rolled into one to make the circuit to simplify and reduce valuable product waste of resources. Figure 1 is a specific application of this Ic in the photovoltaic power generation system, but also the source of this design.

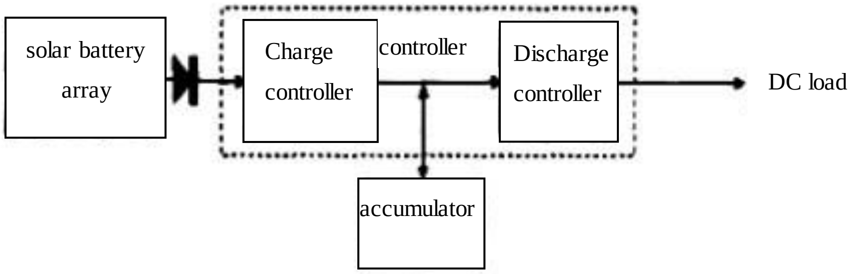

Figure1 Photovoltaic circuit system block diagram

Maintenance-free lead-acid battery life is usually the cycle life and float life factors affecting the life of the battery charge rate, discharge rate, and float voltage. Some manufacturers said that if the overcharge protection circuit, the charging rate can be achieved even more than 2C (C is the rated capacity of the battery), battery manufacturers recommend charging rate of C/20 ~ C/3. Battery voltage and temperature, the temperature is increased by 1 ℃, single cell battery voltage drops 4 mV, negative temperature coefficient of -4 mV / ° C means that the battery float voltage. Ordinary charger for the best working condition at 25 ℃; charge less than the ambient temperature of 0 ℃; at 45 ℃ may shorten the battery life due to severe overcharge. To make the battery to extend the working life, have a certain understanding and analysis of the working status of the battery, in order to achieve the purpose of protection of the battery. Battery, there are four states: normal state, over-current state over the state of charge, over discharge state. However, due to the impact of the different discharge current over-capacity and lifetime of the battery is not the same, so the battery over discharge current detection should be treated separately. When the battery is charging the state a long time, would severely reduce the capacity of the battery and shorten battery life. When the battery is the time of discharge status exceeds the allotted time, the battery, the battery voltage is too low may not be able to recharge, making the battery life is lower.

Based on the above, the charge on the life of maintenance-free lead-acid batteries have a significant impact, while the battery is always in good working condition, battery protection circuit must be able to detect the normal working condition of the battery and make the action the battery can never normal working state back to normal operation, in order to achieve the protection of the battery.

3.Units modular design

3.1The charging module

Chip, charging module block diagram shown in Figure 2. The circuitry includes current limiting, current sensing comparator, reference voltage source, under-voltage detection circuit, voltage sampling circuit and logic control circuit.

