



## Design of photovoltaic automatic tracing system for unattended seismic station

Hong Wei Peng<sup>1</sup>, Yu Jie Cheng<sup>2</sup>, Zhi Guo Hu<sup>1</sup> and Chu Chen Zhang<sup>2</sup>

<sup>1</sup>*Institute of Disaster-Prevention Science and Technology, Sanhe, Hebei*

<sup>2</sup>*Telecommunication and Information Technology Wuhan Institute of Technology, Wuhan, Hubei*

---

### ABSTRACT

*Describing a designing process of single axis photovoltaic automatic tracing system for unattended seismic Station. Structure and principle of this automatic tracing system are analyzed. Giving the methods of hardware and software design that accomplish main-control chip using single-chip computer C8051F310. The field testing results of device to showed which effective raise efficiency of power generation.*

**Key words:** single axis; photovoltaic; automatic tracing; Single-chip computer

---

### INTRODUCTION

Solar energy is a new clean energy security. Have the advantages of abundant reserves, wide application, and security, economic and practical green fossil energy incomparable. However, the current photovoltaic power generation there is a bottleneck in the development that is the power generation efficiency is low. Therefore, how to make photovoltaic cells to a greater extent for solar radiation energy. To improve the efficiency of solar photovoltaic power generation has become the research hot topic at home and abroad. Solar energy is a new clean energy security. Have the advantages of abundant reserves, wide application, and security, economic and practical green fossil energy incomparable. However, the current photovoltaic power generation there is a bottleneck in the development that is the power generation efficiency is low. Therefore, how to make photovoltaic cells to a greater extent for solar radiation energy, improve the efficiency of solar photovoltaic power generation has become the research hot topic at home and abroad [1].

Solar power system without automatic tracking has started to spread in the unattended seismic station. But because the photovoltaic batteries are expensive, non-tracking solar power system energy utilization ratio is low, the seismic spread affected. And this system has the advantages of simple structure, convenient maintenance, low cost. Due to the amount of solar radiation determines how much power generation capacity of photovoltaic power generation system receiving in photovoltaic battery component to the amount of solar radiation, and photovoltaic battery component can be received and the number of solar incident angle theta. Radiation intensity hypothesis in a certain direction of the sun is E, solar radiation intensity of photovoltaic array can be received as  $E * \cos\theta$ , incident angle and so only reduce sun PV array of theta, can obtain the solar radiation intensity greater. And the installation of fixed angle, array of PV modules and mobile does not vary with the change of the position of the sun, only beginning to collect solar energy from one direction, so this method can't make full use of solar energy resources, low conversion efficiency. Based on the above reasons, in the seismic design of automatic tracking photovoltaic power generation system is a pressing matter of the moment [2].

At present, the widespread use of automatic tracking system of three types of photovoltaic, including horizontal single axis tracking, inclination angle of latitude tilted single axis tracking and two axis tracking, where the

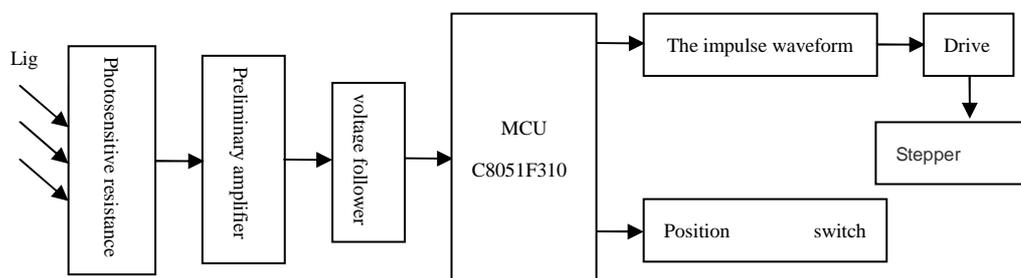
horizontal single axis tracking and tilted single axis tracking only one rotational degree of freedom, two axis tracking has two rotational degrees of freedom. Tracking control strategy using three kinds of tracking system for active tracking control strategy, through calculating the sun is in the sky in the range, and PV array toward [3]. This strategy and requirements of seismic photovoltaic power supply reliability and unattended operation based in Kashi, Xinjiang construction of a unattended seismic station as background, developed the automatic tracking system of single axis pv. Make the solar panels toward the sun remains the largest power generation efficiency, to meet the various requirements of station power supply, has the very high application value.

