SAVONIA

Solar mobile power supply

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THESIS

Abstract

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Abstract

The solar mobile power supply is a comprehensive energy saving and environment protective product. Besides, it consists of solar panels, storage battery and controller as well as other important components.

Based on the traditional solar charging circuit, this solar power supply combines the 5V USB interface and 12V adjustable circuit as well as the 220V inverter and power adapter to greatly improve the function of the power system.

This thesis introduces the internal structure, function and circuit design of solar mobile power supply. Besides, according to the characteristics and requirements of the main circuit, the concrete design steps and parameter calculations are explained as well as possible. Finally, the thesis analyses the benefits and prospects of the solar mobile power supply.

Keywords

Solar panel, controller, inverter, storage battery

CONTENT

SYMBOLS AND ABBREVIATIONS

:

DC	Direct Current
AC	Alternating Current
PV	Photovoltaic
MDP	Main Distribution Panel
MPP	Maxium Power Point
DOD	Depth Of Discharge
GPS	Global Position System
PDA	Personl Digital Assiatant
DVD	Digital Video Disk

1 Introduction of solar mobile power supply

Solar mobile power supply is a device which can transform the solar energy into electricity and reserve the electricity into the battery. The device basically consists of solar photovoltaic cells, batteries, and voltage components. Besides, the power supply can also charge from the electricity socket. So there are two ways to get power. One way is from solar, and the other way from electricity socket. It is convenient to combine these two ways in case that the solar energy cannot charge very soon.

With the rapid development of economy and technology, more and more electric devices are used by people Such devices are mobile phones, digital cameras, cameras, portable DVD, PDA, MP3, MP4, and GPS and so on. All of them need mobile power batteries, but the batteries cannot meet the demand of the normal usage time because of low power capacity. So traditional mobile power supply cannot solve the energy problem and we should develop the technology of solar mobile power supply.

2 The generation principle and main influence factors of solar panels

The solar panel is the heart of a solar electric system. There are various types of a solar panel. The photovoltaic solar panels can generate electricity from the sun. The more powerful the sun's energy is, the more power you can get, although solar panels just generate small amount of electricity in the shade. (Zhou Haiyan 2007)

Most solar panels are made up of solar cells connected together. A typical solar cell will only produce around half a volt, so connecting them together in series inside the panel can achieve more useful voltage.

The solar cell is the semiconductor device, which can directly convert the light into electrical energy. Although there are a variety of forms, the basic principles are almost same. The core part is the PN junction. When the incident light reflects to the battery, photon energy is larger than the silicon band gap through the antireflective film into silicon. In the N District, the depletion region and P region arouse electron hole pairs (photo generated carrier). The photo generated electron hole pairs are generated by the built-in electric field immediately after separation, and then the photo generated electrons are sent to the N zone so that the photo generated holes can promote the P district. When the battery is connected with the last load, the light current from the p zone by the load to n region starts obtain the power output. (Ryan Mayfield 2010)

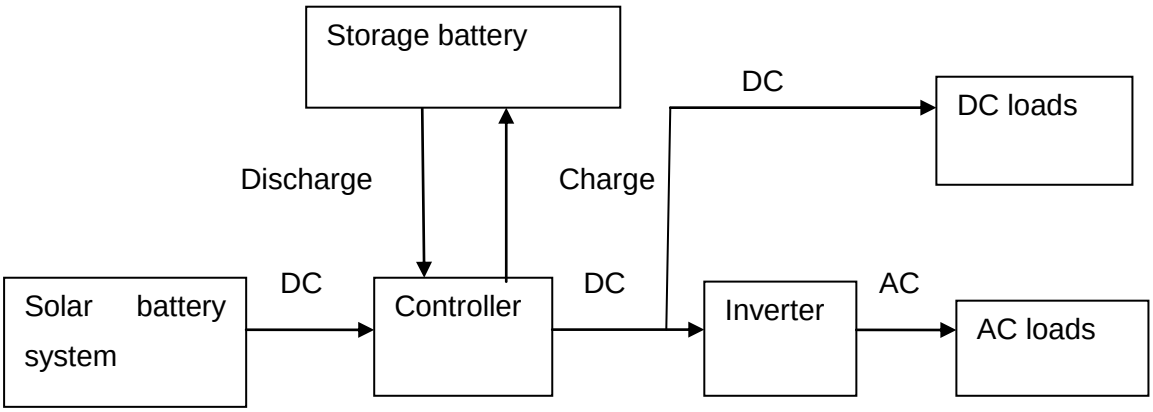


Figure 1. The basic composition of photovoltaic power generation

The main influence factors of photovoltaic power generation are in the following aspects:

Low energy density: Although the total amount of solar energy to earth is huge, it results in that unit area of earth can directly obtain small solar energy due to the large earth's surface.

Intermittence: On the surface of earth, solar photovoltaic power generation system can only generate energy during the day instead of the night unless the space can provide the continuous solar power generation under that specific environment where there is no day and night distinction. But this situation does not match people's habit of electricity usage.

Randomness: Photovoltaic system is affected by climate obviously like snow days and cloudy weather even the cloud change will seriously affect the power generation.

Regional dependence: Different climate depends on the different geographic location, which cause the different sunshine resources in various regions. The photovoltaic power generation system has the good effect on the areas with abundant solar resource.

3 Solar direct current power generation and its application

In 1958, photovoltaic power generation technology was firstly used in space equipment such as the American No.1 artificial earth satellite. Following that, this technology was extended to every field like military, civilian, industrial and so on. So far, the use of photovoltaic power generation is various.

