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Design and optimization of an efficient three-dimensional photovoltaic module

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ABSTRACT

With the development of economy, people's demand for electricity is increasing gradually. With the shortage of resources, it is particularly important to make better use of new energy to alleviate the environmental pressure caused by thermal power generation, so as to promote the sustainable development of human society. People pay more and more attention to the renewable and pollution-free solar power generation. The aim of this paper is to optimize photovoltaic modules, improve the utilization of solar energy and energy conversion capacity of photovoltaic modules, A set of three-dimensional photovoltaic module based on solar radiation meteorology model is proposed, which can realize automatic light tracing and improve the problems of photovoltaic module in power generation efficiency. By improving the solar energy acquisition system and using the wind turbine system, the efficiency of solar energy generation can be effectively improved under the premise of ensuring the safety of photovoltaic panels, It can improve the control performance of the system, prolong the system life, make the whole system achieve high automation, reduce or avoid additional transmission and distribution costs.

Keywords: high efficiency ;three-dimensional; solar energy; Intelligen

1. INTRODUCTION

Energy is an important material basis for the development of national economy and people's life. In the past 200 years, the energy system based on coal, oil, natural gas and other fossil fuels has greatly promoted the development of human society. With the construction and development of smart grid, photovoltaic power generation is increasingly mature, and gradually becomes the focus of the power generation industry. Photovoltaic power generation system can make good use of clean energy to alleviate the environmental pressure brought by thermal power generation. As the sun rises in the East and sets in the west, the installation form and angle of photovoltaic array will directly affect the solar radiation received by the photovoltaic array. The immature power generation technology of photovoltaic system will also lead to low power generation efficiency. At present, many power generation systems have great limitations. In order to meet the sustainable operation of the power industry, how to determine the light tracking angle of photovoltaic panels, how to improve the power generation efficiency and improve the energy conversion rate have become the problems to be solved in the photovoltaic power generation industry. The three-dimensional photovoltaic power generation system can greatly improve the energy conversion rate.

2. DESIGN BACKGROUD AND SIGNIFICANCE

In recent years, the consumption of fossil energy is increasing day by day, and global resources are in short supply. The countries all over the world gradually realize the importance of energy to human beings, and recognize the damage to environment and ecosystem in the process of conventional energy utilization. According to the national conditions, countries have begun to treat and alleviate the deteriorating environment, and take the development and utilization of renewable and pollution-free new energy as an important part of sustainable development. "Green mountains and green waters are golden mountains and silver mountains.". In 2018, China issued the document "promoting the development of the

Yangtze River economic belt, green industry transformation". Therefore, the development of sustainable development of green economy has become an inevitable trend of economic development.

With the development of economy, the demand for electric power in all walks of life is increasing rapidly. China has a vast territory and a long coastline, so there are abundant solar energy resources. According to the estimation of relevant departments, more than $\frac{2}{3}$ of China's areas have annual sunshine amount of more than 2200 hours, and the total solar radiation of all parts of the country can reach 335kj-837kj / cm^2, with an average of 586kj / cm^2. Therefore, the storage capacity of solar energy in China is very large. The effective development and utilization of solar energy will not only reduce the environmental pollution to a certain extent, but also effectively alleviate the current energy crisis. In recent years, China's investment in solar energy has gradually increased, but the utilization rate in this respect is low. I believe that the proportion of solar photovoltaic industry in the market will be greater in the future. Therefore, the photovoltaic economy has great development potential under such a large background. And with the implementation of industrial and commercial roof, photovoltaic poverty alleviation and "photovoltaic +" projects, the application of photovoltaic market will present a wide range and diversified trend, which will produce photovoltaic products to meet various needs. To sum up, the photovoltaic industry will be greatly developed under the guidance of the economic background and its own development trend. In addition to complying with the trend of economic development, the photovoltaic industry has six advantages, such as fast income cycle, low investment cost, convenient grid connection, timely subsidy, high yield, energy conservation and environmental protection, which can make the photovoltaic industry develop in the market in the long term.