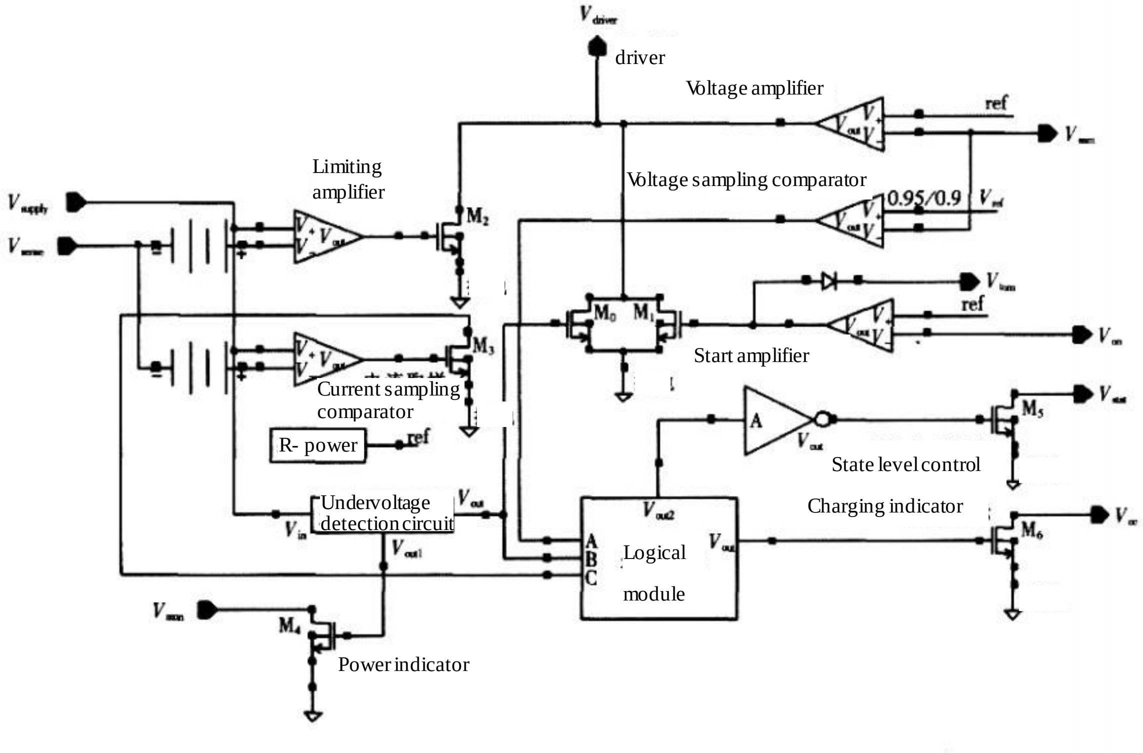

Figure2 Charging module block diagram

The module contains a stand-alone limiting amplifier and voltage control circuit, it can control off-chip drive, 20 ~30 mA, provided by the drive output current can directly drive an external series of adjustment tube, so as to adjust the charger output voltage and current . Voltage and current detection comparator detects the battery charge status, and control the state of the input signal of the logic circuit. When the battery voltage or current is too low, the charge to start the comparator control the charging. Appliances into the trickle charge state when the cut-off of the drive, the comparator can output about 20 mA into the trickle charge current. Thus, when the battery short-circuit or reverse, the charger can only charge a small current, to avoid damage to the battery charging current is too large. This module constitutes a charging circuit charging process is divided into two charging status: high-current constant-current charge state, high-voltage charge status and low-voltage constant voltage floating state. The charging process from the constant current charging status, the constant charging current of the charger output in this state. And the charger continuously monitors the voltage across the battery pack, the battery power has been restored to 70% to 90% of the released capacity when the battery voltage reaches the switching voltage to charge conversion voltage Vsam charger moves to the state of charge. In this state, the charger output voltage is increased to overcharge pressure Voc is due to the charger output voltage remains constant, so the charging current is a continuous decline. Current down to charge and suspend the current Ioct, the battery capacity has reached 100% of rated capacity, the charger output voltage drops to a lower float voltage VF.

3.2 Protection Module

Chip block diagram of the internal protection circuit shown in Figure 3. The circuit includes control logic circuit, sampling circuit, overcharge detection circuit, over-discharge detection comparator, overcurrent detection comparator, load short-circuit detection circuit, level-shifting circuit and reference circuit (BGR).