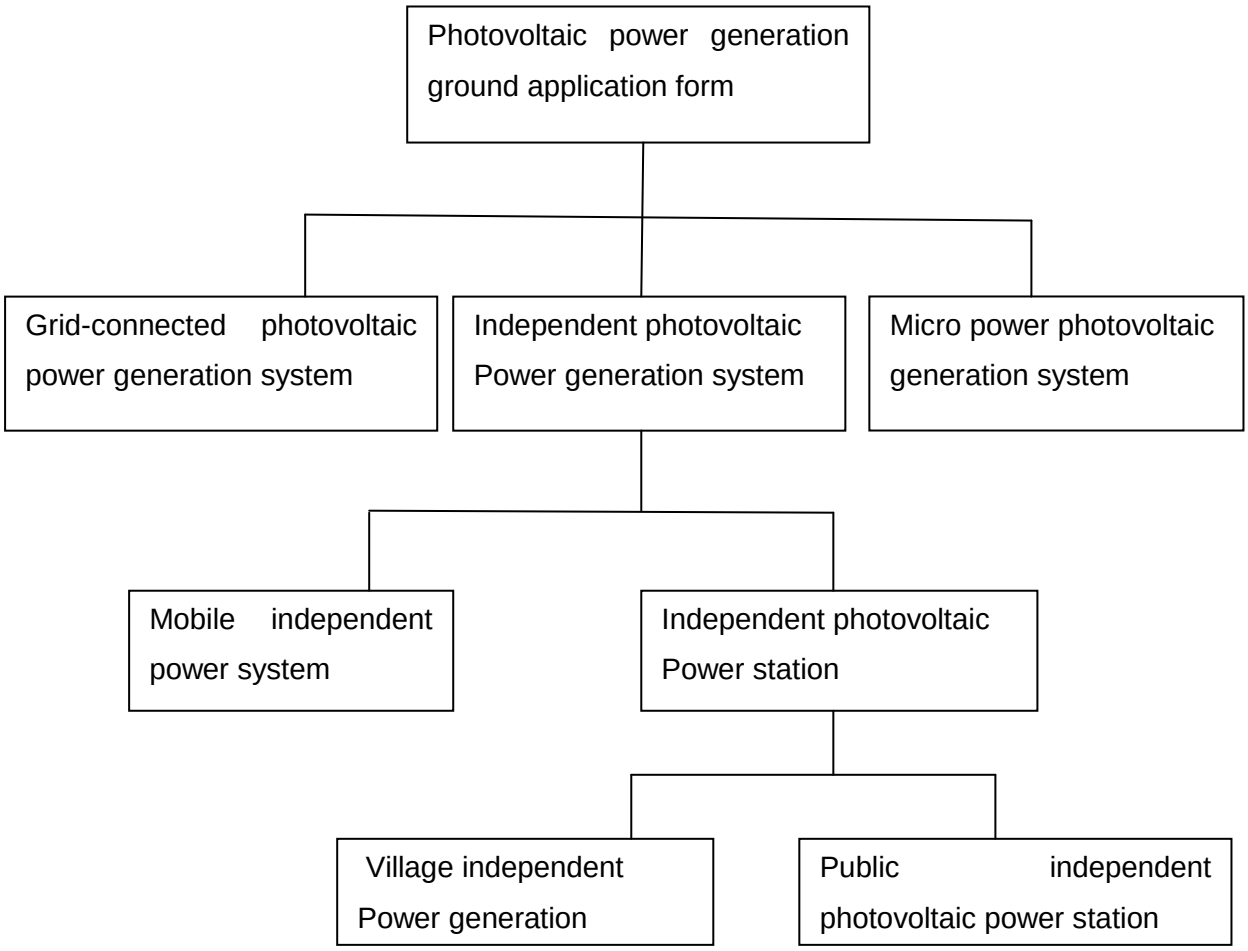


Figure 2. Main application form of PV power generation

3.1 Current situation and characteristics of solar direct current power generation

The photovoltaic products commercialization sale in the Chinese rural and pastoral areas began to develop from the 90's with the help of national and international guide and support such as some international cooperation projects, thus gradually forming a certain scale. By the end of 2005, there were about 750000 sets of domestic solar

photovoltaic power systems into users' homes. These users, most of them are pastoral familes whose electricity consumption level is still relatively low so that the photovoltaic power generation can generally meet their needs. In addition, there are some farmers from forest and agricultural areas as well as the schools, shops and other small units also using the household solar photovoltaic power systems. If the PV power consumption of this household solar photovoltaic system is calculated as 80%, plus the national bright project and power transmission of PV power generation station, there are at least 1 million households mainly relying on the photovoltaic power generation system to solve the basic living lighting electricity.

4 Photovoltaic solar cell

The core part of photovoltaic power generation system is photovoltaic solar cells, which convert the light energy into electrical energy.

4.1 *The Mode of solar cell*

The solar cell of mobile power supply selects the monocrystalline silicon photovoltaic solar cell.

Table 1. Solar cell standards (Baidu Library 2014)

Material	Efficiency (%)	Voltage(V)	Current(A)	Peak power(Wp)
Monocrystalline silicon	14-16	16-18	2	30

Monocrystalline silicon solar module is suitable for strong light conditions and has the perfect consistency of solar component as well as impact resistance, certain seismic resistance.

Figure 3. Monocrystalline silicon solar energy cell board (Baidu 2014)

The expected service life of photovoltaic solar cells in solar generation system is 20 years. The actual service life depends on the performance of solar battery structure and local environmental conditions.