At present, the research on photovoltaic modules mainly includes the optimization of materials and process, but the energy conversion efficiency of the system. In Europe, Matthias Huber and other scholars proposed that adaptability is the ability of the power system to respond to the change of power demand for nuclear power generation. The use of solar energy can greatly enhance the flexibility of the system and avoid strong voltage fluctuations in the process of coal power generation. According to the form of light collection. Spanish scholars can divide the traditional flat plate type of non light collecting type and the tower parabolic type, trough parabolic type, dish type parabolic type, linear Fresnel type and downward reflection type according to the light collection form, and improve the efficiency of photovoltaic power generation by using photothermal technology. In order to improve the efficiency of photovoltaic power generation system, this paper proposes a set of three-dimensional photovoltaic module design scheme, and optimizes the photovoltaic panel's light absorption, security, MPPT and conversion efficiency, In order to achieve the optimal control strategy for the whole set of three-dimensional photovoltaic modules, effectively improve the efficiency of solar power generation, improve the system regulation performance, extend the system life, facilitate the realization of full automation, make the control more simple, reduce or avoid additional transmission and distribution costs.

3. DESIGN OF MODEL STRUCTRE

3.1 Design of 3D light tracing model

The device is composed of a three-dimensional rotator and a photovoltaic power generation board. The three-dimensional rotator is mainly composed of two parts of rotating axes (as shown in Figure 1), which complete the three-dimensional rotation control of photovoltaic power generation board. The single rotation axis of the lower part controls the photovoltaic power generation panel to rotate in the left and right directions. When the rotation angle is maximum, it can make the photovoltaic power generation panel incline to 60 degrees with the ground; the rotation in the front and back directions is jointly controlled by the rotation axis of the upper part, and the maximum rotation angle is also 60 degrees. The photovoltaic power generation panel forms three-dimensional rotation under the joint action of the two parts of the rotation axis, so as to achieve the maximum light intensity in daily work. With the double shaft motor drive system, the transmission structure can bear heavy weight and realize multi angle light source tracking.

Figure 1 Three dimensional light tracing mode

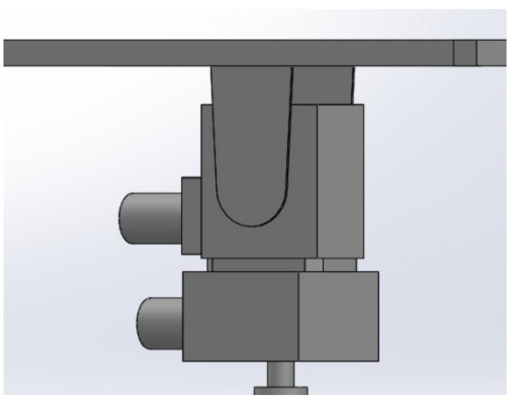

Figure 2 Double shaft motor drive structure diagram

Nowadays, in the field of light tracking technology, most of the PV panel orientation is fixed, or there are some two-dimensional tracking systems, which can realize the plane transfer angle of the photovoltaic panel according to the sun's moving angle, so as to realize the two-dimensional plane light tracing. However, the position of the sun is changing at any time. Neither the fixed angle nor the two-dimensional tracking system can ensure that the sunlight is always perpendicular to the solar panel, which maximizes the conversion efficiency. Therefore, the current two-dimensional light tracing technology still has disadvantages, that is, the conversion efficiency is low, which will increase the required area of battery panel and increase the cost of equipment. Therefore, the generation of three-dimensional light tracking system is the key to improve the efficiency. Based on the two-dimensional light tracking system, the three-dimensional light tracking system realizes the three-dimensional rotation control of photovoltaic power generation panel through two rotating axes (as shown in Figure 1), which reaches the maximum range of light intensity, and then greatly improves the efficiency conversion rate of photovoltaic panels.

3.2 Meteorological model of solar radiation

For photovoltaic power generation system, the installation form and angle of photovoltaic array will directly affect the solar radiation received by photovoltaic array, and the power generation capacity of photovoltaic array is directly proportional to the solar radiation received by the array, so the installation form and angle of photovoltaic array will have a great impact on the power generation capacity of the system. We use the meteorological model of solar radiation, the best installation angle model of photovoltaic panel, and then use MATLAB software to establish the model for simulation, and calculate the relevant solar energy and meteorological data.

Solar radiation is the most important energy source in the earth's ecosystem, the basic driving force for the formation and evolution of weather and climate, and an important natural resource that can be developed and utilized by human beings. The total solar radiation on the ground is composed of direct and scattered solar radiation, which is mainly affected by latitude, altitude, cloud cover and aerosol. Therefore, the solar radiation efficiency is very important for the design of solar panels. There is a certain functional relationship between solar radiation and its total radiation time, so it is also very important to study the temporal distribution of solar radiation for studying the meteorological model of solar radiation.