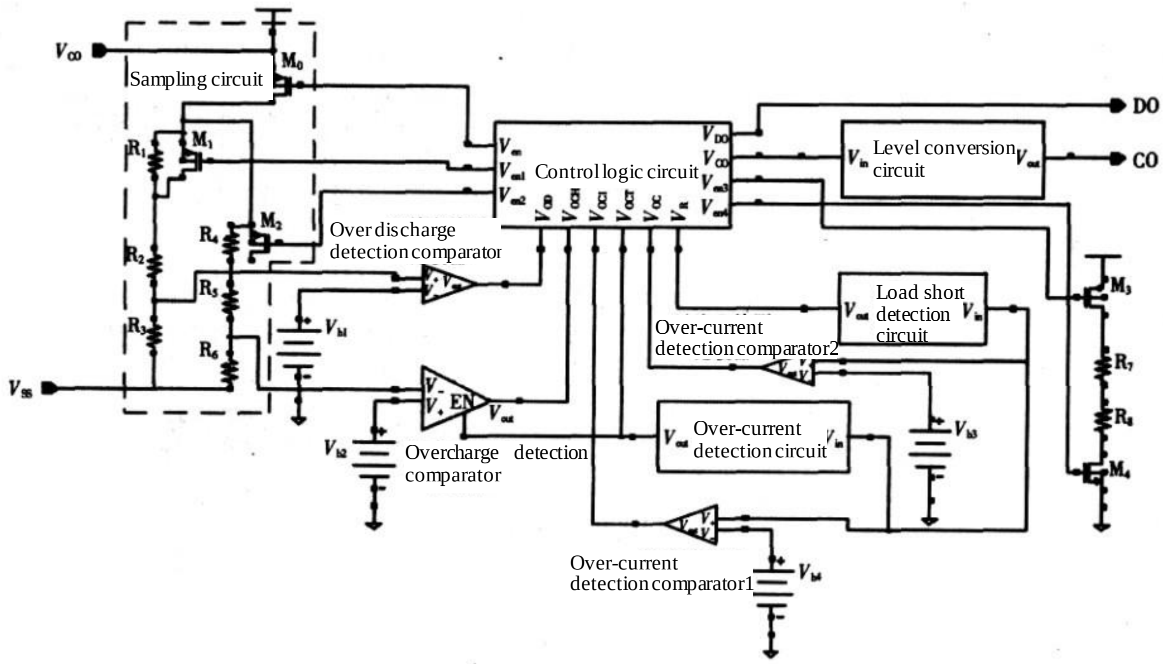

Figure3 Block diagram of battery protection

This module constitutes a protection circuit shown in Figure 4. Under the chip supply voltage within the normal scope of work, and the VM pin voltage at the overcurrent detection voltage, the battery is in normal operation, the charge and discharge control of the chip high power end of the CO and DO are level, when the chip is in normal working mode. Larger when the battery discharge current will cause voltage rise of the VM pin at the VM pin voltage at above the current detection voltage Viov, then the battery is the current status, if this state to maintain the tiov overcurrent delay time, the chip ban on battery discharge, then the charge to control the end of CO is high, the discharge control side DO is low, the chip is in the current mode, general in order to play on the battery safer and more reasonable protection, the chip will battery over-discharge current to take over the discharge current delay time protection. The general rule is that the over-discharge current is larger, over the shorter the discharge current delay time. Above Overcharge detection voltage, the chip supply voltage (Vdd> Vcu), the battery is in overcharge state, this state is to maintain the corresponding overcharge delay time tcu chip will be prohibited from charging the battery, then discharge control end DO is high, and charging control terminal CO is low, the chip is in charging mode. When the supply voltage of the chip under the overdischarge detection voltage (Vdd <Vdl,), then the battery is discharged state, this state remains the overdischarge delay time tdl chip will be prohibited to discharge the battery at this time The charge control side CO is high, while the discharge control terminal DO is low, the chip is in discharge mode.

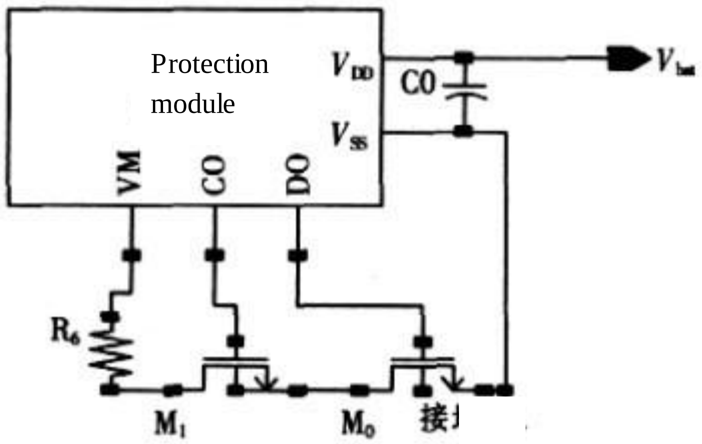

Figure4 Protection circuit application schematic diagram

4.Circuit Design

Two charge protection module structure diagram, the circuit can be divided into four parts: the power detection circuit (under-voltage detection circuit), part of the bias circuit (sampling circuit, the reference circuit and bias circuit), the comparator (including the overcharge detection /overdischarge detection comparator, over-current detection and load short-circuit detection circuit) and the logic control part.

This paper describes the under-voltage detection circuit (Figure 5), and gives the bandgap reference circuit (Figure 6).