The duration of solar system installation and use should notice below things:

- Handle gently
- No collision

- no percussion
- no scratches

The lighting surface of solar battery cells should be kept clean. If there is any dust or other contaminants, the operator should use the water to clear them and use the gauze to dry the surface gently. We must remember that using hard object or corrosive liquor will damage the photovoltaic cell. The installation personnel should pay attention to prevent reversing the cathode and the anode when connecting the output of solar battery components. The photoelectric parameters of solar battery components should have the regular inspection according to some relevant methods. If some defects happen, they must be solved immediately to ensure the normal continuous power supply.

4.2 *The connection mode of solar photovoltaic cells*

The series-parallel of solar cells can make up the solar cell array. Because the electrical property of each cell component could not be absolutely consistent, it makes the total power output of solar cell array less than the solar cells, which becomes the power mismatch. The reasons for this: (1) The production process of solar equipment determines that each component cannot be absolutely consistent; (2) The actual use of each component will cause individual difference due to the occlusion, dust, surface damage and so on.

During the connection process of the solar cell array and storage battery in series, it needs to connect an anti-reverse charging diode. (Zhou Haiyan 2007) Its role is to avoid battery discharging through the solar cell array when the short circuit fault occurs or the solar cells are used in the rainy days. The diode has the one-way conduction effect on the circuit. However, the circuit requires that the diode can bear the large current and that the voltage drop is small. Besides, the reverse saturation current is also required to be small.

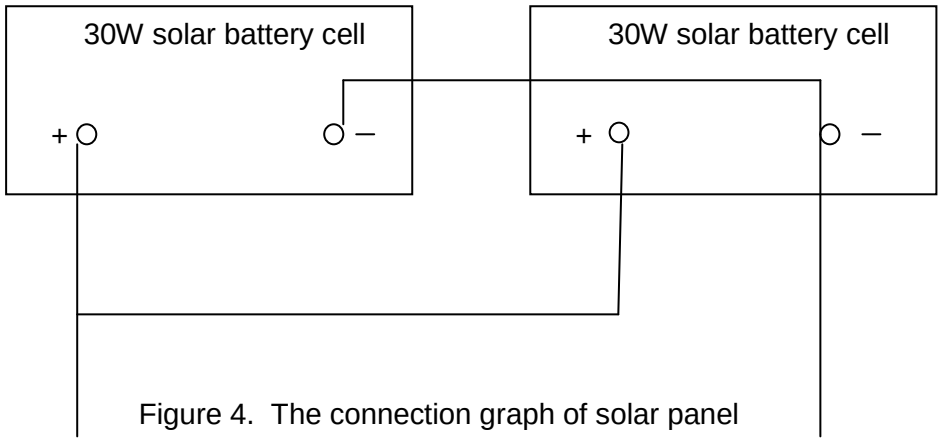


Figure 4. The connection graph of solar panel

5 Storage battery

The storage battery can store the energy through the chemical reaction and also can release the energy to load by chemical reactions.

5.1 *The function of storage battery*

In the photovoltaic power generation system, the solar matrix converts the solar radiation energy into DC power. The electric energy is converted into chemical energy and stored in the storage battery.

The solar cell output power is in proportion to the solar radiation. When it lacks of sunshine and the system needs repairing, the solar cell output power can be reduced or be even without power output. According to the charge-discharge state, the storage battery is divided into a variety of circumstances:

1) When the loads turn off, the solar cell matrix works normally and all power flows into the storage battery. The electrical energy is converted into chemical energy until the battery is full. Then the controller turns off the process.

2) At the same time in solar power generation, the loads are also in the working state. At this point, the solar photovoltaic cell directly supplies the power to the loads and the additional electricity will be transmitted into the storage battery. If the current the loads need is greater than the current produced by solar cell matrix, it needs the storage battery to be supplemented.

3) When the solar cell does not create power, the power of loads is provided by the storage battery. Therefore, the storage battery not only can store electrical energy, but also play an important role in regulating power and stabilizing the output.

5.2 *The selection of storage battery*

There are many types of storage batteries. The lead-acid battery is selected to be used in the solar mobile power supplier.

Table 2. Battery standards (Gao Hai & Tian Qing 2009)

Type	Open circuit voltage	Capacity	Lifetime
Lead-acid battery	12V	32AH	3 years
Li-ion battery	4.5V	10AH	2 years

5.3 *Special requirements for storage battery*

Due to the particular factors of the solar mobile power supplier, its work is characterized frequently in the repeated charge-discharge process as the battery energy storage system.

Furthermore, some situations like overcharging and deep-discharging often appears.

Therefore, the lifetime cycle and working performance of the storage battery has become the most concerned issue. In the current technical situation, the theoretical lifetime of the storage battery is shortest among the main components of photovoltaic system. (Zhang Peng & Li Hai 2006)

Specifications and requirements:

1) Deep-discharge performance
2) Long lifetime cycle
3) High tolerance ability for over-charging and over-discharging
4) Less maintenance or free maintenance performance
5) Good charge and discharge characteristics at low temperature
6) Not sensitive to the high temperature
7) High energy transformation efficiency
8) High cost performance

5.4 *The advantages of free maintenance storage battery*

This storage battery has many advantages such as no need for special maintenance even if the dumping of electrolyte will not overflow and not emit the hydrogen and acid fog to the air, sealing packaging is suitable for long distance transportation.