In bibliography [1], Taking Fuzhou City of Fujian Province as an example, the annual average change of global solar radiation in Fuzhou City from 2007 to 2018 was analyzed, and the annual total solar radiation showed an upward trend. In addition, the monthly distribution of total solar radiation in recent ten years also shows a certain regularity. The following figure shows the variation curve of monthly average solar radiation in Fuzhou in recent ten years.

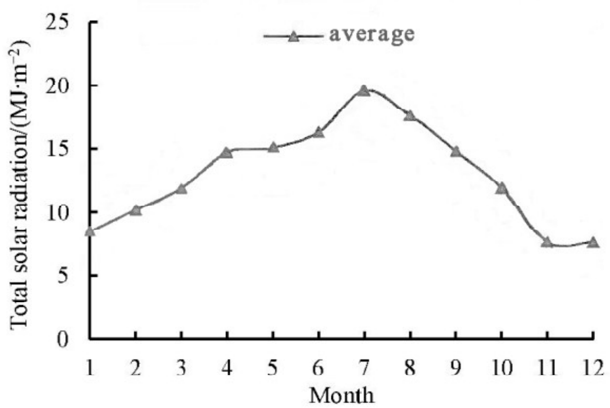

Figure 3 Monthly mean variation of total solar radiation in Fuzhou from 2007 to 2018

It can be seen from the above figure that the monthly average variation curve of total solar radiation in Fuzhou from 2007 to 2018, and the monthly variation of total solar radiation in Fuzhou City is a unimodal image. The total solar radiation increased from January to July, reached the maximum value in July, decreased from July to December, and decreased to the lowest value in December. However, the variation of solar radiation in different years was slightly different. The results show that the solar radiation is the most abundant in summer (July to September), followed by spring (March June), and the least in winter (December to February). Therefore, the total time of solar radiation changes with the year, season and other factors. The calculation method of total solar radiation has become the key core of meteorological model design of solar radiation.

There are many calculation methods for annual total radiation radiation at any angle. In order to meet the domestic engineering design habits, Klein hay model is listed here, which is recommended by the national0standard code for design of photovoltaic power station0 (GB 50797-2012) [7]. The main calculation procedures of the model are as follows:

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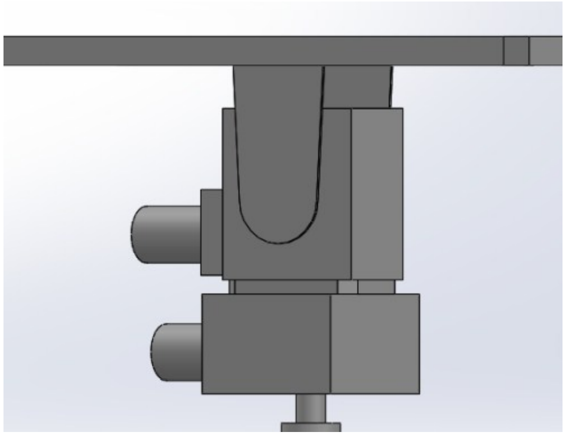

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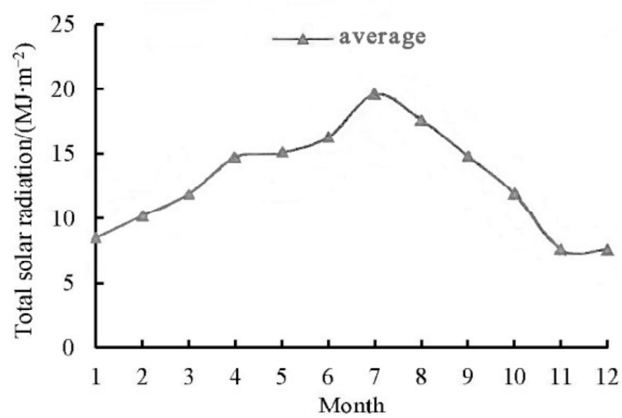

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The total solar radiation intensity on the slope is as follows:

$$Q = S' + D \qquad \text{Formula (1)}$$

The expression of solar direct radiation on horizontal plane is as follows:

$$S' = \frac{T}{2\pi} \times \gamma \times S_0 \times \int_{-w_2}^{+w_2} P_m \times \sinh \times dw_s \qquad \text{Formula (2)}$$

The expression is as follows:

$$\gamma = 1 + 0.033\, cos(\frac{360n}{365}) \qquad \text{Formula (3)}$$

The expression of sky scattering radiation is as follows:

$$D = \frac{T}{2\pi} \times \gamma \times S_0 \times \int_{-w_2}^{+w_2} P_m \times (1 - P_m) \times \sin h \times dw_s \qquad \text{Formula (4)}$$

Among them,h is the solar altitude angle, Q is the total solar radiation intensity, S' is the direct solar radiation in the horizontal plane, D is the sky scattering radiation,w is the time angle, w_1 and w_2 are the sunset angle and sunrise, P_m is the atmospheric transparency coefficient.

