

## **The Realization of Portable Mobile Power Supply with Low Power Consumption**

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**Abstract:** With the emergence of a large number of smart mobile products, it has brought great convenience to our life. However, at present, the battery power of mobile devices cannot provide longer endurance to the equipment, so portable power supply came into being. According to the structure characteristics and working principle of mobile power source, this paper proposes a mobile power supply design scheme with high power conversion efficiency and low power consumption. It gives the hardware circuit design and software process, hardware object debugging, and has very strong practical application value.

### **1. Introduction**

With the rapid development of the global economy and the popularization of 3G, 4G and WiFi networks, a large number of smart mobile products, such as smart phones, tablets computers, digital cameras and smart wearable devices, have brought great convenience to our lives. These smart mobile products generally use lithium batteries for power source. Once the lithium batteries run out of power, they can no longer be used [1]. At present, since the digital products are used more frequently and their functions are increasingly diversified, how to extend the service time of mobile electronic products and give full play to their maximum functions become particularly important.

### **2. Overall framework design of portable power source**

The structure of the portable power source system is shown in Figure 1. The system is mainly composed of the following modules: lithium battery charging module, DC- DC boost module, circuit protection module and MCU (micro- controller unit) control module [2]. When users use the portable power source to charge their digital products, the energy of the portable power source depends on the large- capacity lithium battery pack carried by itself. The lithium battery pack in this system uses the discarded notebook computer battery, realizing the reuse of the battery. The charging module uses the charging controller MT 2011 chip, which is responsible for charging the lithium battery and supports 4.5V to 6.5V voltage input with a maximum charging current of 2A; The boost module uses SY 7065A chip and is responsible for increasing the battery voltage from 3.7V to 5V and charging the mobile digital products; The circuit protection module is responsible for monitoring whether the voltage and current of the system are normal; While the MCU control module is mainly used to control the chips of all modules, calculate the parameters and display the status of the portable power source.

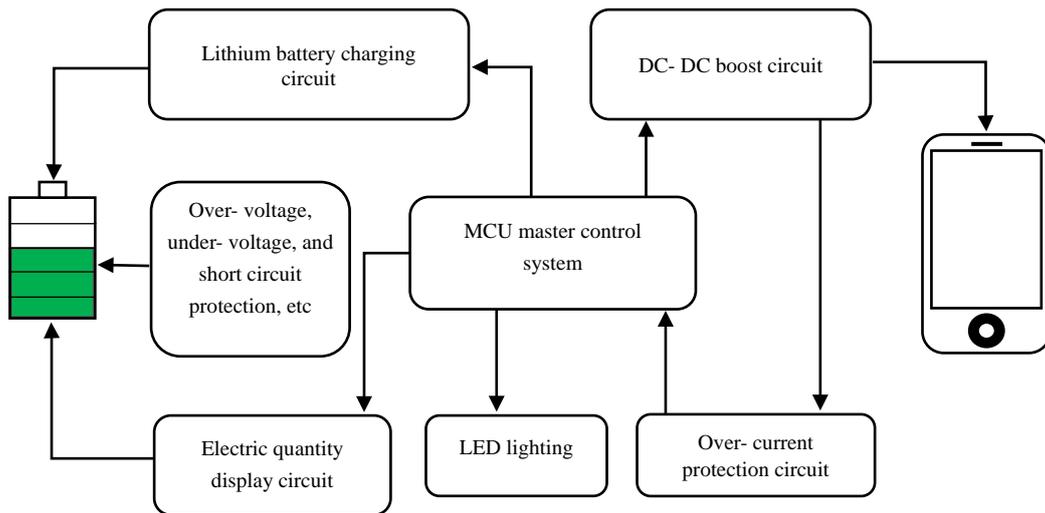


Fig.1. The structure of the portable power source system

This power source has two USB interfaces with output currents of 5V - 1A and 5V - 2.1A, which can charge two portable devices at the same time. In addition, it has the functions of four LEDs to display the power state of the portable power source, USB automatic load identification start-up, short-press start-up without USB access, unloading detection system, automatic dormancy and LED lighting etc, and has multiple protections such as over-voltage, over-current and short circuit to improve the safety and reliability of the portable power source.

### 3. Hardware Circuit Design

#### 3.1 MCU master control circuit

N79E814A chip, as a low-power chip with shutdown and power-down modes, is widely used in consumer electronics and household appliances etc. Therefore, it is selected as the master control chip in this design so as to realize the low power consumption of the portable power source. It is responsible for the functions of detecting and displaying battery power, controlling the charge and discharge chips, identifying whether the port has a load connection, detecting the USB automatic load identification of the output current at USB port, detecting unloading and controlling flashlight LED, etc.

