Research of data fitting method in the installation angle of photovoltaic

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Abstract. The installation angle determined by the radiation of the sun usually affects the use rate of solar energy. In or-der to find the reasonable installation angle of the PV array, this paper applies data fitting method in PV power generation, and takes a sample of a year's solar radiation data to analyze, finally obtain the general rule of radiation intensity. Then we can get the appropriate installation angle to optimize and improve PV system.

1. Introduction

Solar-based new clean energy is more and more widely used in the word. China has a vast territory, there are more than 930, 0000 km2 land area. Xinjiang, Qinghai, Tibet, Gansu and other northwest area because of unique climate characteristics have a very rich solar energy resource and are very suitable for solar power generation. With the proposal of a series of national preferential policies, Chinese PV industry has developed rapidly in recent years. PV array installation angle determines PV power's output. However, both china and abroad, the technical studies on PV are almost about MPPT, isolated land effect and application materials. There is a few research information is about selection of PV array installation angle. Therefore, this paper presents a method of data fitting to seek the optimal installation angle of PV array. It will provide valuable references to the future research on PV power generation.

2. Influence factors and calculation method to PV installation angle

2.1 PV battery output characteristics

PV output characteristics are affected by radiation intensity, in order to better study the output characteristics of PV array, establish following mathematical model of PV battery.

By above the PV battery equivalent circuit and the various physical quantities can get the solar c ell mathematical model formula as following shows:

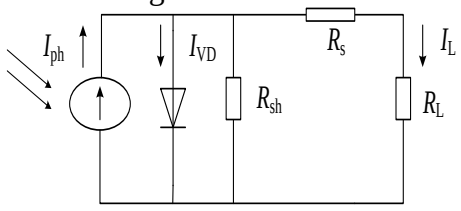

Figure. 1 Equivalent circuit PV cells equivalent circuit

$$I_L = I_{ph} - I_{VD} - \frac{U_L + I_L R_s}{R_{sh}} = I_{ph} - I_0\left(\exp\left(\frac{q(U_L + I_L R_s)}{AKT}\right) - 1\right) - \frac{U_L + I_L R_s}{R_{sh}} \quad (1)$$

$$I_L = I_{ph} - I_0\left(exp\left(\frac{qU_L}{AKT}\right) - 1\right) \quad (2)$$

Since Rsh >> Rs. we can ignore the formula (1)'s last item and the series resistance, then accordingly can be simplified into the following equation:

According to the above formula, created simulation model of PV cells in the MATLAB Simulink software, like the chart shows:

In this simulation mode, set temperature as 25℃, the light intensity G is 100W/m^2, 200W/m^2, 400W/m^2, 600W/m^2 and 800W/m^2.Then carry on the Simulation analysis of U-I characteristic curve and the PU of the system, the simulation results are shown below: system, the simulation results are shown below:

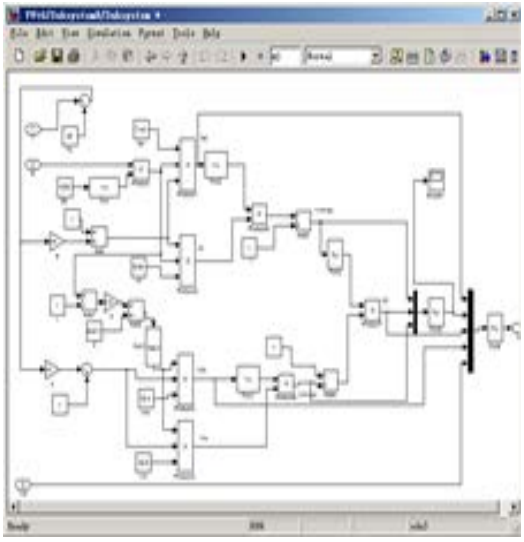

Figure. 2 Simulation model of PV cells Simulink

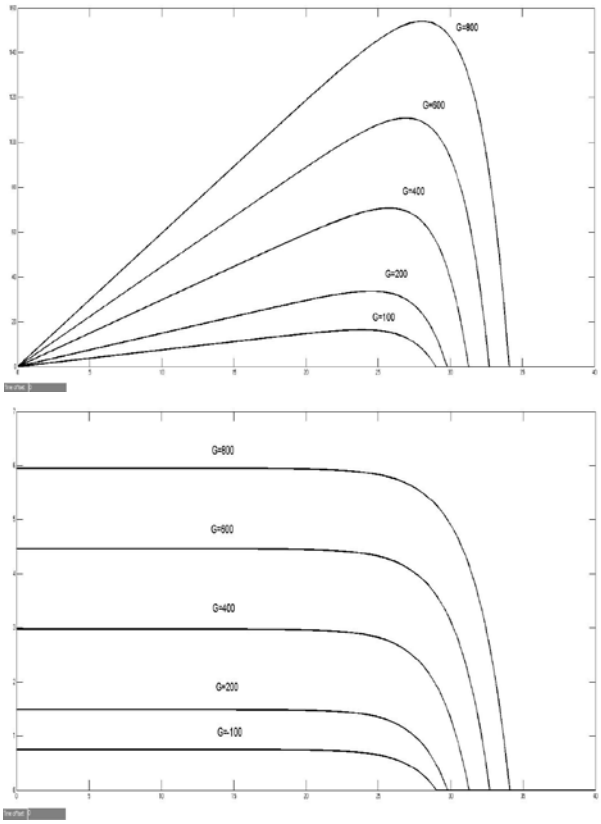

Figure. 3 Output characteristics of PV cells influenced by isolation

According to the simulation results it is not difficult to find that with increasing of the radiation intensity, the output power of PV cells also increases gradually. Therefore, there is a direct relationship between the PV array's optimum azimuth and radiation peak.

2.2 Azimuth

PV array azimuth refers to an angle between PV array's vertical surface and direct-south of geographical environment (Northern Hemisphere faces south, southern hemisphere faces north).The angle is generally defined as East offset to a negative angle, and westward to the positive angle, the angle range is-90°−+90°.The azimuth decides the acceptable amount of PV array radiation in a day.

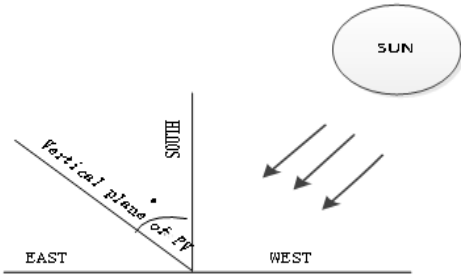

Figure. 4 (a) Azimuth schematic

We use the Beijing time longitude as the standard, however Beijing time is not local time (Beijing east longitude 116.4 degrees), but the local time of Tokyo 120 degrees .In 24-hour format, for example, when H sunshine to the peak, the azimuth of radiation should be determined by the following formula:

$$a = (\frac{H-12}{12} \times 180°) + (\theta - 120°) \quad (3)$$

However, the solar azimuth Angle usually face to south, although some areas have taken the local longitude into account, there is a possible situation that determine the H point of radiation peak according to the experience, which is very unreasonable. It is important to choose a systematic solution to find the peak H time and its variation rule so as to improve PV power generation system.

3. The data fitting in PV application

Because of the earth's rotation irradiation, the sun from morning to night is very unevenly distributed. N China's position the northern hemisphere as an example, normally when the day is sunny, the sunlight intensity gradually increases as the sun raises from the East to the noon. At noon, when the sun is at the direct-south, the sunlight intensity reaches maximum. Afterwards, with the approach of sunset the sunshine intensity reduces gradually. The overall trend of sunlight distribution is symmetrical. In order to make full use of solar energy, making PV array face direct-south can improve the utilization efficiency in a whole day. But since affected by the weather such as rainy day, the daily ground receiving radiation is non-rule distribution in most situations. Even more it appears multi-peak values and multi-extreme values. In this case; it's very difficult to find the change laws of radiation intensity.

To adopt the method of data fitting is a good way to find the variation rules of instantaneous radiant intensity , although the peak value sometimes has much volatility due to influenced by the weather . but overall still accord with Gaussian distribution function, so you can fit the discrete points of instantaneous value with Gaussian fitting method this kind of data fitting is a good way to restrain some natural peak stab value, so though what you chosen is not the actual maximum radiation, in all data change rule is global optimal. Finally it can find radiation value change rule.

Gaussian function method used for data points' function approximation can equal with polynomial fitting. The difference is polynomial method fitting with Power functions and Gaussian method fitting with Gaussian functions .the advantage of fitting with Gaussian function is easy to Calculate integral, Gauss fitting algorithm applied in the quantitative analysis model is feasible , it not only simplifies the model parameters, but also improves the explanatory.