From the above calculation method, it can be concluded that at a certain location (the longitude and latitude are unchanged), the main factors determining the total radiation on the inclined plane are the solar total radiation on the horizontal plane and the scattering radiation from the sky. Therefore, the direct ratio and scattering ratio of the total solar radiation and the sky scattered radiation on the horizontal surface in the total radiation of the horizontal plane can be introduced into the calculation equation. When the atmosphere is very clean, the proportion of direct radiation is high; when the atmosphere is very turbid, the proportion of scattered radiation is high. The proportion of the two radiation components changes with the climate change of the atmospheric environment, which will affect the calculation results of the total solar radiation.

3.3 Model design of optimal installation angle of photovoltaic panels

Because the amount of solar radiation absorbed by photovoltaic panels is related to the optimal installation angle of photovoltaic panels, the model design of optimal installation angle of photovoltaic panels becomes a very important step. At present, there are many methods for the installation of solar panels at home and abroad. There are two most common methods, one is fixed installation, the other is rotary installation. Different installation methods have different choices for the best inclination angle. Therefore, the ultimate goal of the optimal installation angle model of photovoltaic panels is to form a certain angle between photovoltaic panels and the incident direction of the sun, so as to achieve the purpose of direct sunlight on photovoltaic panels and increase the power generation of photovoltaic power supply system. (and this angle is called the best inclination angle of photovoltaic panel.)

At present, when calculating the best tilt angle at home and abroad, we should first calculate the solar radiation, and then calculate the declination angle and horizontal sunset angle according to the local latitude. Finally, combined with the calculated parameters, the best dip angle is obtained. Klein’s method is often used to calculate solar radiation. The influence of altitude on the optimum tilt angle is not considered in the calculation of solar radiation and various local parameters. According to the optimum dip angle calculated by the general method, the inclination angle of Lhasa is quite different from that of other major cities, and there is an abnormal phenomenon. This shows that it is necessary to analyze the functional relationship between latitude and optimum dip angle. The in-depth analysis of the optimal tilt angle is conducive to the full utilization of solar energy by photovoltaic panels and the increase of power generation of photovoltaic power supply system, so as to achieve the maximum effective utilization rate of energy conservation and environmental protection.

Table 1 the best dip angle of ten major cities in China

Cities	Chengdu	Nanning	Guangzhou	Wuhan	Xi'an	Shanghai	Lhasa	Yinchuan	Urumqi	Harbin
Latitude	30.67	22.82	23.13	30.63	34.30	31.17	29.70	38.48	43.78	45.68
The dip angle is	15	17	22	24	26	27	33	37	38	43

As shown in Table 1, the best dip angle of each city is different due to the latitude of the region. Therefore, according to the latitude of the ten major cities in China, the optimum inclination angle can only be applied to a single area. Moreover, due to the sun's revolution and the earth's rotation will affect the illumination angle of each region, the simple calculation method is not suitable for real-time changes; and the method used is more cumbersome, which is not conducive to promotion in practical application. Therefore, according to this conclusion, this paper will use the method of data fitting to explore the functional relationship between latitude and the best dip angle.

According to the data in Table 1, the trend and trend of the image can be roughly determined. According to further data statistics, more accurate images can be drawn by statistical analysis of the representative latitude regions in each stage. It can be concluded that the trend of the image rises exponentially, but in the rising process, there are alternating changes in the form of sine or cosine function. Therefore, it can be preliminarily considered that the function to be fitted is the superposition of exponential function and sine function. However, the upward trend of the curve is not a regular exponential form, so it is necessary to introduce a function of order for further adjustment.

Finally, the function form to be fitted is as follows:

$$\beta = \frac{\alpha \sin(kw+b)}{m-w} + \frac{e^{Ww}}{w} + cw \qquad \text{Formula (5)}$$

Among α、m、c are constants of exponential function and are definite values.