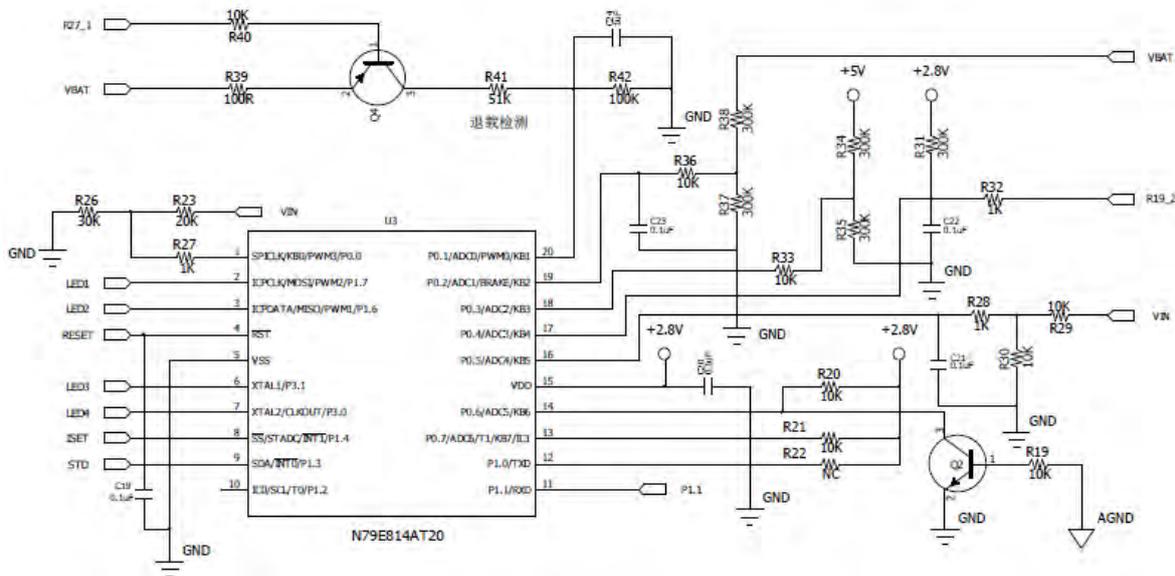


Fig.2. MCU control circuit

The MCU control circuit monitors the input voltage, battery voltage and output voltage, and

performs analog- to- digital conversion according to the sampled voltage for the MCU to process and judge. The P 1.3 port is connected to the START terminal of MT2011 to indicate whether the battery is fully charged. When the output of the START terminal changes from low level to high level, the battery is fully charged. The P 0.1 port is connected to the LX terminal of the boost chip SY7065A, controlling chip to start or stop boost operation. When the P 1.4 monitors the input voltage, the charging current can be automatically adjusted according to the power source's voltage. The MCU monitors the battery voltage. After the different voltages are processed by the algorithm, the electric quantity is displayed by four LED lights. In the mean time, by measuring the DC- DC voltages of USB, it can determine whether the DC - DC boost circuit is over- voltage and whether the circuit is in a short circuit state. The MCU control circuit is shown in Figure 2.

### 3.2 Lithium battery charging circuit

The charging management circuit adopts MT2011, which supports 4.5V to 6.5V voltage input, and its output voltage can follow the lithium battery voltage. It has the functions of soft start of charging current, anti- phase current diode, charging current sampling, and perfect output short-circuit protection and over- temperature protection etc [3]. With the working frequency of 1.5 MHz and a synchronous rectification structure, the MT2011 can reach the efficiency of up to 93 %. The circuit diagram of charging module is shown in Figure 3.

