Performance Analysis of Vertical Wall Light-Tending Solar Photovoltaic System

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***Abstract**:*

This paper proposes ray detector to be the solar radiation angle sensors, and send the output signal to stepping motor after the treatment of HT66F50 single chip. Thus, it can reach adjust to the angle of photo-voltage modules automatically. These results provide useful information for the circuit and mechanical structure design of the renewable energy

Keywords

Photo-voltage modules, stepping motor, shading device, HT66F50 microprocessor, application examples

1. Introduction

Over the last years, due to limitation of the fossil fuel resources and Kyoto Protocol of Ratification, promotion of the renewable energy applications appears to be more and more important to reduce the CO2 emission, besides developing substitute energy resources. Therefore, interconnected with utility grid systems, the amounts of dispersed generation systems, such as photovoltaic and wind generations, increase yearly.

In the solar power supply system, the "Grid-connected photovoltaic system" is that when the sunshine is sufficient, the solar battery provides electrical energy to its own load, and if there is excess power, it will be stored separately. When the power generation is insufficient or none, the required power is provided by the power company.

Because electricity can be provided by power companies when electricity is insufficient, unlike a "Stand-alone power system", it is necessary to increase the cost in order to prepare a large battery capacity, nor does it consider the distribution problem when the "Feedback power system" is to be sold to the company.

Therefore, compared with "Stand-alone power system" and "Feedback power system", "Grid-connected photovoltaic system" may be suitable for general institutions and households.

But when we consider using the "Grid-connected photovoltaic system" in the city, because the available space is limited, except for the roofs of various buildings, there seems to be no place to install solar panels, and the solar panels that can be erected are limited. If the roof has other uses, there is nowhere else to use. For tall buildings in the city, the wall area of the building is usually larger than the roof. Installing solar panels on the sun-facing wall of the building should effectively increase the solar panel area. If the solar panel is directly embedded on the wall, the conversion efficiency may be poor due to the angle of the light. A solar panel that is inclined on the vertical plane may be blocked by the upper shadow. Therefore, we propose to install a phototaxis system that can adjust the solar panel according to the sunshine angle on the wall of the building. The angle of the solar panel can be adjusted to obtain better conversation efficiency. The proposed system installs solar cells on the walls of buildings in a structure similar to shutters. It uses a light detector to detect the sunshine angle and send the sunshine angle data to the microcontroller. After the information is judged by the microcontroller, the solar panel angle control motor will be adjusted to the desired angle. The microcontroller used in our system is the Holtek HT66F system microcontroller.

2. Operation principle

Because the solar cell's power generation efficiency is related to the angle with the incident sunlight, the maximum efficiency can be obtained when sunlight enters the solar panel perpendicularly.

In general design, the solar panel is fixed at an inclined angle, and the angle is based on the full year average noon daylight angle. In Taiwan, it often faces south, inclining around 23.5°. We take the Tropic of Cancer 23.5°, which is the noon solar radiation angle during the spring equinox and autumn equinox. When using a fixed inclining angle, the effectiveness of solar cells in the morning and afternoon is significantly lower due to oblique radiation. If the solar photovoltaic module is installed on the vertical side of the building, the design will directly embed the solar panel on the wall, because of the problem of the light angle, the efficiency may be poor. In terms of design, the solar panels inclined on the vertical plane may be blocked by the upper shadows from the lower solar panels. The design of placing the photovoltaic modules on the vertical surface of the building is considered suitable for high latitude areas and not suitable for Taiwan.

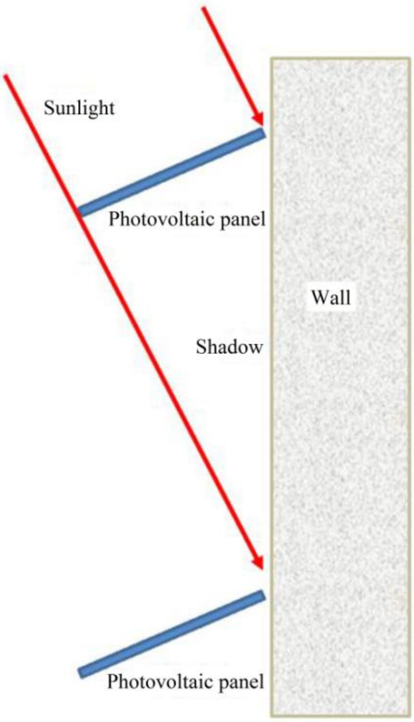

Figure 1. Consideration of shadows when installing photovoltaic panels on walls.