Using the data in Table 1 and the form of fitting function, the results can be obtained by computer simulation, that is, the image of optimal latitude and best inclination angle. That is, the trend of fitting curve basically conforms to the distribution of discrete points. And the discrete points are distributed on both sides of the fitting curve, and the fitting curve is smooth. Therefore, it shows that the specified function analytic formula can basically reflect the mathematical relationship between latitude and optimum inclination angle. At the same time, the relevant parameters of latitude and optimum dip angle can be obtained, which is convenient to calculate the optimum inclination angle of this area at any latitude. And then solve the problem that the best dip angle is not the same, so that the corresponding area of each latitude can calculate the optimal tilt angle of the place, and solve the related problems of the photovoltaic panels to make full use of the solar energy and increase the power generation of the photovoltaic power supply system.

The relationship between the final latitude and the optimum dip angle is as follows:

$$\beta = \frac{-2.703\, sin(-4.088w+125.2)}{30.64-w} + \frac{e^{-0.8188w}}{w} + 0.9041w \qquad \text{Formula (6)}$$

Among β is the best dip angle, w is the regional latitude.

SYSTEM COMPOSITION

The new system is composed of solar cell module, three cup anemometer, battery (GFM400ah / 2V), control inverter (3000W / 48V), Mitsubishi servo motor, Mitsubishi PLC controller, etc. The new system can be divided into four parts: central control system, energy collection system, data collection system and avoidance system.

1. Composition of central control system

The central control system includes power supply system, data processing system and equipment management system.

The central control system is mainly responsible for the beneficial connection between sensors and components, including program debugging, signal processing, equipment management, etc.

1 Equipment management Dh-03x 110kg / cm steering gear receives the angle signal of single chip microcomputer and assists the photovoltaic panel to rotate.

2 Power supply system The central control system is connected with the battery and powered on to each module through the single-chip microcomputer to ensure the normal operation of each module.

3. Data processing The data collection system will upload the collected information to the central

control center in real time. There is a set of program written in the MCU chip of the central control system. The program will screen the data and compare the appropriate light intensity.

2. Energy collection system Special energy storage batteries for wind turbines and photovoltaic panels are selected.
3. Data acquisition system The application of the lighting positioning module installed on the photovoltaic panel, combined with the control system, can intelligently judge the direction of the sun light and collect the sunlight intensity. When the sunlight intensity reaches the preset value, the control system will control the photovoltaic panel to be perpendicular to the sunlight through the double axis drive motor, so as to achieve the best lighting angl
4. Circumvention system
    1. Avoidance of three cup wind speed sensor The product is equipped with a three cup wind speed sensor, which can collect the wind speed in real time. When the real-time wind speed reaches the preset value, the control system will control the horizontal placement of the photovoltaic panel through the double shaft drive motor to prevent the damage of the photovoltaic panel and prolong its service life.
    2. Electrostatic precipitator The use of TCO glass and electrostatic shielding principle can ensure that the normal operation of photovoltaic modules will not be affected while removing dust.

4.1 MPPT algorithm

The output of photovoltaic power supply is easily affected by environmental factors. The solar panel working at the maximum power point can make it work to the optimal state. It mainly depends on the working temperature of the panel and the light level at that time. The maximum power point (MPPT) of solar panels is different under different temperatures and light intensities. In order to make the solar panels work at the maximum power point as much as possible, it is necessary to use the maximum power point tracking (MPPT), It can effectively track the maximum power point under the rapidly changing weather conditions, and control the battery board to work at the maximum power point as much as possible.

Professor Xu Honghua of Chinese Academy of Sciences used genetic algorithm to solve the problem of nonlinear control of photovoltaic power generation system, and quickly found the optimal configuration scheme and optimal control strategy of the system. The advantage of this kind of control is that it does not need to consider the continuity of function and derivation, and directly operate the structure object to study. In addition, many domestic scholars will use maximum power tracking algorithm. The representative methods are constant voltage method, disturbance observation method and conductance increment method. Matlab simulation is used to study the tracking effect and tracking speed of the three algorithms to the maximum power point. At the same time, the application scope and related characteristics of the three algorithms are studied.

The maximum power tracking of solar photovoltaic power generation needs to be based on the prediction of solar radiation intensity. The daily or hourly observation data of solar radiation constitute a time series with strong randomness. At the same time, the temperature also has a certain impact on the amount of photovoltaic power generation, but there are still some certain rules within the solar radiation series. The training matrix can be constructed by extracting the radiation data from 8:00 a.m. to 8:00 p.m., taking the first three days as input and the next day as output. The test matrix and training matrix are established by radiation and temperature, and then the BP network is trained.

