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Development of Solar Photovoltaic Charging Controller Based on MPPT

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Abstract. Aiming at the problems in the traditional solar photovoltaic charging control, the MPPT control method of the maximum power point tracking of a photovoltaic cell array is studied. The scheme of the hardware of the controller based on AT89S51 MCU is designed. A high performance control strategy is developed, which can not only track the maximum output power of photovoltaic cells, but also improve the charging efficiency of the battery. MPPT control with intelligent, adaptive control characteristics, so that the entire solar photovoltaic charging system has the characteristic of stable and reliable operation. The power battery pack can be charged to improve the state of charge, and extend the mileage and service life of the electric vehicle. The device can detect battery group's voltage and charge current to prevent battery overcharge and has over-current protection.

Introduction

Solar energy electric vehicles has characteristics of no pollution, low noise, easy operation and maintenance and low operation cost advantages, and has the incomparable superiority in environmental protection and energy saving. It is an effective way to solve the social huge energy consumption and environmental pressure. At present, a major bottleneck restricting the development of electric vehicles is the battery related issues. Fast charge is difficult to fill the battery, a one-time charge to continue driving the mileage is short, limited by the cycle life, etc.. The photovoltaic battery charge recharge of electric vehicle batteries, can be a long time in the small current electric vehicle battery charging, prolong the one-time charge mileage and maintenance of power battery, prolong the service life, visible photovoltaic battery charging device plays an important role.

Equivalent Circuit of Photovoltaic Cells

Independent photovoltaic power generation system by solar radiation solar array to produce photovoltaic effect, the radiation energy is converted into electrical energy supplied to the load. And a lot of surplus power by charging and discharging controller is stored in the form of chemical energy in lead-acid batteries. The single photovoltaic cell sheet is the most basic unit of photovoltaic cells. When the photovoltaic battery is used, the capacity of the single cell is small, and the power demand of the load cannot be satisfied.

Therefore, a few pieces, dozens or hundreds of single cell battery through a series of parallel connection to form a combination, the formation of photovoltaic cells. Engineering application of photovoltaic panels is the basic unit of photovoltaic cells; The output voltage is generally more than a dozen to tens of volts. In addition, can also according to the load capacity requirements, a plurality of photovoltaic panels, and the success rate of the joint after a string of actual large power supply device, called photovoltaic cell.

Control Strategy

Incremental Conductance（INC）method is one of the most commonly used MPPT control algorithm, which is based on the comparison of the output voltage and current of PV cell array to change the control mode of the system. The conductance increment method is simple and accurate, and the response is fast. It is especially suitable for the changing of the light intensity. The output characteristic curve of PV cells is a single peak curve, as shown in Fig.1.

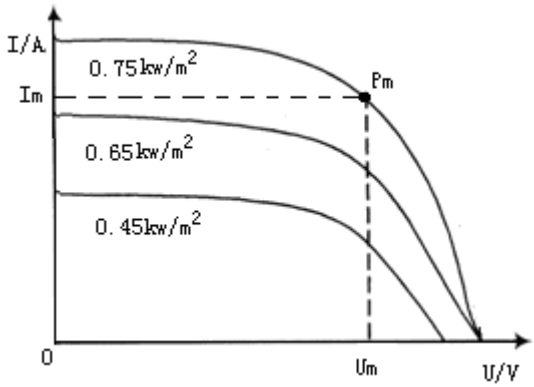

Figure 1. Characteristic curve when T=25°

From above picture, we can see that, in a certain temperature and light intensities, different solar light intensity curve can find a Pm maximum power output point, assuming a solar photovoltaic battery work almost always work hours at the maximum power point Pm, it can greatly improve the efficiency of the solar photovoltaic energy conversion efficiency rise, how to use the best way to find the maximum power point, and work in the vicinity of the maximum power, maximum power point automatic optimization.

At the maximum power point: dP/dV =0. P is the PV array output power, V is the output voltage. Therefore we may think: If dP/dV>0, the system works on the left side of the maximum power point, if dP/dV<0, the system works at the right side of the maximum power point.

For photovoltaic cells, P=IV:

$$dP / dV = I + VdI / dV \tag{1}$$

From this we can know:

$$dI / dV = -I / V = G + dG \tag{2}$$

In the formula, the G is the conductance of the output characteristic curve, and the dG is the increment of the conductance G. By judging the I/V+dI/dV of the symbol can determine whether the photovoltaic array is working at the maximum power point. The biggest advantage of the conductance increment method is that it can quickly and accurately track the maximum power point of the photovoltaic array, and there will not be the principle of the disturbance observation method. Even when the external illumination condition changes drastically, the conductance increment method can be tracked smoothly and quickly, and the system operation effect is good. Incremental conductance method is an ideal MPPT strategy.