5.5 *The main factors affecting the normal work and lifetime of battery*

1. Temperature
2. The rate of discharge
3. The depth of discharge
4. Partial discharge

5.6 *The basic working principle of lead-acid battery*

The reversible reaction theory of lead-acid batteries in the charging and discharging process is complicated. The effective substances and sulphuric acid are changed into sulphuric acid compounds after reaction; it is recovering to the original lead and carbon dioxide after charging. (Gao Hai & Tian Qing 2009)

Chemical reaction equations:

$PbO_2 + 2H_2SO_4 + Pb \Leftrightarrow PbO_4 + 2H_2O + PbO_4$ (1)

PbO_2 = lead dioxide
H_2SO_4 = sulphuric acid (electrolyte)
Pb = lead
PbO_4 = leaching tetroxide
H_2O = water

Due to the development of the lead-acid battery technology, the major manufacturers have introduced the industrial controlled valve or sealed battery, and the chemical reaction principle is almost same. During the battery charging period, the positive plate produces the oxygen, and the negative plate produce the hydrogen. Below is the reaction equation:

Anode: $H_2O \longrightarrow 1/2\ O_2 + 2H^+ + 2e$ (2)
Cathode: $2H^+ + 2e \longrightarrow H_2$

O_2 = oxygen
H+ = hydrogen ion
e = electron
H_2 = hydrogen

The Valve-regulated lead-acid battery:

In order to solve the water electrolysis after charging, the grid plate of the original valve control accumulator was improved, which adopts the lead calcium alloy grid and improves the electric potential of releasing hydrogen as well as inhibiting the hydrogen

production, thus reducing the gas emission and the self-discharging rate. Using the properties of anode active material and spongy lead can inhibit the water reduction. In the final stage of charging or over-charging, the energy is consumed in the decomposition of electrolyte water, making the positive plate to produce oxygen. The oxygen reacts with the spongy lead and sulphuric acid, so that the oxygen is converted into water again. At the same time, a part of the negative plate turns into the discharging state, thus also inhibiting the negative plate to generate hydrogen. The cathode material can return to the spongy lead after charge, resulting in that more than 90% gas generated in the battery float process can be eliminated. A small amount of gas is released through the valve, which achieves the sealing condition. This is VRLA (valve-regulated lead-acid) battery. (Zhang Peng & Li Hai 2006)

6 Inverter

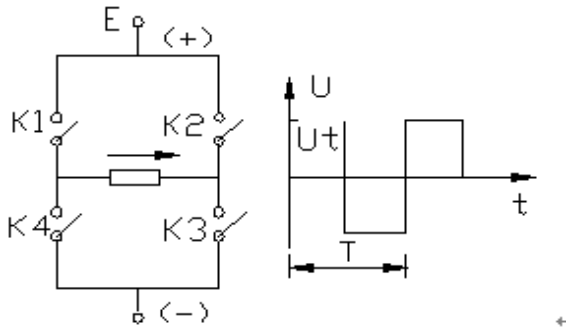
1) Brief introduction of an inverter

A DC/AC inverter is the device to convert the direct current into the alternative current. In China, most of the families use the standard of AC power supply is 220V and 50HZ. (Gao Hai & Tian Qing 2009) In order to facilitate the users to directly use the electrical equipment and facility, it is needed to configure the inverter to transform the DC to AC electricity. The inverter also has the automatic regulation function, which can improve the power quality of solar photovoltaic power generation system. In addition, compared with the 12V low voltage DC output current provided by storage battery, the DC of 220V can provide bigger power supply radius.

2) Theory of an inverter

There are many types of inverters. Their specific working principle and working process are different. It illustrates the working principle by the single-phase inverter circuit.

As shown in the Figure 7-1(a), the input voltage is E and the R is the pure resistance load of the inverter. When the switches K1 and K3 is switched on, the current flows through K1, K2 K3 and the load voltage polarity on the left is positive and on the right is negative; when K1 and K3 are switched off and K2 and K4 are switched on, the current flows through the K2, R and K4 and the load voltage polarity is opposite. If the two groups of switch K1, K3, K2 and K4 can alternatively work with frequency f, the load R can get the alternative voltage Ut. The waveform is shown in the Figure 5(b) below.



(a)Single phase bridge inverter principle (b) Alternative voltage Ut waveform

Figure 5. Single-phase inverter principles (Zhou Haiyan 2007)

3) The type of inverter

According to the output waveform of the inverter, the inverter can be divided into a square wave inverter, a ladder inverter and a Sine wave inverter.

The AC voltage waveform of the inverter output is the square wave, although the used inverter circuits of the inverter are not exactly the same, but the common specification is the relatively simple lines as well as the few power switch amounts. The general design power fluctuates from 100 watts to 1000 watts. The merits of square-wave are simple circuit, cheap price, and convenient maintenance; due to the shortcomings of the square wave voltage containing lots of harmonics, it will generate additional loss in the load with iron core inductor or transformer, which will have interference with the electric appliances and some of the radio communication equipment. In addition, this type of an inverter and the voltage regulating range is not wide enough, and it has the big noise and other shortcomings.

7 Controller

The Solar controller is the core of the system. It is used to automatically control the solar power generation, battery charging-discharging, load management as well as circuit protection. The controller plays different functions during the different charging-discharging processes.

1. Fast charge Constant current

When the battery voltage is low, it can be charged with high current and high voltage at fast speed. However, there is a control point, also called a protection point. When the charging voltage is higher than the protection value, the controller can stop the charging process. Otherwise it will cause the over charge, which can damage the battery.

2. Supplement charge

After the fast charge, the condition of the battery is just 80%, the supplement stage can fill the battery to 100%. (Gao Hai & Tian Qing 2009)

3. Floating charge

The function of the floating charge is to help the battery keep uploaded.

4. Over-discharge protection

Generally, the voltage of battery cannot fall below a certain value, so the controller can avoid the battery to discharge too deep.

Figure 6. Controller board (Baidu 2014)

8 The design of mobile power supplier

Better design can fulfil more specific requirements and get more advanced functions of device. Besides, a logical design can make the equipment work more efficiently and create more value, so the designer should pay more attention to the design area.