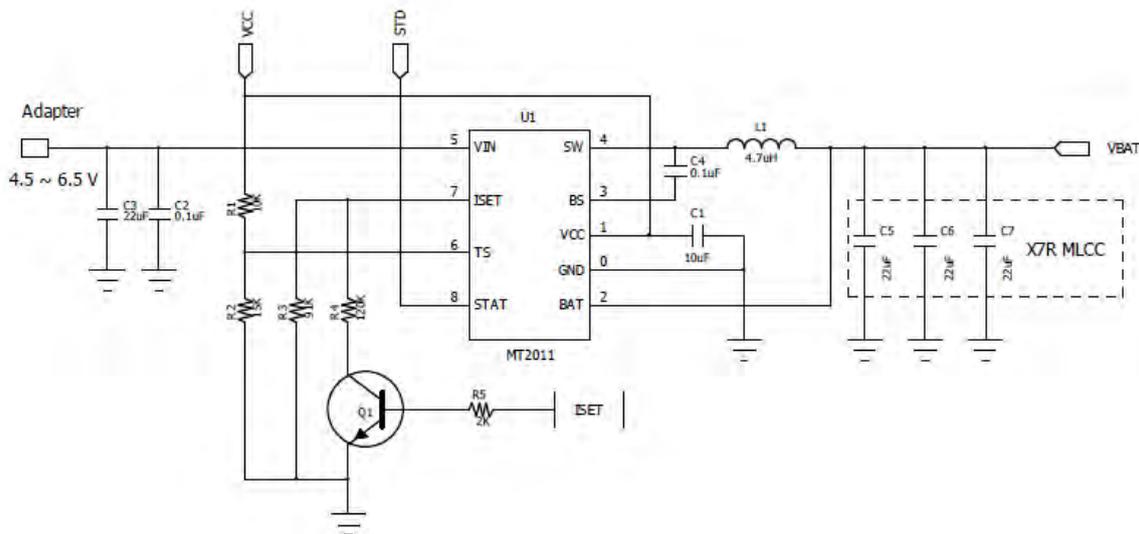


Fig.3. The circuit diagram of MT2011 charging module

### 3.3 DC- DC boost circuit

SY7065A is composed of the reference voltage source, current sensor, error amplifier, over-voltage protection circuit, PWM control circuit and so on. It adopts NMOS main switch and PMOS synchronous switch- over that its output efficiency and output peak current are up to 98 % and 5A [4] respectively. The internal MOS tube, inductance and follow- current diode form the topological structure of the boost circuit. It can be seen from the boost circuit's topology that the power factor can be improved by connecting inductance in series at the input terminal. The circuit of the SY7065A boost module is shown in Figure 4.

During reflow soldering, given that there is no suitable inductance, the author firstly takes 2.2uH as the inductance, but a momentary ringing occurs during the actual test. After that, the author improves the circuit and change the inductance from 2.2uH to 3.3uH. At this time, the PWM waveform between inductance L2 and follow- current diode is measured and has a better square wave.

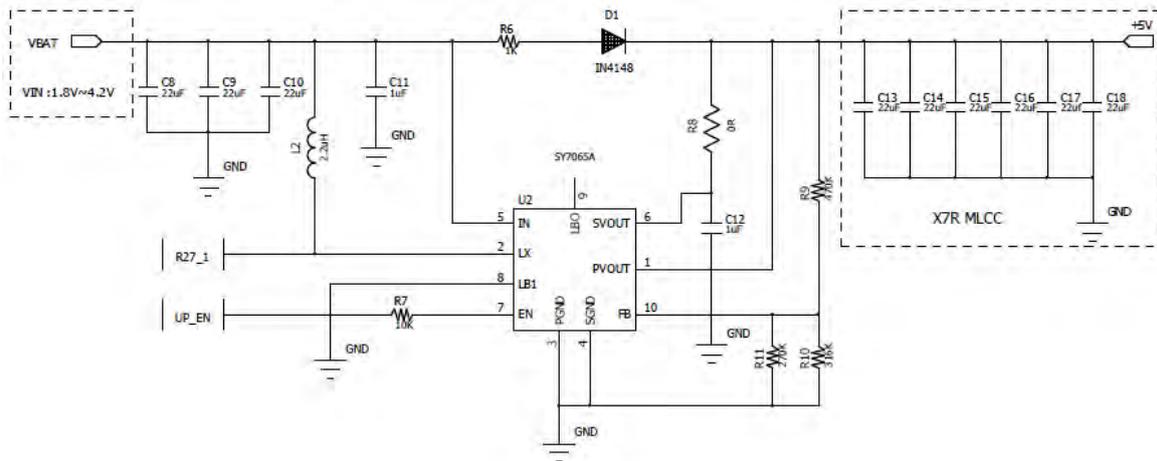


Fig.4. The circuit diagram of SY7065A boost module

The system SY7065A has a boosted voltage of 5.06 V (unload), while the designed system output voltage is 5.07 V. This is because the voltage will drop after the load is connected. Therefore, raising the designed 5V voltage a little can improve the load carrying capacity, reduce voltage lost in lines and ensure the voltage to the load terminal to be 5V.