However, space is limited in the city, and solar panels are erected on the sun-facing wall of the building. When the cost of solar panels is lowered, the more and the more there is room for examination. The solar panel inclined on the vertical plane plus light-tending device, the solar panel tilt angle can be adjusted according to the sunshine angle, and the solar panel can obtain better effect.

The time that the lower solar panel is covered by the upper shadow is actually limited to the noon in summer. In other seasons and during the day, all layers of solar panels can be effectively operated [1-10].

Our proposed system install the solar cell on the wall of the building according to the structure of like shutters. But it is not closely connected like shutters. Because it is necessary to consider the problem that the lower solar panel will be covered by the upper shadow, the solar panels should be far away from each other. As shown in Figure 1, when installing solar panels on the wall, consider the location of the solar panels to avoid shadows completely.

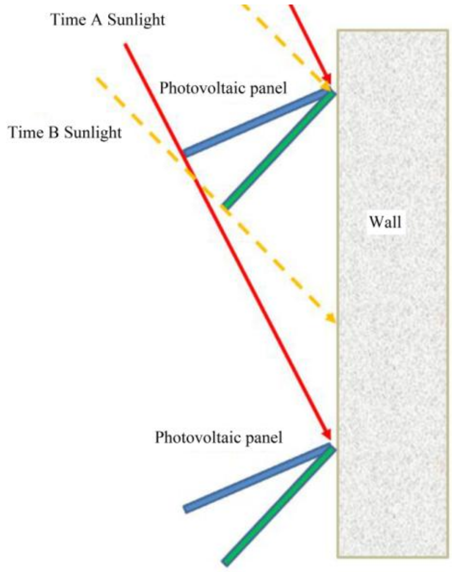

Figure 2. According to the sunshine angle, the photovoltaic panel inclining angle is adjusted.

The proposed system with the addition of light-tending device, the inclining angle of the solar panel is adjusted with the sunshine angle. As shown in Figure 2, the daylight angle is different due to time is different. The light-tending device adjusts the photovoltaic panel angle to the sunlight perpendicular to the solar panel, so that the solar cell can get better power generation efficiency.

3. Hardware functions and features

The proposed system can be used on the sun-facing wall of the building. In cities with high-rise buildings, it provide electricity users who lack space. A solar power supply system such as a grid-connected photovoltaic system can be installed to make the use of solar energy more popular. For countries in high latitudes, this proposed system is more suitable. The proposed system provides a more efficient solar power supply system in urban areas.

Only after calculating the increased cost of installation and the expenditure under space saving, we can determine which areas are suitable for erecting the proposed system.

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4. Complete production structure

4.1 Hardware production

The proposed system is to install photovoltaic panels on the wall of the building, uses the sunshine angle detecting circuit to detect the sunshine angle. The detectors send the sunshine angle data to the microcontroller circuit. After the microcontroller judges the information, the microcontroller decides the solar panel angle. The microcontroller also knows the photovoltaic panel angle from the photovoltaic panel angle detection circuit. Using the motor and sunshine angle detection circuit, the photovoltaic panel angle control circuit adjusts the photovoltaic panel to the desired angle. The hardware block diagram is shown in Figure 3. Each component is explained as follows:

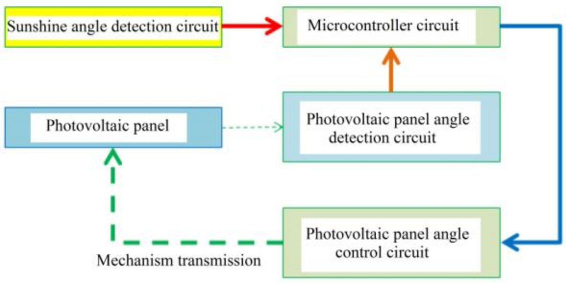

Figure 3. The proposed system hardware block diagram.

1. Photovoltaic panel: Add the solar cells of the mechanism device that can control the angle, and wire it to the load system.
2. Sunshine angle detection circuit: It is composed of multiple photo-detectors at the different positions, comparing the different photo-detector to detect the difference with light intensity and determining the sunshine angle. It compares the difference of the light intensity ratio at different position, not the difference of the light intensity value.
3. Photovoltaic panel angle detection circuit: Because the solar panel is at outdoors, the panel angle will be affected by some external factors. The photovoltaic panel angle must be monitored, so add a panel angle detection circuit to the photovoltaic panel.
4. Photovoltaic panel angle control circuit: The motor drives the mechanism device that controls the control angle on the photovoltaic panel. The mechanism turns the photovoltaic panel to the required angle.
5. Microcontroller circuit: Monitor the sunshine angle, monitor the photovoltaic panel angle, and control the solar panel angle 's main control circuit.