## 1. The structure and principle of automatic tracking system

### 2.1 The overall design of the system

C8051F310 is a RISC structure with the high performance MCU, it has 29 IO ports, 14 interrupt sources and 8 reset source. The controller mainly consists of C8051F310 single-chip microcomputer control unit and drives the actuator part [4]. The control unit calculates and feedback control, enabling signal, motor drive signal generation, signal processing and human-machine communication protection of five parts by the angle. The system features are as follows: single loop detection of photovoltaic array position, and with the calculated at the local sun altitude angle and azimuth angle are compared to determine whether the tracking photovoltaic array on the position of the sun, if not meet and starting signal starting conditions, monolithic machine sends out the command of the rotation of the driving electric motor protection signal is guaranteed; operating instructions performed by the system to the outside world and other non-human factors situation, to ensure that the system is not damaged, so as to improve the reliability of the whole system. Drive the execution unit main function is used to drive motor and rotating, and by mechanical transmission mechanism to drive the photovoltaic battery array rotation [5].

Solar automatic tracking system is mainly composed of two parts of control circuit and mechanical structure. The control circuit includes signal acquisition, amplification, processing, drive circuit. Photovoltaic array bracket, the rotation axis and the mechanical structure of the stepping motor. Light sensors to determine the position of the sun according to the strength of light, and then drive the rotation of the motor to track bracket. The light sensor has received the most radiation from the sun, when the sun goes down or the sky light range, automatically return to the initial position of the east toward the light sensor [6]. Automatic tracking system basic structure as shown in Figure 1 is mainly composed of light sensors, signal processing circuit, MCU, stepper motor.



**Fig.1:Structure of the automatic tracing system**

Its working principle is: read the signal from the light sensor and to compare the data, according to the data values are determined motor steering (if the difference is in the range of error, cancel the motor rotation). The drive motor steering again after the read signal light sensor, so the cycle moves with the sun moving light sensors, to achieve the goal of tracking. In addition, the step tracking method, compared with the continuous tracking mode, step tracking mode can reduce their energy consumption tracking system greatly [7].

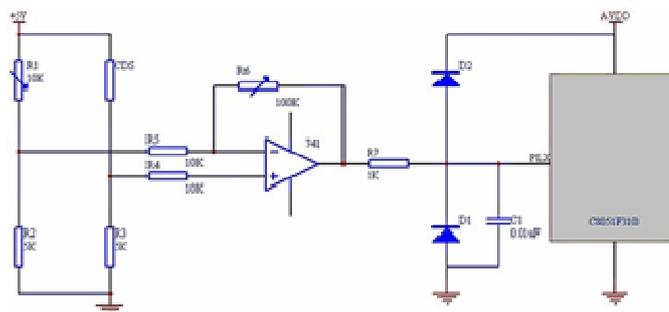
In order to further improve the operation accuracy of the control system, this system adopts double axis tracking device, the device also sun tracking range by two perpendicular directions. According to the test, power generation capacity of the dual axis tracking system installation height of 30% to 40% than the fixed angle, can effectively improve the efficiency of power generation.

### 2.2 The working principle of optical pickup

A light sensor by resistance value of photosensitive resistance with increasing light intensity changes, system use photosensitive resistance CDS as the light sensor to detect changes in solar intensity, to track the sun maximum intensity range by comparing the resistance difference angle [8]. The model is GL125, bright, dark resistance are respectively 4~11K and 120Kou.

If the circuit shown in Figure 2 consists of a Wheatstone bridge circuit rheostat R1 resistance, sliding CDS and two of 5Kou. There are two such bridge circuit and signal to the single chip of C8051F310. Differential amplifier as a

voltage amplifier, the output signal of the bridge after amplified can improve the load capacity, the voltage follower 741 chip voltage signal, then the C8051F310 built-in 10 bit high accuracy calibration ADC analog to digital conversion, and then a data processing machine.



**Fig.2: The bridge circuit of Whiston**

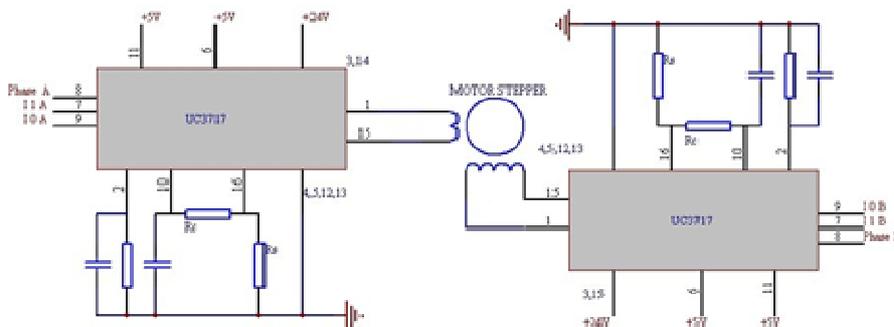
In the seismic field testing, to ensure that the analog signal to boot into C8051F310 ADC in the 0~+2.5V range to, otherwise it will lead to start the ADC reference voltage terminal voltage free. At the same time, but also to ensure the analog voltage output is 741. Therefore, the output voltage follower is connected as shown in Figure 2 is composed of a D1 and a D2 clamp circuit, ensure that ADC input safety input is in the range of the analog-to-digital converter. In addition, the capacitor C1's role is to ensure the ADC conversion accuracy.