8.1 *The basic design idea*

The design of photovoltaic power generation system is divided into software design and hardware design, and the software design should start earlier than hardware design. Software design includes:

- Load consumption calculation
- Calculation of cell matrix surface radiation from the sun
- Battery consumption
- Calculation of solar array installation inclination
- The forecast of the system situation and the analysis of the economic benefit

Hardware design includes:

- Load selection
- Solar battery box design
- Selection and design of inverter
- Selection and design of controller

Due to the complex calculations, the software design is usually completed by computers; in some loose requirement circumstances, the calculation can also be solved by the estimate.

8.2 *Capacity design*

For the design of the photovoltaic cell power generation system, the matter of priority is the calculation determining the system capacity. The DC system capacity is determined by two parameters: the solar battery module and the storage battery. For the AC system, the inverter also needs to be concerned. These parameters are interrelated, interdependent, and relatively independent. Among them, the solar battery components determine the possible power amount of the whole system. The capacity of inverter depends on the type of loads. The capacity of the storage battery is determined by the power amount of charging-discharging and the maximum discharging and so on.

8.2.1 Storage battery capacity

The selection of battery capacity is one of the key problems in the household solar photovoltaic power system. Battery maintenance is the highest cost in this system. Battery design and unreasonable allocation will greatly accelerate the battery damage. The too large capacity design will cause three problems: one is increasing the cost, which is clearly not appropriate; another one is that the excessive capacity not only cannot play the function of the equipment, but also increase the self-discharge and unnecessarily consume the electrical energy emitted by solar photovoltaic cells; the most serious one is that the household solar photovoltaic power system is generally not large and cannot produce high current. Once the battery is too large, the storage battery could not reach the full capacity condition, which will increase the salinization of the polar plate and accelerate the battery damage. In contrast, the small electric capacity cannot store the electricity produced by solar photovoltaic cells completely. Besides, the battery is always in deep discharging state, which also easily causes the damage.

The formula of calculating the storage battery capacity is:

$$C = \frac{E_O D}{D_O D_\eta} \qquad (3)$$

C = Capacity of storage battery, W*h
E_0 = The average daily power consumption of load, W*h
D = The days of power supply, days
D_0 = Battery discharge depth, %
D_n = Inverter efficiency, %

The calculation unit in this formula is the W*h. If it is transformed into A*h, it should divide the system voltage. In addition, it should also take the effect of the temperature into consideration on the storage battery.

The solar mobile power supply is mainly used temporarily, so there is no need to ensure the self-sufficient days. In consideration of the usage condition, economic and practicality, strong versatility, the design capacity is 32AH. This capacity can satisfy most users' needs.

The best charging and discharging current is generally based on 10 hours. As for the 32AH battery, both the best charging current and discharging current are 3.2A. Due to

the special character of the storage battery, it can choose the small charging current and large discharging current.

Therefore, when the maximum discharge current is 10A, the discharging period is:

$$32Ah/10A=3.2h \quad (4)$$

When the discharging current is standard 3.2A, the discharging period is:

$$32Ah/3.2A=10h \quad (5)$$

Ah = Ampere-hour (the unit to measure the storage device capacity)
A = Ampere
h = hour

9 System configuration and component installation

The main purpose of this part is to optimize the system configuration and design and finish the component fixation so that the whole device can work normally by the combination of the system and components.

9.1 *The design and selection of operation interface*

The operation interface of mobile power supply should have the characteristics like reasonable configuration, simple and durability, convenient operation as well as obvious indication.

In this system, the switch controls the voltage meter respectively to measure the storage battery voltage and adjustable output voltage. This system can supply the alternative current for users through a DC/AC inverter and also have the LED lamp indicator. There is a multifunctional AC output socket at the lower part of the box body in order to meet the needs of various electrical equipment. On the other side of the operation interface, installing the AC connector can help the user to use the DC electric appliance. At the same time, the upper box has the master switch and the fuse wire.

9.2 *System wire design*

(1) Calculation of the DC input wire diameter

The solar power system should not only minimize the loss of the system, but also take the system economy into consideration. The loss of the common photovoltaic power generation system by the voltage drop is generally 2%, but because the domestic solar photovoltaic power system is the DC current and voltage level is relatively low solar battery module and storage battery match very well. So in the domestic solar photovoltaic system, the standard loss from the solar battery to the controller is 5%. (Zhang Peng & Li Hai 2006)

$$\Delta P = \frac{\Delta U^2}{R} = \Delta U^2 / \left(\rho \frac{L}{S} \right) \tag{6}$$

$$S = \frac{\Delta P \rho L}{\Delta U^2} \tag{7}$$

ΔP = Power loss, w (Watt)

R = Conductor resistance, Ω (ohm)

ΔU = Voltage loss, V (Volt)

ρ = Electrical resistivity, Ω·m

S = Wire cross sectional area, m^2

L = Wire length, m (meter)

(2) Calculation of DC output wire diameter

$$R = \rho \frac{L}{S} \tag{8}$$

$$R = \frac{u^2}{P} \tag{9}$$

P = Rated power, w (Watt)

R = Conductor resistance, Ω (ohm)

ρ = Electrical resistivity, Ω·m

u = terminal voltage, V (Volt)

S = Wire cross sectional area, m^2

L = Wire length, m (meter)

$$S = \frac{\rho PL}{U^2} \tag{10}$$

In the portable multifunctional mobile power supply, the design of the input wire line and output wire line between controllers and the appliance is pretty important because of the low operating system voltage.