4.2 Software production

The proposed system control program flow chart is shown in Figure 4.

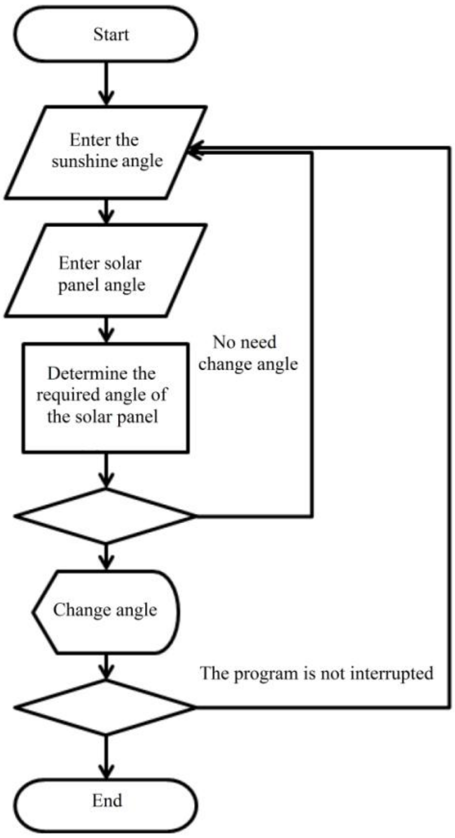

Figure 4. The control program flowchart of the proposed system.

First, we enter the sunshine angle and photovoltaic panel angle data from the sunshine angle detection circuit and the photovoltaic panel angle detection electricity circuit. The microcontroller determines whether the photovoltaic panel angle needs to be adjusted and adjust the angle. The microcontroller sends the control signal to the photovoltaic panel angle control circuit for controlling the solar panel to change the angle. If there is no special big break command, repeat the above procedure.

5. Hardware architecture

This hardware is composed of HT66F50 single-chip control circuit, photosensitive detection circuit, transparent acrylic board, stepping motor, photovoltaic panel, reset circuit, ULN2803 current amplification drive circuit and other parts. The overall block diagram is shown in Figure 5.

In Figure 6, VSS is the 14th pin of the HT66F50, which is the ground pin of the circuit. VDD is the 19th pin of HT66F50, the power pin needs to be connected to 5V. We use an internal oscillation

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circuit, so there is no need to connect an external oscillation circuit. We use two 0.1uf capacitor (C1, C2) parts to make the frequency of HXT oscillation circuit of HT66F50 is equals to 1MHz.

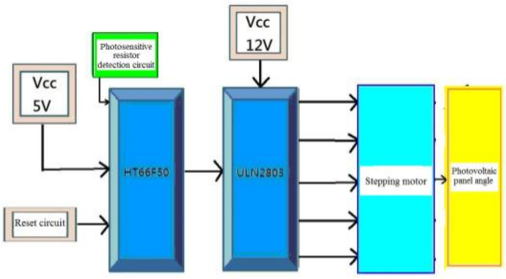

Figure 5. The overall block diagram.

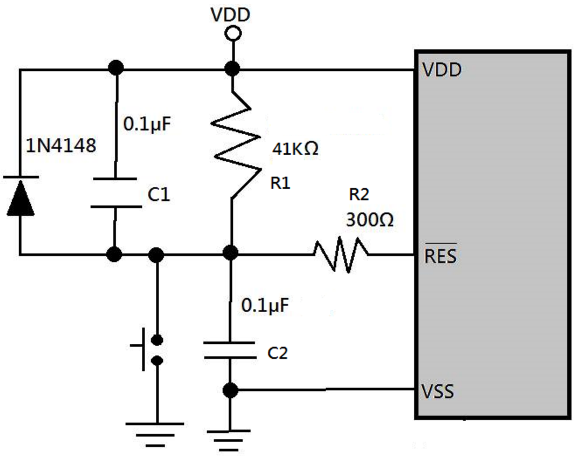

Figure 6. HT66F50 reset circuit connection diagram.