When the light is off the solar angle, the resistance of the CDS smaller lead to voltage corresponding to bridge arm output increases, then the differential voltage signal output of the larger two bridge arm. After the treatment of SCM control commands issued to the stepper motor rotation corresponding angle, this process until the light sensor on the sun. At this point, differential bridge output voltage signal CDS corresponding to less than a prescribed value, the stepper motor not running [9].

**2.3 Stepper motor driver**

UC3717 is a professional PWM chopper two-phase stepper motor driver chips. It integrates segmentation, decay mode setting, regulation circuit, CMOS power amplifier circuit, step angle is 0.9 degrees. The decay mode regulating terminal speed and mixed decay regulation. Drive circuit with the external circuit can be simple to achieve high performance, multi segment, and large current, to reflect the advantages of low cost, low vibration, low noise, and high speed in this design.

As shown in Figure 3, phase step consists of two UC3717 and a few external components into the motor drive system has simple features, by overheating in chip and overcurrent detection can design the drive protection circuit is very convenient. When the circuit works, the driving current step motor winding is gradually increasing, 16 feet of the external resistor divider VRS, VRS pressure on the pin 10 through a resistance Rc low pass circuit. This time through the detection of the chip logic circuit supply voltage Vc output close below 3.9V, the output opening protection function is greater than 4V. When VRS increases higher than built-in voltage threshold voltage, current switching operation will be off, resulting in reduction of VRS. When the VRS is reduced to less than the threshold voltage, the starting current of switching operation, this move in circles to stepping motor's winding current reversed phase.



**Fig.3: Driving circuit of UC3717**

When the stepper motor stops running, because the system inertia or environmental wind caused twisting or rotating

shaft will therefore deflection, which influence the accuracy of tracking. Therefore, when the motor stops to the motor shaft a locking torque locking motor spindle is very necessary. UC3717 chip manual knowledge, its 7、 9 feet is connected with a motor, for controlling the output drive current end. When 7、 9 feet is "1", A0, B0 output current of UC3717 is 0. Maximum average output current is "1". So when the motor stops when the rotor to the magnetic force balance, so as to ensure the precision of control.

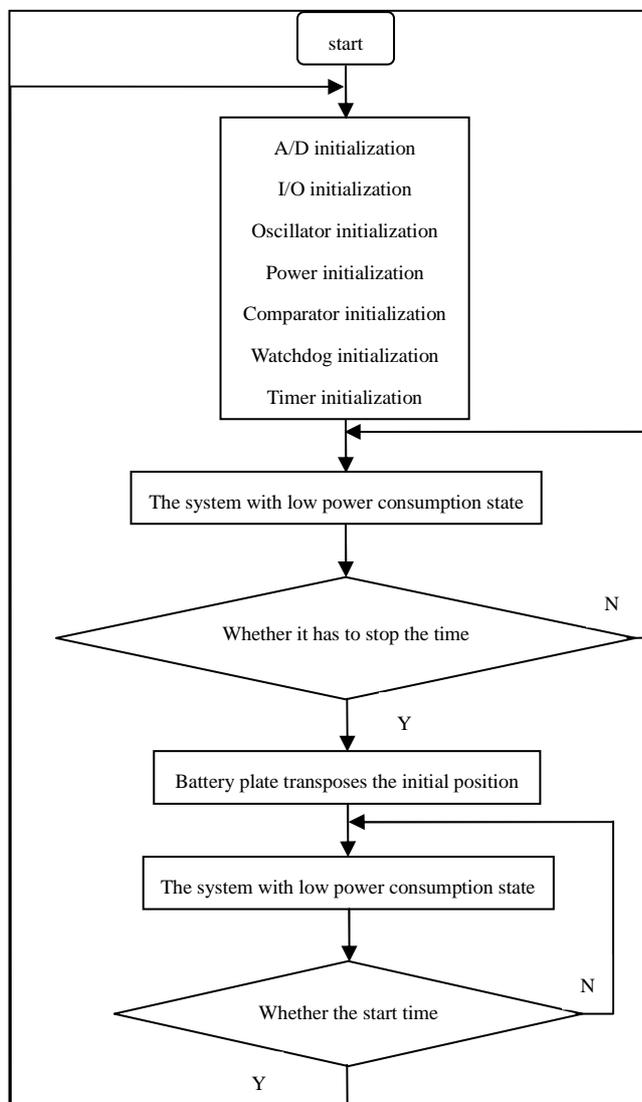


Fig.4:Flowchart of the control algorithm

## 2. The software design of the system

Software adopts modular design, according to the overall function of the system is divided into several different modules, and then a separate design, programming, debugging, finally each module assembly debugging, software system. System design software including: tracking system main program, motor driver, serial port to send a program, INT0 interrupt service program, data acquisition and processing program, communication program control system.

