Design of Solar Energy Automatic Tracking Control System Based on Single Chip Microcomputer

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Abstract. To improve the photovoltaic conversion efficiency of solar energy, promote the development of photovoltaic industry and alleviate the pressure of energy shortage. This paper designs a biaxial solar ray automatic tracking system, which combines sun-path tracking with photoelectric detection tracking. When the system is running, the weather condition is judged by photosensitive resistance at first. The cloudy day adopted the sun-path tracking by getting the time date in the clock module. The azimuth and altitude angles of the current sun are calculated by the corresponding calculation formula. Then the stepper motor is controlled by a single chip microcomputer to adjust its position accordingly. The sunny day adopted the photoelectric detection tracking mode, the light intensity signal collected by four photosensitive resistors is converted into a voltage signal to identify the orientation. The single chip computer controls the rotation of the horizontal and vertical stepper motors after program calculation. In this way, the biaxial automatic tracking of solar panels is realized. Practice shows that, the tracking system can continuously improve the utilization rate of solar energy, and high tracking accuracy, it has strong practical value.

1. Introduction

In the situation of increasingly serious energy shortage and non-renewable energy sources are running out, vigorously develop renewable resources is imperative. The solar energy as a new energy, it has advantages of renewable, clean, and reserves the endless, etc. Therefore, it has become a hot research topic in various countries. However, the solar energy has the disadvantages of dispersion and instability, this has become one of the bottleneck restricting the application of solar energy. At present, the solar energy tracking control system can improve the utilization efficiency of solar energy. Practical research shows that, the weather is good and other conditions are the same, biaxial automatic tracking of the sun than fixed installation has not been tracking power generation overall increases by about 35 percent[1-2]. Therefore, research and design of biaxial solar energy automatic tracking control system, it is of great practical significance to improve the utilization rate of solar energy resource.

At present, there are two main tracking methods for the sun, that is, sun-path tracking and photoelectric detection tracking[3]. The sun-path tracking accuracy is low, but not outside interference. Photoelectric detection tracking accuracy is high, but it's susceptible to produce a false action. In this paper takes the single chip microcomputer as the control core, adopted the method of combined sun-
path tracking with photoelectric detection, achieved different weather conditions can be tracked accurately, then achieved the purpose of improving the utilization rate of solar energy.

2. Principle of automatic tracking

2.1 Principle of sun-path tracking

The sun-path tracking is through the astronomical formula to calculate the current time solar altitude Angle and azimuth Angle, from this can get the Angle at which the device needs to turn to aim at the sun, using computer program to control motor rotation, thus adjusting the height Angle and azimuth Angle of solar panels, achieved tracking device can track the sun[4]. This tracking method is an open-loop control, not affected by weather conditions.

2.2 Principle of photoelectric detection tracking

Using the photoelectric detection and tracking mode to realize the automatic tracking of solar illumination intensity. Its implementation steps are: after starting up, power on reset, process system initialization and fault diagnosis. Then, the system first determines whether there is light or not. If there is no light in the night, the system will automatically enable interrupt handler to enter a waiting state. If there is daylight in the light, system enters photoelectric tracking mode, automatically adjust to the position and height at which the maximum light intensity is acceptable.

In this control system, the photoelectric detection device is mainly composed of four SG5516 photosensitive resistors with the same characteristics, using the value of photosensitive resistance decreases with the increase of light intensity[5]. By collecting the partial pressure value of the fixed resistance to determine the variation of light intensity and solar azimuth, the schematic diagram of photoelectric detection device is shown in Figure 1.

![Figure 1. The Schematic Diagram of Photoelectric Detection Device](image)

The four photosensitive resistors are mounted symmetrically in the top, down, left and right four positions of the photoelectric detection device. The left and right (east and west) are used to detect the changes of solar azimuth Angle, the top and down (north and south) are used to detect the changes of solar altitude Angle. When the sunlight vertically irradiate on the panel, the left and right photosensitive resistors are completely in the lighting area. It outputs two electrical signals of the same size (the output signal difference is 0) the horizontal motor does not rotate at this time. When the direction of the sunlight changes and is not perpendicular to the panel, the photosensitive resistors of the left and right receive different light intensity. That is, the resistance value is different, so that the output signal has a difference value. When the difference reaches a certain threshold, the motor drives the solar panel to rotate in a horizontal direction, reduce the deviation, until the signal difference is 0. That is, both sides photosensitive resistors receives the same illumination intensity (the solar ray perpendicular to the solar panels), to achieve accurate tracking of the sun.
3. System fault self-diagnosis
The solar energy automatic tracking system should ensure the photoelectric detection device can normal operation in sunny days, only in this way can ensures accurate track, increases the utilization rate of the solar energy. So after the system is initialized, firstly, the photoelectric detective device should be proceed fault self-diagnosis. If the photoelectric detection device going wrong, should notify users in time, and execute the sun-path tracking control program.

It can be seen from Fig.1 that the system by collecting the photosensitive resistance voltage value to detect and judge the change of light intensity and solar Angle. So according to the characteristics of this system, the method of self-diagnosis of photoelectric detection device is signal pretreatment method, by comparing and analyzing the collected 4-way voltage values, using the photoelectric control program can judge whether the photoelectric detection device is working normally or not. When the photoelectric detection device fails, there are two main situations, analysis as follows:

(1) When there is a problem with the circuit connection of photoelectric detection device, the collected 4-way voltage value all is VCC or 0 (when the sun height Angle is greater than 0). When the collected voltage value appears VCC or 0 exceeds a set time, is that the photoelectric detection device power supply line has fault.