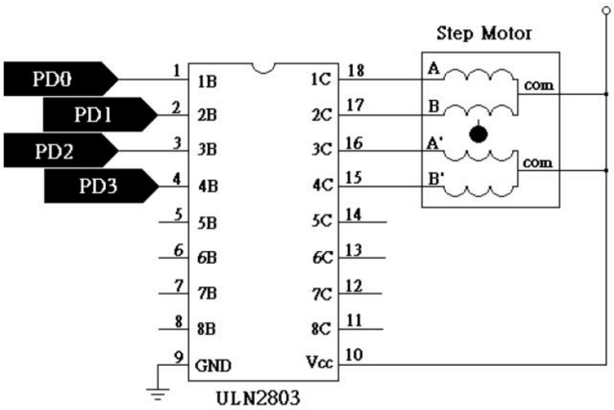

Figure 7. Schematic diagram of connecting the PD0 to PD4 pins of the HT66F50 to the ULN2803 and stepper motor.

Pin 19 and pin 20 of the HT66F50 are reset circuits, as shown in Figure 6. The reset circuit requires a 300 ohm resistor (R2), 41K ohm resistor (R1), IN4148 diode, two 0.1uf capacitors (C1, C2) and an external reset button, as shown in Figure 7. The 5th, 6th, 7th and 8th pins of HT66F50 are Input / Output pins. Because the output voltage of HT66F50 is too small, we added a ULN2803 circuit to increase the output voltage to 12V. The Input / Output pin is input from the ULN2803 Darlington circuit and then output from the 18th, 17th, 16th, and 15th pins of the ULN2803 via 12V. ULN2803 requires an additional 12V voltage, and then the stepping motor.

Figure 8. Light-sensitive detection circuit detector.

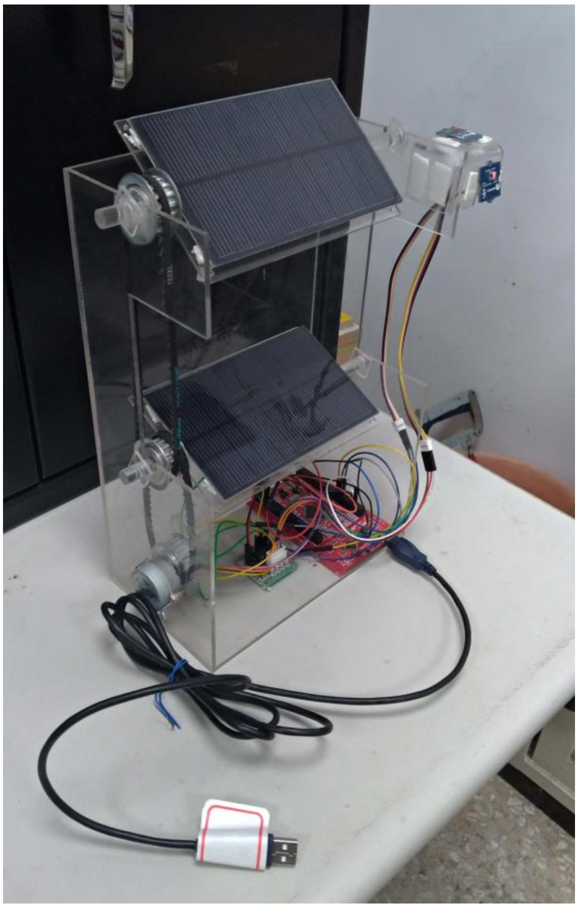

Figure 9. Result photos.

We have packed the solar panel, acrylic, photo-detector, and stepping motor shaft into a block package. Shown in Fig. 8, when the light-sensitive detection circuit detector absorbs light energy, the analog signal is transmitted to the HT66F50 to receive the signal and judge. HT66F50 send a signal to Darlington transistor ULN2803 to amplify the current, the stepper motor receives the signal action and engages in forward or reverse revolution. Let the angle of the solar panel change so that the sunlight enters the solar panel perpendicularly.

6. Conclusion

The result photo is shown in Figure 9. Solar photovoltaic energy is renewable energy. This implementation uses a light detector to detect the sunshine angle and sends the sunshine angle data to the microcontroller. After the information is judged by the microcontroller, the solar panel angle control motor will be adjusted to the desired angle. According to the requirements set by the user, output signals to the stepper motor, thus can achieve automatic control of the motor to adjust the solar panel to the desired angle. It can be as a reference for researchers engaged in related research.

7. Acknowledgements

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