The main program flow is shown in figure 4. Systems need to initialize the module includes: analog to digital converter, input and output port, the system oscillator, watchdog timer, interrupt, UART0, power supply etc. In addition, the programmable counter array (PCA) module implements the WDT function, in order to prevent the program into disorder or illegal state.

## 3. The system of anti-interference measures

To stable and reliable operation is automatic solar tracker has become the premise of mature products, two aspects of the system from hardware and software to enhance the anti-interference measures, the main means of:

- (1) The external input signal and control signal are not common ground;
- (2) Some external input signal input prior to the MCU internal through opt coupler circuits strictly segregated;
- (3) The optimization of PCB routing structure, reduce the hole, in order to reduce the effects of parasitic capacitance and stray inductance;
- (4) The entire system to ensure reliable grounding;
- (5) The external signal using the shielding cable transmission;
- (6) Measures increase the filtering software, software at the door timer and the software trap, ensure software self-recovery in the crash, run away when a fault;
- (7) System is an important protection such as limit protection from software and hardware to double protection, in order to improve its reliability.

#### 4. Test results

In order to validate the scheme, an unmanned station in Xinjiang Kashi from 6 a.m. to 7 p.m. on the system test. With the peak power of APM72M240W single crystal silicon photovoltaic battery array 240W experiments, four 12 volt An-hour, 100 depth of discharge for lead-acid battery 65%, every two batteries in series as a single group, no automatic tracking system for solar power and photovoltaic power automatic tracking system using a set of. During the experiment, the current compared two groups of photovoltaic battery to charge the batteries of the value, the test results are shown in table 1.

Table 1 data shows, the automatic tracking system of device is connected, the output power of photovoltaic cells has been significantly improved. The experimental results agree with the theoretical analysis, to realize the automatic tracking photovoltaic array on the optimum illumination.

**Tab.1: Comparison of test results**

Day Point of time (Hours)	The charging current without automatic tracking system(A)	The charging current automatic tracking system(A)	Output power Improve the percentage (%)
6	9.72	16.07	65.31
7	10.46	16.49	57.62
8	11.44	17.18	50.14
9	12.40	17.61	42.01
10	13.06	17.55	34.39
11	14.02	16.74	19.42
12	15.06	17.40	15.58
13	16.20	18.20	12.33
14	17.22	20.68	20.11
15	18.20	23.34	28.23
16	14.88	20.14	35.36
17	12.90	18.48	43.27
18	12.70	19.39	52.69
19	11.62	18.97	63.24

#### CONCLUSION

At present, automatic tracking device without Xinjiang Kashi unattended seismic station photovoltaic system, power generation efficiency is low. In the light of this situation, design of a single axis tracking system. Through practical application and testing, effectively overcomes the bottleneck of photovoltaic power generation investment is too high. For the unattended seismic station network is difficult to reach, this method has the advantages of simple structure, has the very strong applicability, is bound to have a broad application market.

#### Acknowledgments

The work was supported by Special Fund of Fundamental Scientific Research Business Expense for Higher School of Central Government (Projects for young teachers) (No. ZY 20140212) and Special Fund of Fundamental Scientific Research Business Expense for Higher School of Central Government (Projects for creation teams) (No. ZY20110104).

## REFERENCES

- [1] Paskaleva K. *International Journal of Innovation and Regional Development*, v.1, n.4, pp.405-422, 25 January, **2009**.
- [2] Arora A.. *Traffic Engineering and Control*, v 53, n 10, p 375-378, November **2012**.
- [3] B. Chen and H. H. Cheng. *IEEE Trans. Intelligent Transportation Systems*, vol.11, no.2, pp.485-497, **2010**.
- [4] Seng Dewen. *Applied Mechanics and Materials*, v. 189, p. 482-485, **2012**.
- [5] SENG Dewen, LI Zhongxue. *Journal of Liaoning Technical University*, Vol.27(1), pp.9-12, **2008**.02.
- [6] Dikaiakos M. D.. *Minersoft: ACM Transactions on Internet Technology*, v.12, n.1, June **2012**.
- [7] Seng Dewen, Shu Yueqing. *Advances in Intelligent Systems and Computing*, p. 393-400, **2013**.
- [8] Di Lecce, V. Amato, A. *IET Intelligent Transport Systems*, v 5, n 3, p 149-158, September **2011**.
- [9] Prashant T., Kavita D., Manish S.. *International Journal of Soft Computing and Engineering*, v.2, July **2012**.
- [10] LIN T. Y. *Granular Computing: From Rough Sets and Neighborhood Systems to Information Granulation and Computing in Words*. European Congress on Intelligent Techniques and Soft Computing, Heidelberg, Germany, pp.1602-1606, September 8-12, **1997**.