(2) In the process of system tracking operation, the collected 4-way voltage values are approximately equal in general. When the sun moves, there is no vertical irradiation to solar light and photosensitive resistors, at this point, the detection device the voltage value of 4-way will appear unequal situation. At this moment, the system will control the motor to rotate to adjust the solar panel perpendicular to the incident light. That is, the time when the voltage value is not approximately equal is very short. So, when the collected voltage is not approximately equal and exceeds a certain time, at this time, it can be considered that the photoelectric detection device fails. Then, by analyzing the magnitude relation of several voltage values to determine which photosensitive resistance is fault.

4. System design

4.1 System hardware design
The system hardware structure block diagram is shown in Figure 2. It is mainly composed of photoelectric sensor, photoelectric signal conversion circuit, single chip microcomputer, driving power, clock module, stepping motor and corresponding circuit. The whole control part is a closed-loop control system with STC89C52 single chip microcomputer as the core unit. The single chip microcomputer is responsible for processing the data returned form each input port and analyzing and calculating according to the software process, finally give the motor control signal, make it complete the desired trace action.

Figure 2. The System Hardware Structure Block Diagram
The system first determines whether it is cloudy or sunny by rain or shine detection circuit composed of photosensitive resistors. The cloudy day system runs the sun-path tracking mode. By
obtaining the time data of the clock module, the azimuth and altitude Angle of the sun at the current
time are calculated by the corresponding algorithm. Single-chip Microcomputer Controls Stepper
Motor by Software for Corresponding Angle Adjustment. The sunny day system runs the photoelectric
tracking mode.
This design adopted STC89C52 single chip microcomputer module generated by STC. The chip
has 8K bytes of system programmable memory and 512 bytes of RAM, 32-BIT I/O port. STC89C52
uses the classic MCS-51 kernel, and made a lot of improvements. It can control the electromechanical
system with low energy consumption, high performance, low cost and high reliability requirements[6].

4.2 System software design
The control system program flow diagram shown is Figure 3.

Figure 3. The Control System Program Flow Diagram

The program design of this system mainly includes 3 parts: the photoelectric detection tracking,
sun-path tracking and fault diagnosis. The system software design is as follows: after the system starts
up, first proceed the initialization of each module and the fault detection of photoelectric detection
device. When the photoelectric detection device is normal, it is judged by the photoelectric sensor
whether it is day or night. If it is night, system does not start, enter low power mode. If it is day, judge
whether it is sunny or cloudy. Sunny days, system enters photoelectric detection tracking mode. Rainy
days, system enters sun-path tracking mode. When the photoelectric detection device fails, the system
will notify user system failure and the possible causes of system failure in a timely manner, and
transfer to the sun-path tracking mode.

4.2.1 Photosensitive resistors signal collection procedures. Four photosensitive resistors convert the
intensity signal of the collected light into a voltage signal, single chip microcomputer respectively
read and enlarge (that is, change the units into mv), the main procedures are as follows:

```c
void main()
{
```
while(1)
{
    Pcf8591SendByte(2);
    AdNumBack = Pcf8591ReadByte()*2;
    BackValue = AdNumBack/2*0.01953;
    AdNumBack = BackValue*1000;
    Pcf8591SendByte(3);
    AdNumRight = Pcf8591ReadByte()*2;
    RightValue = AdNumRight/2*0.01953;
    AdNumRight = RightValue*1000;
    Pcf8591SendByte(1);
    AdNumFornt = Pcf8591ReadByte()*2;
    ForntValue = AdNumFornt/2*0.01953;
    AdNumFornt = ForntValue*1000;
    Pcf8591SendByte(0);
    AdNumLeft = Pcf8591ReadByte()*2;
    LeftValue = AdNumLeft/2*0.01953;
    AdNumLeft = LeftValue*1000;
    Motora();
    Motorb();
}

4.2.2 Stepper motor control procedure. Control motor rotation using comparison program to achieve, the method is: the output voltage values of the four photosensitive resistors read by the previous single chip microcomputer, compare left and right, up and down respectively, calculate the difference value. The difference value is compared with the set threshold (50 mv), thus control the motor to make the corresponding rotation, to get the solar panel to the desired position. The main procedures are as follows:

    void Motora()
    {
        profile=AdNumLeft-AdNumRight;
        if(profile>50)
        {
            pwma=1;
            motora1=1;
            motora2=0;
        }
        else
        {
        }
    }

    void Motorb()
    {
        forntage=AdNumFornt-AdNumBack;
        if(forntage>50)
        {
            pwmb=1;
            motorb1=1;
            motorb2=0;
        }
        else
        {
        }
    }
if(profile<-50) if(fortnage<-50)
{
    pwma=1;
    pwmb=1;
    motora1=0;
    motorb1=0;
    motora2=1;
    motorb2=1;
}
else
{
    motora1=0;
    motorb1=0;
    motora2=0;
    motorb2=0;
}

5. Conclusion
With the application of solar energy more and more extensive, the research of sun automatic tracking control system is more and more important. This paper designs that hardware and software of the solar energy automatically select the tracking mode according to the weather and day and night, and it can adjust the Angle in real time according to the direct sunlight, to achieve accurate tracking. Practice shows that, the control device has high tracking precision, simple structure and high conversion efficiency, has the promotion application value.

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