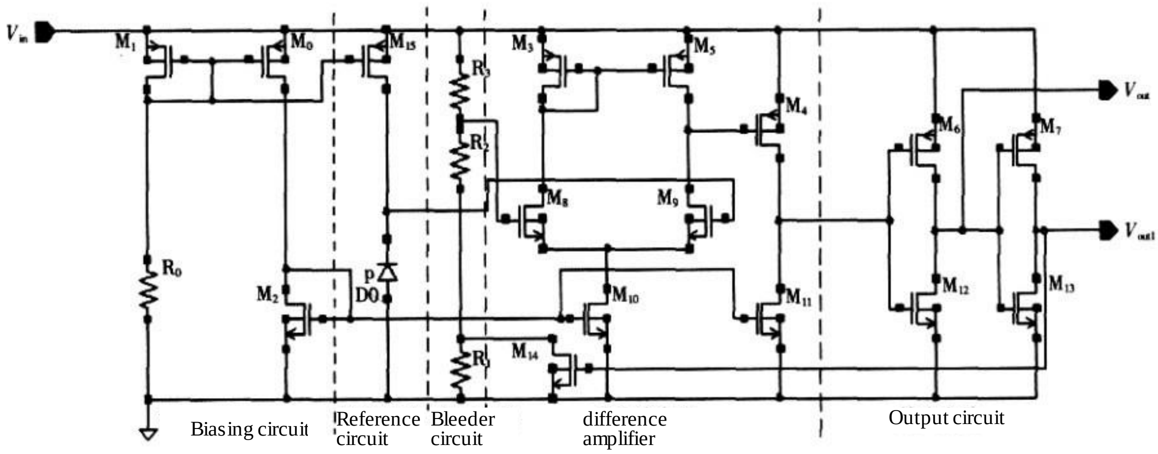

Figure5 Under-voltage detection circuit

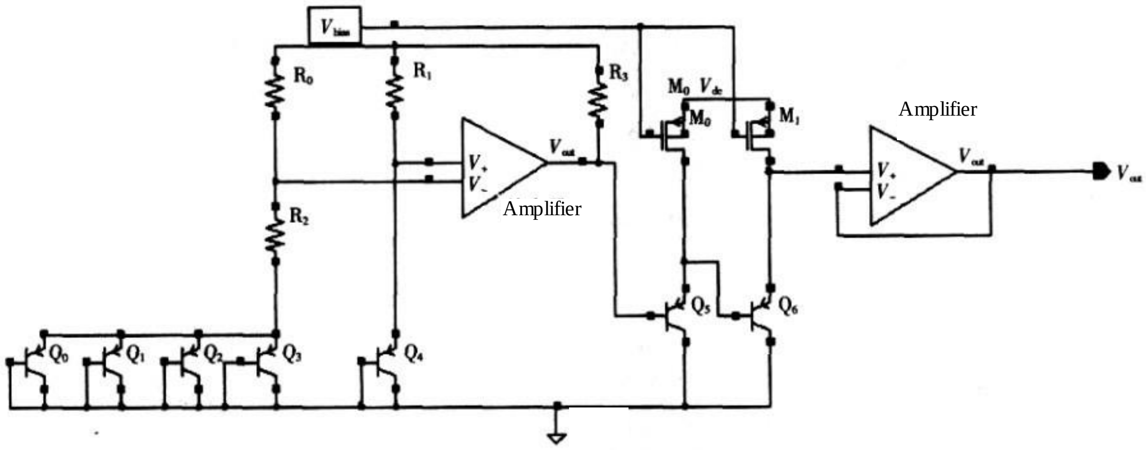

Figure6 A reference power supply circuit diagram

Battery charging, voltage stability is particularly important, undervoltage, overvoltage protection is essential, therefore integrated overvoltage, undervoltage protection circuit inside the chip, to improve power supply reliability and security. And protection circuit design should be simple, practical, here designed a CMOS process, the undervoltage protection circuit, this simple circuit structure, process and easy to implement and can be used as high-voltage power integrated circuits and other power protection circuit.