1. The selection of the wire length

   Considering the all-in-one machine principle of the mobile power supply, the wire length is generally not more than 1 m.

2. Wire diameter selection

   In order to minimize the system damage and improve the economy of the system, the output line uses the copper wire and diameter is 1 mm. The wire area through the inverter to an external load is 6 square mm.

9.3 *Box design*

1. Material selection

   In order to make the appearance to be beautiful and easy processing, the box should be wood wrapped by drawing aluminium outside.

2. Box making

   The box is made by the box making factory according to the drawing blueprint. The box and related size are shown in Appendix 1.

3. Box function

   The box body can provide the protection for the storage battery, inverter and controller in case that they are not affected by the collision and water damage. The box body is a metal structure. Besides, the box cover and the box body are connected through a hinge connection. There are lap joints between the box cover and body, which can conveniently open or close the power box. The box sides are pressed with the reinforcing rib and also have a pull rod below the box. The box is designed with a handle on the side, which is easy to carry. The storage battery is in the middle position of the box. The inverter and controller are respectively in the interior sides of the box. The panel board installs a variety of output, input socket, display meter, control switch and other operating components.

9.4 *Circuit design*

The controller of portable multifunctional mobile power supply is the part of circuit and should also have the intelligent charge-discharge control, various obvious indications, economic and durable, conveniently operable, reliable, sensitive and other characteristics. So the controller should have the following functions:

- Signal detection

  The detection of photovoltaic system device and each unit state and parameters can provide the basis for the system judgment, control and protection. The necessary physical quantity detection is the input voltage, the charging voltage, output voltage and output current.

- Optimum battery charging control

  The controller determines the best way to achieve the efficient charging based on the current solar resources and battery charging state. Furthermore, the controller should also consider the charging method affecting on the battery life.

- Battery discharge management

  For the management of storage battery discharge process, the load can automatically control the machine to switch off and switch on, preventing the load ending the voltage by error protection etc.

- Equipment protection

  The electrical equipment connected by the photovoltaic system needs the controller to provide protection in some cases such as the inverter circuit fault and the emergence of load short-circuit and over-current. If the situation is not controlled in time, it may cause the damage on the electric equipment of the photovoltaic system.

- Fault diagnosis

  When a fault occurs in photovoltaic system, the system can automatically detect the fault types and indicate the fault accurate location, which can offer the convenience for the system maintenance.

- Operation status indication

  The operation status of the photovoltaic system and the fault information can be indicated through the indicating lamp. Photovoltaic system plays its function under the management of the controller. The controller can use a variety of technical means to achieve its control function. There is a most common logical control based on simulative and digital circuit controller through the relevant parameters measurement. The circuit can realize the specific control function by the calculation and judgement.

  The controller circuit is divided into five modules circuit diagram.

9.5 *The basic working principle of each circuit module*

1. The basic principle of charging circuit

   The charging voltage of solar panels is 16.8V~18V. Therefore, in order to prevent

the battery overcharging and electrolyte boiling, the battery voltage is limited in 14.8V. When the battery voltage is higher than 14.8V, a relay is normally closed state. On the contrary, the relay is in the operating state.

2. The basic principle of discharging circuit

When the battery storage drops to 10.8V, in order to prevent the depth of discharge and the battery power depletion, the load and the battery should be separated at this time. The working principle of discharge circuit and technical parameters analysis are similar with the charging circuit. Regulating the precise positioner RP2 resistance can reduce the battery voltage to 10.8V and the battery no longer supplies power.

3. The basic principle of DC5V circuit

In the 5V generation circuit, through the LM2575 transforming the 12V to 5V, the output current is far greater than the input current, which is decided by the energy conservation. The pin 4 is a feedback effect, so most of the current goes through the pin. The general charging current is 500MA with the help of big heat sink solving the overheating. (Zhang Peng & Li Hai 2006)

4. The basic principle of adjustable output circuit

The output voltage range of adjustable output circuit is 0-11V. The LM317 pin 1 is connected with the ground wound resistors by a wire. The adjustment of wire wound resistors can achieve the purpose of adjustable voltage output.

5. The basic principle of DC12V output circuit.

In the discharge circuit, the voltage of the battery is the relay J2 output and its value is about 12V. By connecting the inverter, it can obtain the A220V voltage.

6. Circuit board welding

The circuit board is produced by the manufacturer according to the circuit drawings. The required electronic element of circuit board refers to the circuit drawings. The electronic element name is marked according to the circuit drawings. Besides, the electronic devices are welded on the circuit board by the electronic iron. During the welding period, the operator should pay attention to the temperature and the amount of the solder, to avoid welding too fast and cause overheating to affect the device quality. At the same time, the operator should focus on checking the solder joints to prevent the insufficient solder joints. The final job is to coat the thermal grease on the heat sink of electronic heating component. (Zhang Peng & Li Hai 2006)