Bibliography [2] proposed a MPPT algorithm to find the global maximum under multi peak conditions, and Bibliography [3] proposed a maximum power point tracking method based on adaptive step size hysteresis comparison method of linear function, which can accurately track the maximum power point of photovoltaic array and improve the MPPT performance

4.2 power compensation in case of local shadow

When there are local shadows, the photovoltaic array will be affected. Each photovoltaic module is in parallel. When one module is interfered by the local shadow module, the current of the local interference module will change to some extent. When there is local interference, the current value will decrease, which will lead to the double peak value of the P-V curve of the photovoltaic array. In order to eliminate the double peak value, the energy storage battery group will be used to compensate the photovoltaic output power in the local shadow In order to maintain the photovoltaic output power constant.

The solar cell super capacitor device is selected as the energy storage battery pack for power compensation. Solar cell supercapacitor is a new type of large three port device by using the back electrode of solar cell as the anode of supercapacitor, which reduces the complexity of the system structure. Assuming that the I PV module is locally disturbed and other PV modules are not interfered by PV modules, the supercapacitor connected in parallel on the PV module compensates the current. According to the degree of shadow shading, it can be divided into two cases In shadow shading, after super capacitor compensation, the output current of the I photovoltaic module is consistent with that of other photovoltaic modules. At this time, the series branch current remains constant, and N photovoltaic modules can still continue to work normally. When the local shadow disappears, it will return to the initial operation state; if the photovoltaic module is heavily shaded, the I photovoltaic module will be compensated by super capacitor current The total output current of the module is still unable to reach the output current of other photovoltaic modules. For light shadow, the supercapacitor in the photovoltaic module can fully compensate the power shortage of the solar cell to keep the series current constant, so as to maintain the single peak value of the output power of the photovoltaic array. In the case of severe shadow, the supercapacitor can only compensate part of the solar cell power shortage, and the output of the array can not reach the single peak value. The photovoltaic array is connected to each other through three ports of solar cell super capacitor device to form a switch network. The port 1 and port 3 of each solar cell super capacitor device are connected in parallel with any port 1 and port 2, thus forming a supercapacitor discharge circuit. A switch is placed on the diagonal of each solar cell supercapacitor device. The switch on the diagonal line actually makes the converter buck that controls the power compensation of each solar cell supercapacitor device_-Boost circuit topology.

Buck boost circuit is also known as Buck chopper circuit, which is mainly composed of controllable switch (MOS transistor or IGBT, etc.), diode, inductance and capacitor. In the process of use, pulse signal is often added to the gate to make the voltage difference between the gate and the emitter, and then make the IGBT turn on. When there is no voltage between the gate and the emitter, or when the reverse voltage is added, it will stop. The diode is composed of n-type semiconductor and p-type semiconductor. When the forward voltage is applied to the PN junction, the diode is on in the forward direction; when the reverse voltage is applied to the PN junction, the diode is turned off in the reverse direction. Buck boost circuit is mainly composed of these two devices. When the pulse signal triggers the controllable device to turn on, the power supply charges the inductor, but because the diode is cut off by the reverse voltage, the capacitor only outputs voltage to the load; when the switching device is cut off, the energy stored in the inductor should be released to the load and the capacitor should be charged. Because the voltage of inductance is equal to the voltage of power supply when the controllable switch is on, and the output voltage is equal to the voltage of inductance when the controllable switch is turned off, so the input voltage U_{in} multiplied by the turn-on time T_{on} of the controllable switch is equal to the output voltage U_o times the off time T_{off} of the controllable switch, and then the output voltage U_o is equal to the time when the controllable switch turns on T_{on} multiplied by the power supply U_{in}, and then divided by the off time T_{off} of the controllable switch.The total formula is $U_o = (a / 1\text{-}a) * U_{in}$, and a is the duty cycle (the turn-on time of a cycle device is divided by the time of a cycle). Therefore, as long as we adjust the duty cycle, the circuit can play the role of voltage rise and fall. When a is greater than half of the circuit voltage rise, when a is less than half of the circuit, the circuit plays a role in reducing voltage. Controllable switch is triggered by pulse signal to turn off or turn on. Since the discharge of supercapacitor is determined by the power of photovoltaic module, the PWM control of power feedback can be used to realize the discharge of supercapacitor by controlling the on-off of circuit switch.

4.3 The avoidance system by three-cup anemometers

4.3.1 The influence of wind on PV array

Zhuhai City is located in coastal area, is influenced by the subtropical monsoon climate and the wind is strong all the year round. We referred to bibliography[4] which was about the calculation of solar-tracking angle, for example the best PV array's installation angle was 20.1

degree. In fact, the terrains and climatic conditions in Zhuhai City make PV array's installation angle be approximative 10 degree in the practice, it causes to the failure to maximize solar conversion efficiency.