1) Output voltage setting

In order to minimize power consumption at light load, it is desirable to select the resistance values that have high R9, R10 and R11. If the output voltage is 5V and  $R_9 = 470K$ ,  $R_{10} // R_{11}$  can be calculated by Equation 1:

$$R_{10} // R_{11} = \frac{1.2V}{V_{OUT} - 1.2V} R_9 \tag{1}$$

Theoretical calculation of  $R_{10} // R_{11} = 148.4k\Omega$ . Since there is no such resistance in reality, so  $R_{10} // R_{11}$  parallel connection is used. The output voltage is adjusted according to the magnitude of the feedback resistance, and the actual output voltage satisfies Equation 2:

$$V_{OUT} = 1.2V \left( \frac{R_9}{R_{10} // R_{11}} + 1 \right) \tag{2}$$

It is calculated theoretically that the output voltage is 5.07 V, and the actual measured output voltage is 5.06 V (unload), meeting the charging requirements of portable equipment.

2) Selection of inductance L2

The selection of inductance is to provide the required ripple current. Therefore, it is recommended to select the maximum output current with the ripple current of about 40%. The calculation of inductance is shown in Equation 3:

$$L = \left( \frac{V_{IN}}{V_{OUT}} \right)^2 \frac{(V_{OUT} - V_{IN})}{F_{SW} \times I_{OUT,MAX} \times 40\%} \tag{3}$$

Among them,  $F_{SW}$  is the switching frequency and  $I_{OUT,MAX}$  is the maximum load current. In SY7065A, the voltage stabilizer IC can withstand wide ripple current. Therefore, the final selection of inductance can deviate slightly from the calculated value without affecting its significant performance. Finally, the author chooses 3.3uH inductance for the portable power source.

3) Selection of input capacitance

It is important to reasonably choose input capacitance to handle the ripple current. In order to obtain the highest performance, the design of this portable power source selects the X7R 22uF/6.3V ceramic capacitor which has better temperature characteristics. During the test phase, the lithium-ion battery always has hot-plug between the integrated circuit IN and GND pins, which may lead to large peak voltage or even IC EOS failure. Therefore, in order to avoid such potential danger, a 22uF ceramic capacitor with equivalent resistance of 0.1Ω in series is used to absorb the input peak voltage, thus reducing the peak voltage from 6.13V to 5.29V. The peak voltage waveform of using this ceramic capacitor and the peak voltage waveform of not using this capacitor are shown in figs. 5 and 6.

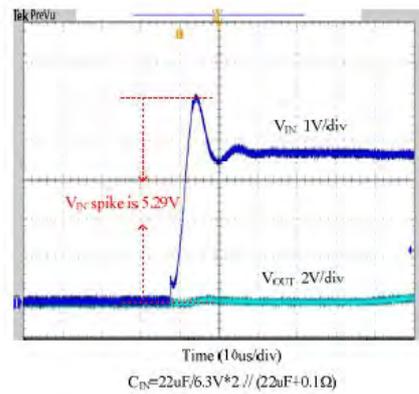
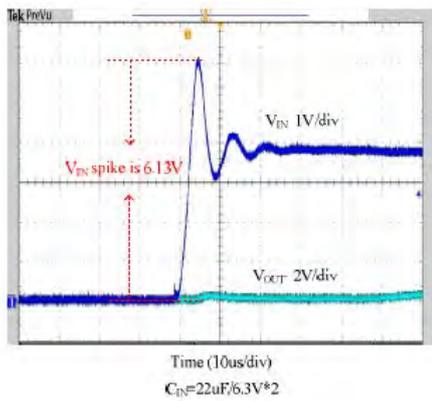


Fig.5. Not using the 22uF ceramic capacitor Fig.6. Using the 22uF ceramic capacitor

#### 4. Hardware Circuit Debugging

The circuit board of the portable power source in this paper is designed by PADS software and soldered by reflow soldering. This portable power source is designed with the separation of analog circuit and the digital circuit. And the size of the MCU control circuit's PCB is 63 mm long and 20 mm wide. In the circuit board of the portable power source, a LDO is connected to the analog voltage VBAT firstly, and then the analog voltage is filtered to supply power for the digital power source to the MCU. The analog circuit adopts the design of four-layer circuit board, the power source and the ground both having independent planes, while the analog ground and the digital ground being separated and co-located. In addition, the digital ground and analog ground should be grounded at a single point, or otherwise the digital ground reflux will flow through the analog ground and cause interference to the analog circuit. The physical hardware of the portable power source is shown in figure 7, among which the batteries are a six-lithium-battery-pack removed from a discarded notebook computer, realizing the reuse of lithium battery waste.



Fig.7. Hardware of mobile power supply

#### 5. Conclusions

This paper designs a portable power source with low power consumption, which has high boost circuit efficiency and DC-DC circuit conversion efficiency. In the meantime, the paper also introduces all modules of the portable power source and its peripheral circuits. The design not only is high cost performance, convenient to carry and easy operation, but also can prolong the endurance of portable equipment.

## **References**

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