Undervoltage protection circuit schematic shown in Figure 5, a total of five components: the bias circuit, reference voltage, the voltage divider circuit, differential amplifier, the output circuit. The circuit supply voltage is 10V; the M0, M1, M2, R0 is the offset portion of the circuit to provide bias to the post-stage circuit, the resistance, Ro, determine the circuit's operating point, the M0, M1, M2 form a current mirror; R1 M14 is the feedback loop of the undervoltage signal; the rest of the M3, M4 and M5, M6, M7, M8, M9, M10, M11, M12, M13, M14, composed of four amplification comparator; M15, DO, a reference voltage, the comparator input with the inverting input is fixed (V+), partial pressure of the resistance R1, R2, R3, the input to the inverting input of the comparator, when the normal working of the power supply voltage, the inverting terminal of the voltage detection is lost to the inverting terminal voltage of the comparator is greater than V+. Comparator output is low, M14 cutoff, feedback circuit does not work; undervoltage occurs, the voltage divider of R1, R2, R3, reaction is more sensitive, lost to the inverting input voltage is less than V when the resistor divider, the comparator the output voltage is high, this signal will be M14 open, the voltage across R into M at both ends of the saturation voltage close to 0V, thereby further driving down the R1> R2, the partial pressure of the output voltage, the formation of the undervoltage positive feedback. Output, undervoltage lockout, and plays a protective role.

5. Simulation results and analysis

The design of the circuit in CSMC 0.6 μm in digital CMOS process simulation and analysis of the circuit. In the overall simulation of the circuit, the main observation is that the protection module on the battery charge and discharge process by monitoring Vdd potential and Vm potential leaving chip CO side and DO-side changes accordingly. The simulation waveform diagram shown in Figure 7, the overall protection module with the battery voltage changes from the usual mode conversion into overcharge mode, and then return to normal working mode, and then into the discharge mode, and finally back to normal working mode. As the design in the early stages of the various parameters to be optimized, but to provide a preliminary simulation results.

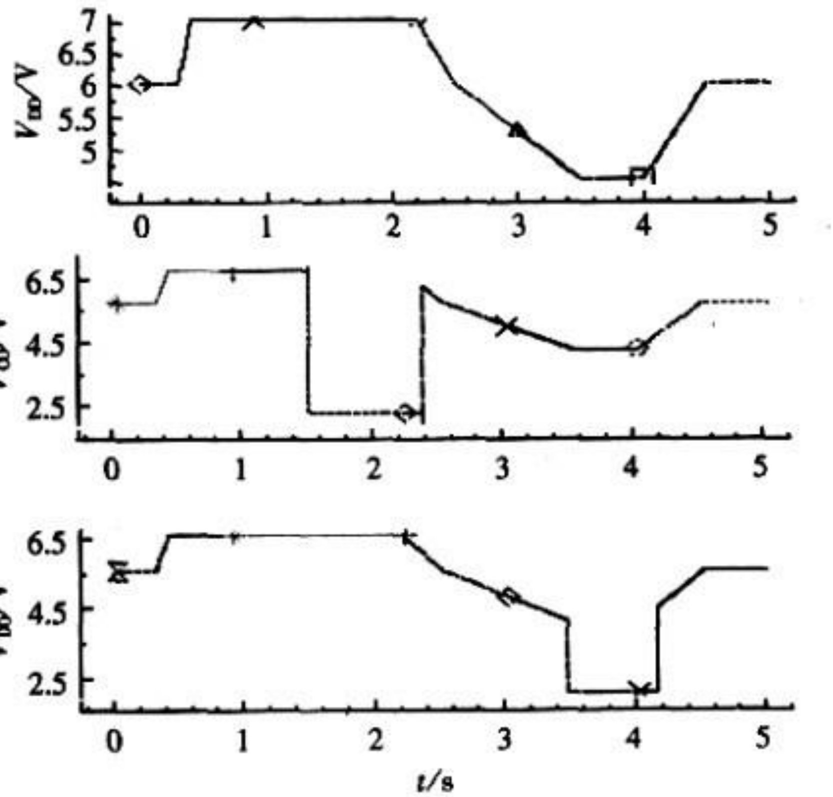

Figure7 Overvoltage and under-voltage protection circuit simulation waveform

6.Conclusion

Designed a set of battery charging and protection functions in one IC. This design not only can reduce the product, they can reduce the peripheral circuit components. The circuit uses the low-power design. This project is underway to design optimization stage, a complete simulation can not meet the requirements, but also need to optimize the design of each module circuit.