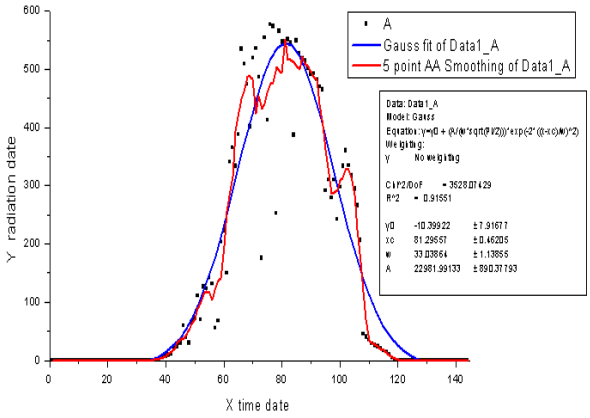

Figure. 4 (b) Gauss curve fitting results schematic

The original fitting data is discrete data point set (x, y).The purpose of using the Gauss fitting is to find the function relationship between the variables X and Y. And in order to improve fitting accuracy, it needs delete bad data before fitting. The general expression of the Gauss function is included peak height A, peak position H and width W. It's specific formula as:

$$f(x)=A*\exp^{(-(x-x_c)/w)^2} \tag{4}$$

When fitting, there is no need to make curve through all data points, just as far as possible to make Gauss curve reasonably distributes on data points and reacts variation of all data. Gauss's functions can well reflect the distributed situation of daily radiation and easy get the abscissa of the peak point. By taking abscissa of peak point into formula (4) can get corresponding azimuth.

4. APPLICATION EXAMPLE

This article uses the history data of Guilin local weather station to analyze with Gaussian fitting method. Those data are collected every ten minutes. Its total 144 separate data points' entire day. Taking sample of data 2013.7-2014.6 to analyze .take a group of data once a month .Obtain the corresponding x-coordinate 12 peak point as following table 1 shows:

Table1. Sampling data fitting parameter table

Sampling point	Parameters A	Parameters W	Parameters Xc
1	588.56	78.8	32.07
2	596.52	78.4	33.12
3	517.44	77.7	31.05
4	489.74	77.3	30.48
5	388.52	76.2	30.31
6	296.31	75.2	29.67
7	223.94	73.1	29.57
8	211.59	72.8	29.52
9	231.81	73.6	29.91
10	331.31	74.4	30.15
11	412.92	75.2	31.52
12	546.31	76.5	32.58

Using 12 data points to make second fitting, as the result shown in Figure 5, by using the fitting formula (5).We can easily find the variation is periodical. It's also coincided with the radiation values and earth periodic revolution. From the curves of the figure above, we can choose different azimuth for different time so as to make the best use of solar energy efficiency peak.

$$f(x)=a_1*\exp^{(-(x-b_1)/c_1)^2}+\cdots+a_4*\exp^{(-(x-b_4)/c_4)^2} \tag{5}$$

Table2. Parameters values in formula (5)

	a_i	b_i	c_i
$i=1$	57.37	-2.84	9.49
$i=2$	80.78	18.04	16.72
$i=3$	-1.52	7.44	0.67
$i=4$	1.53	4.98	2.12

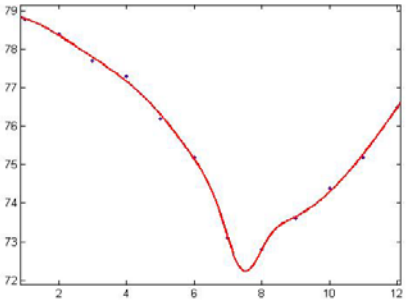

Figure. 5 Parameter W gauss fitting results schematic

5. Conclusions

This article firstly creates and analyzes the mathematical model of volt battery. The result shows the output power of PV array enhances along with the increasing of radiation intensity. In order to obtain more reasonable PV array azimuth, using discrete data Gaussian fitting method to accurately reflect the value of the instantaneous radiation. Based on local climatic characteristics of Guilin, adopt the sampling analysis method to obtain general rule on yearly solar radiation maximum. It has very high scientific value in improving the azimuth of PV and enhancing utilization rate of solar energy.

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