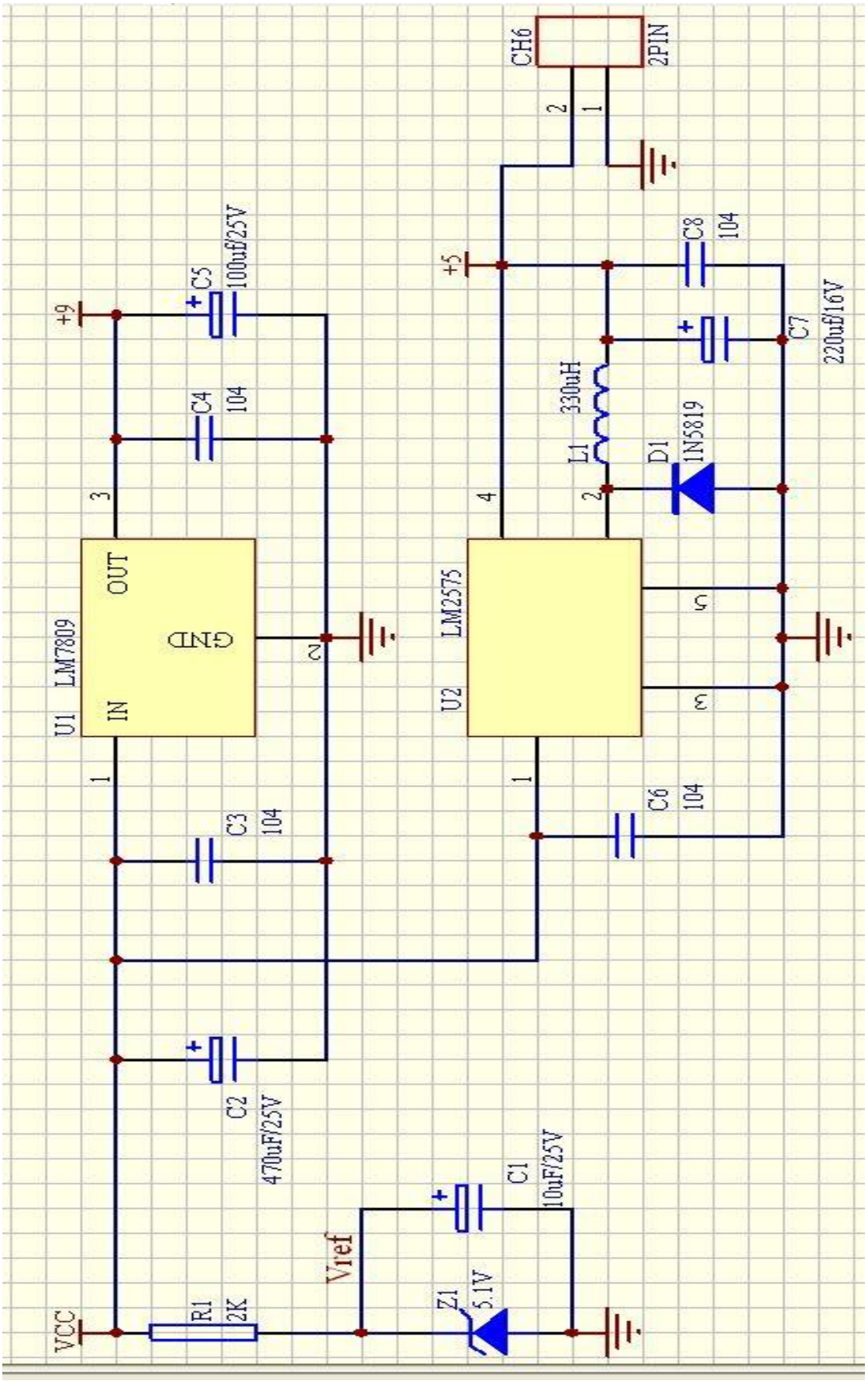


Figure 7. Circuit diagram

9.6 *The box electrical component installation*

The electrical component installation includes the battery, inverter, controller, circuit and so on.

9.6.1 Battery fixation

The battery is put in the bottom slot of battery box, and then the U aluminium strip is used buckling the battery. The aluminium strip is fixed by a fixing screw. Finally, the separator at the junction and the aluminium strip should be painted with the silica gel to prevent loosening.

9.6.2 Inverter fixation

The fixation of the inverter is the same way than the way of battery. Before fixation, the operator should install the inverter work indicating lamp (double colour, common cathode or common anode), power outlet and wire control switch to the specified location of control panel.

9.6.3 Controller fixation

The controller should be installed into the groove relatively near the control panel bottom, using a screw to fix it and make hot silica gel to prevent loosening.

9.6.4 The connection of controller circuit board wire

According to the wire column installation drawing, the wire is wired into the connecting plug, and then inserted into a connecting groove corresponding to the circuit board. The diameter of the metal wire inner core is inappropriately too small and the suitable size is 3 mm. Furthermore, the length of the wire should not be too long, which can reduce the loss of the voltage and avoid affecting the normal power output.

9.6.5 Electrical components installation on control panel

First the high performance and good quality components must be selected. Then the components should be installed on the control panel and fix all of the components except the voltage meter. The voltage meter is inserted into the control panel not fixed. It is convenient to fix the screw on the control board.

9.7 *Box assembling*

The assemble process is to fix the each part in the specific location inside the box.

9.7.1 The controller debug

After each transmission wire is finished connection, the operator should check each line is connected properly by using the electrical multimeter. As for the control plate connection, the operator should check whether the various functions can meet the specific requirements. (Ryan Mayfield 2010)

9.7.2 Power leads connection of solar cell board

The operator should use the appropriate wire length to connect the power battery plate lead wire. After connection with two diodes, the metal wire should be wrapped by insulation tape.

9.7.3 The performance test of solar battery board

The voltage meter can measure the function usage situation of solar panel. First of all, the anode and cathode of voltage meter should be connected to the two poles of the storage battery. Then using the opaque objects can shelter the upper and lower panels respectively. After that, we should check the numerical voltage fluctuation situation. As for the result, the numerical change shows the battery board playing the function. Otherwise, it needs to continue debugging the device.

9.7.4 Battery plate and aluminium frame fixation

1) Drilling the holes on the upper part of box body
   The operator should drill two 4 mm diameter holes on the left and right sides of the box cover respectively. When punching on the box body, it should use the nail hitting a groove in the centre location to prevent the slippage.

