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A photovoltaic solar tracking system with bidirectional sliding axle for building integration

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Abstract

A new single-axis solar tracking device is designed and explored, which is able to lift and lower the photovoltaic panels. The photovoltaic panels can be tilted to east-west directions in the process of tracking the sun. In windy weather, the solar panels can be placed close to horizontal rail by using stent, which can minimize the frontal area. What's more, the mechanical strength of this device is better than traditional single-axis solar tracking system, so as to enhance wind resistance in windy weather. The device in this paper is suitable for PV power plants on building roofs because it can meet the strict requirements of wind resistance capacity and safety.

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Keywords: solar tracking, shelter, building integrated, bi-directional sliding shaft

1. Introduction

Existing tracking photovoltaic system can be divided into single-axis tracking system and dual-axis tracking system. The single-axis tracking system with the axis perpendicular to the ground can only track solar azimuth, but can't track solar altitude. However, the dual-axis tracking system can track both solar azimuth and altitude [1]. Under same conditions, the photovoltaic system with dual-axis tracking system obtains significant higher generating efficiency than that with single-axis tracking system [2]. Ali Al-Mohamad [3] designed a solar tracking device that controls and supervises the photovoltaic cell panel by PLC circuit, finding a 40% higher generating capacity of the photovoltaic system with dual-axis tracking system compared with that with single-axis tracking system under same conditions. Kashif Ishaque [4-6] et

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al. developed a maximum power tracking technology for photovoltaic cell panel based on the particle swarm optimization algorithm, which overcame the local shadow of traditional direct control system. Yi Maa [7] et al. carried out a theoretical study on the optical performance of solar panel with three-azimuth solar tracking system.

A photovoltaic solar tracking system with bidirectional sliding axle is developed in this paper. With bidirectional turnover of the solar panel and lower windward side adjustment of the photovoltaic cell panel from the bidirectional push system, it is easy to be installed on the building surface, realizing the goal of building integration.

2. System configuration

The developed photovoltaic solar tracking system with bidirectional sliding axle can provide bidirectional solar azimuth tracking, thus increasing the utilization rate of sunlight and the generating efficiency of the cell panel. The solar orbit can be calculated from horizontal coordinate system, which lays foundations to the prediction and analysis of real-time position of the sun. The real-time tilt of the solar panel will be reflected by the tilt sensor and analyzed by the control system. Finally, the solar panel will be adjusted to be at the best tilt state through the bidirectional pushrod which is driven by motor.

2.1. Overall structure

As shown in Fig.1, the developed system includes a stress carrier (slideway, grillage and radius rod), a drive mechanism (electromotor and pushrod) and a power generator (solar panel).

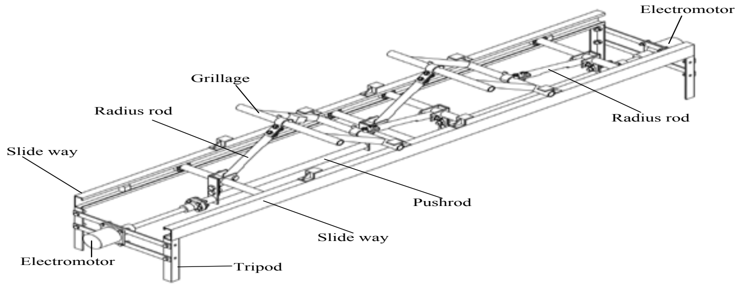


Fig. 1. Overall structure of photovoltaic solar tracking system

2.2. Bidirectional tracking system

The developed system can provide a bidirectional solar azimuth tracking for its involvement of a bidirectional sliding axle. The solar panel, fixed on the ground slideway, is pushed and pulled by the stepping motor-driven pushrod, with a tilt angle ranging between 0°~60°, thus achieving a bidirectional tracking to the sun position.

The solar panel is in horizontal position in the evening and morning (Fig.2(a)). The corresponding longitude and latitude of the sun are calculated from the GPS coordinate system and use the controller to control the movement of the stepping motor-driven pushrod to enable the solar panel achieve the best tilt angle, ensuring vertical sunshine on the solar panel all the time (Fig.2(b)). At noon, the solar altitude is about 90° and the solar panel returns to the horizontal position (tilt angle= 0°) (Fig.2(c)). As the sun goes westward continuously, the solar altitude starts to decrease and the solar panel slides from one baffle side to the other side under the effect of pushrod, increasing the tilt angle of the solar panel along the other direction until reaching the maximum tilt angle (Fig.2(d)). After the sunset, the controller will make prompt response to strong wind and enter into the shelter mode to have the solar panel return to the horizontal position (Fig.2(a)) for temporary for protecting the solar panel.