System Hardware Design

Fig. 2 shows the principle of the hardware design of MPPT.

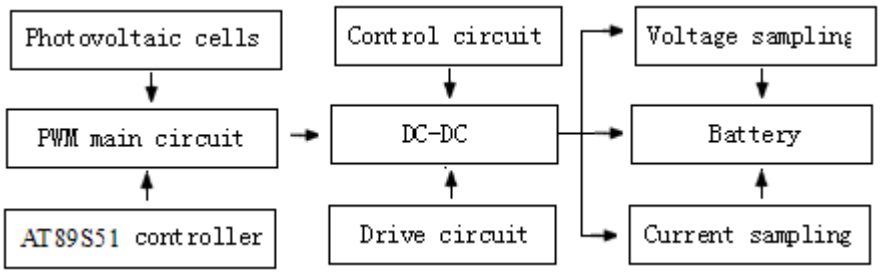

Figure 2. MPPT hardware design structure diagram

The micro controller using AT89S51 microprocessor, output voltage and output current sampling of power supply using A/D module, system can adjust the pulse width modulation (PWM) of the duty ratio, then the maximum power output of photovoltaic cells can be achieved.

The current sampling circuit can measure and sample the working voltage at both ends of the resistor, and then amplify it through the differential amplifier. The results are output to the A / D sampling end of the AT89S51, so that the current value of the solar photovoltaic control main circuit can be obtained. The signal can be accurately sampled and isolated from the power source. The single chip and the peripheral circuit of the single chip microcomputer and the peripheral circuit are realized by using the battery isolation transformer, and the external power supply is not required.

In regulating the process of measuring the battery charging power, based on it to adjust the working point of photovoltaic cells, so that the battery can maintain the maximum charge power. We should pay attention to the following two points:

1) Design and device selection of the converter . According to the output voltage range of the solar cell, the maximum power point voltage and the charging voltage of the battery pack, the suitable switching device and the driving control circuit parameters are selected to improve the operation efficiency of the converter.

2) Converter input, output DC filter. Because the input or output current of the converter is intermittent pulse current, and output current of photovoltaic cells for continuous values, in order to increase utilization efficiency of solar battery, system need to set the input filter in order to achieve the goal of constant voltage charging.

3) Output current, voltage detection. The output current and the voltage of the converter are the standard to determine the residual capacity of the battery pack. We should design accurate detection circuit, so that the detection value of the error is less than 5%, and with high accuracy of the voltage, current meter calibration.

Software Design

System software design to adopt a modular design program, will complete a specific function of the sub module of the success of a combination of modules, a unified call by the monitoring program. The design of this paper uses conductance incremental to carry out solar photovoltaic maximum power tracking. We must design input under voltage protection, mainly for photovoltaic cells in the case of weak sunlight, the photovoltaic cell output power is too low, at this time the system to enter the state of protection, stop charging the battery, and enter the low power consumption mode. When the open circuit voltage of PV cells is restored, the system is self-restored and enters the working state. The flow chart of the program is shown in Fig. 3:

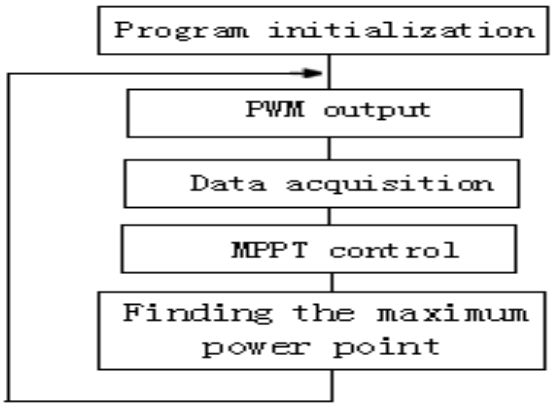

Figure 3. Main program flow chart

In the measurement of the signal sampling, each measurement of a signal to be repeated sampling. The collected data is sorted by size, only the middle of the value, to ensure the accuracy of the sampling.

Conclusion

The system adopts MPPT control method based on single chip microcomputer AT89S51. The maximum power point tracking is achieved by controlling the duty cycle of the solar charging converter. The results show that the control method can accurately and quickly track the maximum power output point of the solar cell and the controller is easy to implement. Solar electric vehicle charging system has good practicability, and it has very good and practical advantages.

Acknowledgements

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