4.3.2 The influence of typhoon on PV array

Zhuhai City is influenced by the subtropical monsoon climate where is frequently hit by typhoons. According to the relevant statistics, there are 9.8 typhoons influence Guangdong Province every year, and there were up to 7 typhoons that made landfall in Guangdong Province in the past. The super typhoons like Typhoon Wilson in 2014 year and Typhoon Lekima in 2019 years can devastate PV array, PV support bracket and so on.

4.3.3 The contrast with common kinds of anemometers

Because the wind has a great impact on PV system, we try to use anemometers on PV system. First, the data are collected by sensors. Then the related regulators change angle of PV array though deriving servo motors. When the wind is wreaked, we can escalate the PV array's angle until optimal conditions which can promote the solar conversion efficiency. In case of the gale weather or typhoons, the avoidance system can put PV array on the smooth position automatically so that it can prolong the service life and descend the probability of PV system being destroyed in extreme weather.

Now the common anemometers on sale mainly be divided into the following four types:

1. Cup anemometers: they have been widely used in many fields since they were invented by Robinson sun of England. The whole component consists of three paraboloid or hemispherical hollow cups which have the constant angle, the same orientation and be fixed on a freely rotating shaft. There is a positive correlation between the rotational speed of the cup anemometer and the speed of winds, we can calculate the speed of winds by their algorithm after measuring the rotational speed.
2. propeller anemometers: The whole component consists of three-blade propeller or four-blade propeller which be fixed on a horizontal shaft. blade propellers usually are installed at the head of the anemometers to the plane of rotation face the wind. There is a positive correlation between the rotational speed of the propeller anemometer and the speed of wind.
3. Hot wire anemometers: They work by the continuous flow of air crosses a wire heated by the electric current to descend the wire's temperature. We can calculate the speed of wind by using a linear correlation between the speed of the losing temperature and Square of speed of wind. They are usually used to measure low wind speed because they have high sensitiveness in the low wind speed and they are important tools to Measure the atmospheric turbulence and the agrometeorology.
4. Acoustic anemometers: They work by the wind speed vector in sound wave propagation direction can Strengthen or weaken the speed of sound wave. an acoustic anemometer only consists of two pairs of the sensors that includes a transmitter and a receiver each pair.

First, we can set the two transmitters in the opposite direction, one is set along the direction of wind, another is in the direction of headwind. Second, we collect the data of time difference between two receivers. Finally, we can calculate the wind speed by using relative algorithm. We can learn about their characteristics are high anti-interference and high directivity that application of ultrasonic.

4.3.4 The application of three-cup anemometer on PV array

Three-cup anemometers are widely used, running stably, low cost and meeting requirements of application of PV array. We can install the anemometer on the PV array to detect the wind speed. When the wind rose to be certain speed, the three hemispherical hollow cups will rotate around perpendicular shaft. When the regulators detect the wind speed over the threshold which the wind scales have bad impacts on PV array, the PV will be put on the smooth position automatically with three-dimensional transmission structure which consist of some servo motors. It can prolong the service life and protect the PV system.

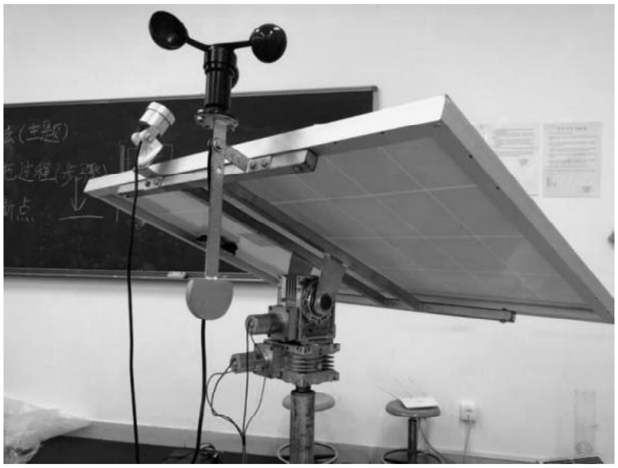

Figure 4 Picture of application of three-cup anemometers in the practices.

4.4 The technology of autonomous dust cleaner in PV array

4.4.1 The influence of deposition dust in PV array

During the PV system run, there will appear deposited dust. The dust can prevent PV array from receiving sunlight and then descend the PV array running efficiency. Lots of dust will cut down the output from the power stations fell away.