2) Drilling the hole on the aluminium frame
   The solar battery plate is put into the box body and the level of plate is parallel to the box body panel. Then the self-tapping screws are drilled into the hole by using a screwdriver. When the screws touch the aluminium frame, the operator should

control his strength slightly so that the screw can leave traces on the surface of aluminium frame, then stop the drilling. It is worth noticing that whether the drilling location can meet the standard requirements. If there is no conflict, then the operator starts to drill holes in the battery plate according to the traces left by the screws. If there is a conflict, the operator must adjust the position of holes and then determine the location of aluminium frame.

10 Power box function debugging

The various electrical function debugging includes the adapter charging, indicating lamp working state as well as the solar panel charge situation and so on. If the power supply is kept at home for a long time, the battery needs to be charged every three months.

10.1 *The operation steps of mobile power supply*

1) Main power initiation

   The first step is to press the “main switch” button by hand; therefore the circuit power system is switched on. The “indicating lamp 1” and “indicating lamp 2” begin to display the current operating state of the circuit power. Before using this device, we should detect the state of the green lights. As the result, the state indicates that the battery internal power is sufficient and it is in the normal state of preparation. If the red light is bright, the storage battery needs to be charged, because this state indicates that the battery is in the under voltage condition.

2) Charging process of the power supply box

   If the weather permits, it can use the solar energy to charge the power box. Firstly, putting the box in the good light conditions can benefit the equipment to absorb more power, and then open the upper cover to spread the solar panel as vertical as possible with the sunshine. At this time, the indicating lamp is red. When the light turns into the green, it means the power is full. During the process of charging, the device allows to provide power to the load. After the storage battery is full, the solar photovoltaic system can also provide power for the loads.

3) Output of alternative current

   The circuit is switched on the AC output when it opens the “AC switch” button. At this time, the green light shows that the AC output circuit starts to work. The output ability of universal socket is AC 220V/110V. (Ryan Mayfield 2010)

4) USB(5V) voltage output

   Ensuring the total power opening state, you can use USB (5V) voltage output function. The electrical equipment can be inserted into the USB joint on the USB output interface. Following that, the 5V voltage starts to supply the power for the electronic equipment. It needs to pay attention to that the load current should not exceed 1A. Besides, overload will cause the power transmission damage.

10.2 *Operation requirements of solar mobile power supply*

1. Environment conditions:

   (1) Altitude below 1000m (2) air temperature: -25~+50℃ （3）humidity: 30%~40% (Zhou Haiyan 2007)

2. Charging mode:

   a) Solar panel charging voltage: DC16V~18V Charging current: ≦2A
   b) Charger input voltage：AC220V/110V， frequency 50/60Hz ; output voltage 14V, current 3.5A
   c) Charging duration： about 8~10 hours (solar charge); about 5~8 hours(rectifier charge)
   d) Current output voltage: 0V~11V/3A continuous adjustment (±2%), 5V/1A (USB connector) (±2%),
   e) Alternative current output voltage: 220V (±3%) 50Hz/60Hz (±0.5%)
   f) Storage battery standard: 12V/32AH
   g) The maximum current of direct current socket output: 10A
   h) External fuse: 30A
   i) No-load power consumption<1.8w
   j) Normal voltage range of storage battery: 10.8-14.8V
   k) Alarm voltage: 10.8V (Zhang Peng & Li Hai, 2006)

11 The advantages and specification of solar mobile power supply

The solar mobile power supply has more specific advantages than other power supply and the advantages are the reason why we choose the solar mobile power supply. The advantages are listed below:

- Flexible charging
- Long service life
- Wide range of use
- Convenient to carry
- Energy saving
- Simple operation
- Small volume
- Continuous and adjustment output voltage
- Light weight
- Long discharge time
- Over current protection
- Short circuit protection
- Overload protection
- Over temperature protection

12 The market prospect of solar mobile supply

In conclusion, the solar mobile power supply is practical power equipment, which represents a new power generation of green energy. Furthermore, it is widely used in automobiles, ships, long-distance travel, and household appliances and so on. Besides, it is suitable for forest, grassland, desert, mountain and other area without electricity.

In China, the solar energy resource is very rich and there are millions people without electricity. Therefore, some related enterprises began to compete for the “bright project”. The photovoltaic industry development prospect is very broad.

In 21th century, non-renewable resource depletion, energy shortage and environmental pollution are very strict so that the market needs some renewable and clean resources to replace the old resource like solar energy. At present, there are about 50% villages and towns have the severe power shortage, so the market potential is huge.

The solar mobile power supply is a comprehensive energy saving and environmental protection product. One-time investment can get long-term benefit. Obviously, there is no pollution, no noise, and no waste emissions of solar energy, which just meet needs of the market. At present, the bottleneck of the development of solar energy products is the high price. However, with the further popularization of the application of solar energy and the development of solar technology, more and more solar products will enter the public life like the solar mobile supply.

13 Conclusion

In this thesis, I have tried to design the solar mobile power supply producing energy as much as possible and improve the energy transmission as well. At the same time, I still met some problems like choosing the suitable storage battery for the whole system. At last, I selected the Lead-acid battery as my system storage battery because of the stable reaction and cheap price and so on. Besides, the correct fixation of each component was also very important, which spent me a long time to concern how to fix each part accurately.

During the thesis design, I deeply felt that you must try your best to focus on the thing so that you can complete it perfectly. Besides, when you met some problems, you must gather any resources to get help and find the suitable solutions. Finally, I think I have enriched my knowledge about the energy transition and circuit design and improved the ability to do something on my own by finishing this thesis.

14 References:

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Appendix 1: Design blueprint