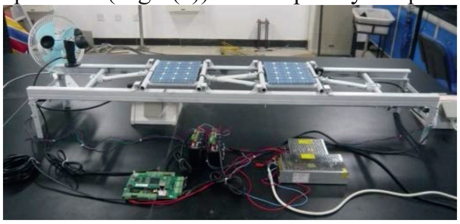
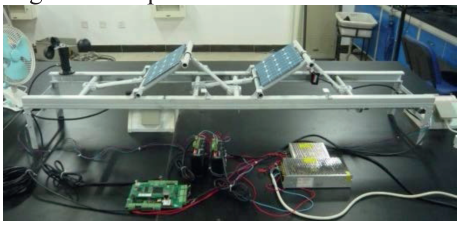



Fig. 2. (a) Working position in the evening (leeward) Fig. 2. (b) Working position in the morning

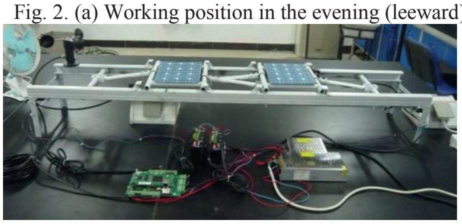
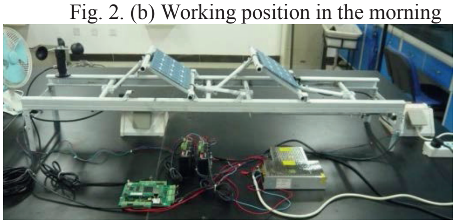



Fig. 2. (c) Working position at noon Fig. 2. (d) Working position in the afternoon

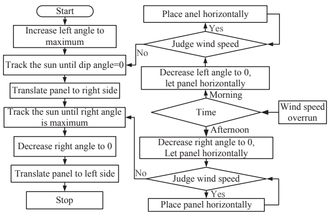
2.3. *Wind resistance and building integration design*

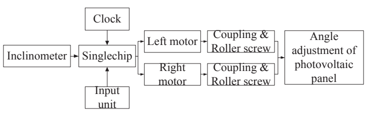
The solar panel is fixed on the slideway, which enables to control the height of gravitational center of the solar panel and increases its wind resistance. During strong wind, the height of the gravitational center of the system can be adjusted by adjusting the tilt angle of the solar panel. To decrease the windward area of the solar panel and increase the wind resistance of the system, the solar panel shall be locked and fixed horizontal and close to the horizontal slideway by using the radius rod.

3. Control system and control strategy

The longitude and latitude of the sun can be calculated by the GPS coordinate system. The real-time position of the sun is calculated by the singlechip based on the horizontal coordinate system and the next position of the sun is predicted through the prediction algorithm. Data from tilt sensor are compared with that of horizontal coordinate system for calculating the difference and adjusting the solar panel to tracking the sun position. During strong wind, the solar panel is locked and fixed horizontal and close to the horizontal slideway to increase wind resistance and prevent parting. The control flow is shown in Fig.3.

The solar panel is installed on the horizontal slideway and can slide back and forth on it. Connected with two motor-driven pushrods, the solar panel is driven and adjusted. The application of linear actuator with large reduction ratio and bidirectional linear actuator with low-power DC servo motor can control the solar panel at the best tilt state flexibly and accurately. The running process of system is shown in Fig.5.





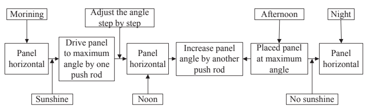


Fig.3. Control flow Fig.4. Work flow of the sensing system Fig.5. Running process of system

4. Conclusions

A photovoltaic solar tracking system with bidirectional sliding axle is developed in this paper, which can be used to track photovoltaic system on building top for its high wind resistance.

(1) The developed system is equipped with actuating devices on both sides, which can provide a bidirectional tracking of solar altitude.

(2) With controllable height of gravitational center, the developed system can lock and fix the solar panel horizontal to the building surface through the drive mechanism when facing with strong winds, thus protecting the photovoltaic system and preventing parting of solar panel.

(3) The developed system is superior for its few structural components, simple assembling, light weight, low cost, easy installation on building surface. It is a feasible photovoltaic tracking system for building integration.

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Biography

Jifeng Song is a Ph.D. in North China Electric Power University. His research interests focus on the collector area test of solar thermal power generation, regulation and utilization of concentrated sunlight, and integration and design of energy system.