We can know that it can visibly impact maximum output power, conversion efficiency, short-circuit current and open-circuit voltage both of PV system as the increasing dust density though variation of positive volt-ampere characteristics isn't influence by the density of the coverage dust from bibliography[6]. The study in bibliography [7] found the influence of deposited dust on PV array can up to 10% ~ 25%. The study in bibliography[8] found there was an inverse correlation between the dust density and PV system working efficiency when the researchers simulated the spontaneous deposited dust by software and then they concluded that the linear fitting formula about the density of deposited dust and output power of PV system. The study in bibliography[9] found the conversion efficiency of PV system descended 16.59% when the density of deposited dust was 0.1244 g/m^2 and when the density of deposited dust was 0.898 g/m^2 , it would even descend 54.95%.

4.4.2 The contrast with common kinds of technology of autonomous

Because the PV array is obviously influenced by the posited dust, Dust cleaning is a very important work for daily maintenance. The highly efficient and low-costed dust cleaning not only can keep high conversion efficiency of PV system, but also can reduce the PV power station's maintaining budgets.

Now the common cleaning technology on sale mainly be divided into the following four types:

1. Traditional manual cleaning methods: They are widely used, according to the relevant statistics, clean amount of 1MW PV system needs a ton of water every time. There need lots of cleaners which is not easy to be regulated, the cleaning effects is not well and different from each time and the traditional manual cleaning may damage the PV array to become opaque and shorten the working life.
2. washing with high- pressured water guns: Now it usually uses watercarts to wash the PV array, this way is good at to clean the PV array but it needs a lot of water. The high-pressured water gun may damage the PV array.
3. spray systems: the spray systems are widely used to the PV array installed on roofs, its advantage is using machines cleaning automatically, but there is not good cleaning effect.
4. washing with special equipment: the advantage of using special equipment is good at to clean the PV array. It not only needs to buy lots of special equipment which is a large budget, but also needs to recruit the professional persons or train the laymen. It can't be used in the arid area neither.

4.4.3 The application of electrostatic precipitator on the PV array

In order to solve problems of PV array's low conversion efficiency with deposited dust and the arid area without lots of water. We can use electrostatic precipitator to clean the PV array, and we can use the TCO glass to ensure the PV system running well while cleaning the PV array.

Electrostatic precipitator's performance very depends on dust's resistivity, it is about 104 ~105 Ω·cm with good conversion efficiency. When the voltage on PV array's glass increases to threshold, there is an electrostatic field between the cathode with DC power and earth wire with anode. Then the negative ion wind from electronic ionizer electrify the dust particles. Because the gas containing dust is ionized by the cathode, the dust particles influenced by electromagnetic force will be put to anode. finally, we can clean the PV array by this way.

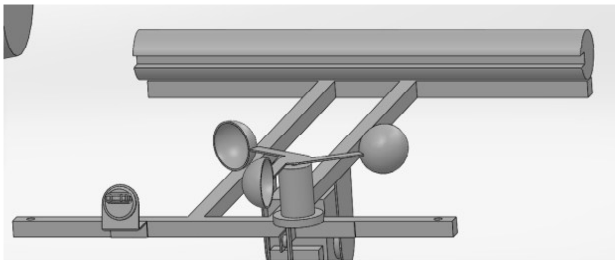

Figure 5 Model diagram of electronic ionizer

CONCLUSION

At present, there usually are some limitations in many power systems on sale. We combined theory and practical engineering experience to study in the new energy resource field. We aimed for promoting PV system productive efficiency base on improving PV system. We focused on the optimal control strategy of three-dimensional and solar-tracking PV system's running efficiency, and then we designed a kind of PV array which can do three-dimensional rotating. The designed PV system can track solar maximum power point automatically from many different angles and also can clean the surface of the PV array in fixed time automatically by using the autonomous dust cleaner. In addition, the regulator can collect the data of real-time wind speed, and it can reduce the force of wind on the PV array by using corresponding avoidance algorithms to ensure the system product with high efficiency and run steadily as well.

After contrasting this three-dimensional highly efficient control strategy with common control strategy, we found it is higher mobility in special environment, prolonging the service life, higher energy efficiency and productive efficiency. We analyzed the characteristics and components of three-dimensional PV array, we focused on indicating and designing the optimization of construction and summarized the designed mentality and the optimal process to provide researchers with referring. According to the policy of new energy resource and relevant national policies, if this designed three-dimensional highly efficient control strategy could be used in the PV industry, it can relieve the pollution of coal-fired stations.

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