

Algorithm Study on Improving Application Efficiency of Independent Solar Power Supply System

Jigang Cao¹

1.Kun Ming Gold Pioneer Intelligent Meter Co., Ltd ,650216 ,Yunnan, Kunming,China

ABSTRACT With the development of photovoltaic (PV) technologies, applications of photovoltaic have grown rapidly, indicating that the photovoltaic are attractive to produce environmentally benign electricity for diversified purposes. In order to maximize the use of solar energy, this thesis focuses on the PV power generation systems, which includes modeling of PV systems, maximum power point tracking (MPPT) methods for PV arrays. Maximum Power Point Tracking (MPPT) method is an important means to improve the system Efficiency of PV power generation system. MPPT theory and various MPPT algorithms are introduced in the literature. Based on those researches, this thesis proposes a novel implementation of an adaptive duty cycle P&O algorithm that can Reduce the main drawbacks commonly related to the traditional P&O method.

KEYWORDS

Solar energy
Photovoltaic cell
MPPT
Adaptive control

INTRODUCTION

In the 20th century, the world energy structure, energy use by a human is mainly oil, natural gas and coal and other fossil fuels. With the development of economy, the increase of population and social improvement of living standards, the future of the world

Energy consumption will continue to grow, the amount of fossil energy available in the world one day will reach the limit. As the fossil energy consumption step by step, the energy crisis has been displayed in front of the human. About the world in the early 21st century has proven reserves of energy data of survey of fossil energy can be mined are numbered; By the end of 2000, China's proven reserves can develop energy always accounts for about 10.1% of the world total, its structure is: Raw coal accounted for 58.8%, crude oil (58.8%), natural gas accounted for 1.3%, water 36.5%. China all kinds of primary energy of proven reserves surplus (to store/mining, say) and the world is shown in figure 1. It is visible that, in addition to the solar energy, China's primary energy resources are lower than the world average, China's demand for energy is facing more serious challenges.

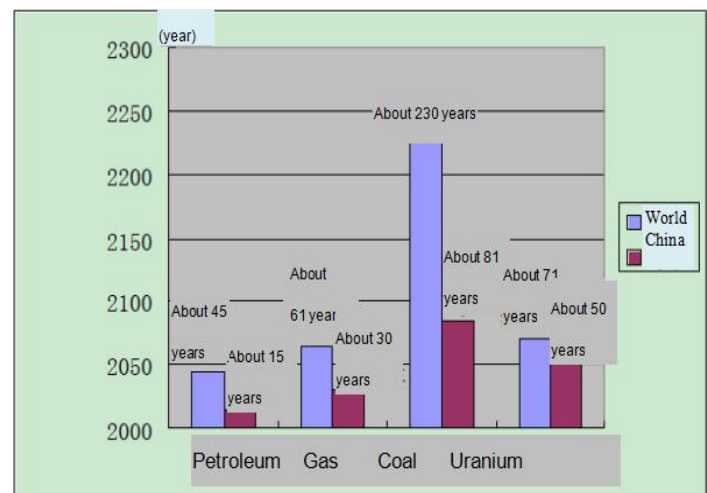


Figure 1 Compare of energy proven reserves

Based on the present status of the resource, based on the relevant policy of country, the national call to sustainable development, we put forward the wireless meter reading system based on independent solar power supply system, give full play to the advantages of using solar energy, improve product competitiveness, beautify the environment, reduce pollution emission and building green system;

Copyright © 2016 Jigang Cao
doi: [10.18686/esta.v3i1.2](https://doi.org/10.18686/esta.v3i1.2)

This is an open-access article distributed under the terms of the Creative Commons Attribution Unported License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

1. Basic principle and composition of photovoltaic power system

Photovoltaic power system is able to convert sunlight into high grade of energy - electricity device, based on the relationship of photovoltaic system and power grid, and can be divided into independent photovoltaic system and grid photovoltaic system. Independent photovoltaic system structure is shown in figure 2. A basic set of independent photovoltaic system generally consists of pv array, DC/DC conversion circuit, MPPT controller and its load.

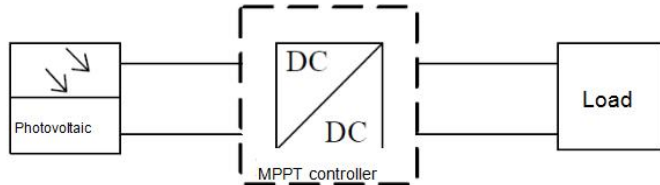


Figure 2 Structure of independent photovoltaic power system

2. Study on the meaning of MPPT

In a given environment temperature and intensity of the sun, the photovoltaic cells will be in a specific working point reach up to the maximum output power, the working point is called the "maximum power point. PV system can always put the maximum output power points as a working point, but in fact the maximum power point of solar energy

Due to various reasons and change in a wider scope, this change not only depends on the photovoltaic array of

Environment temperature and sunshine intensity, photovoltaic battery life and the electrical characteristics of the load is the cause of the instability. So, in order to make it work at maximum power point, in the output parameters of photovoltaic array and can happen Change the need for a time-varying matching network between the load as an interface, the interface is maximum power point tracking Network, usually by switch mode DC/DC conversion circuit, based on the technology of maximum power point tracking (MPPT), by pulse width modulation (PWM) control method, it ensures that in case any atmospheric environment and the change of load, maximum power point of pv array can work in, and the maximum drawing energy from the pv array. Make it always work near the maximum power point, this process is called control of maximum power point (maximum power point tracking, MPPT).

3. Basic component of photovoltaic power generation systems with the function of maximum power tracking

If connect the photovoltaic array and storage battery directly, due to the output characteristics of photovoltaic array is related to such factors as the sunshine intensity and temperature, on the one hand the battery internal resistance with maximum power point of photovoltaic cells output varies, that cannot be adjusted by the output of photovoltaic cells, causing a waste of resources; Between the pv array and storage battery so need to join the maximum power tracking link, it can track the maximum power output of pv arrays, and can output stable voltage for rechargeable battery. With the function of maximum power tracking photovoltaic (pv) power system block diagram is shown in figure 3.

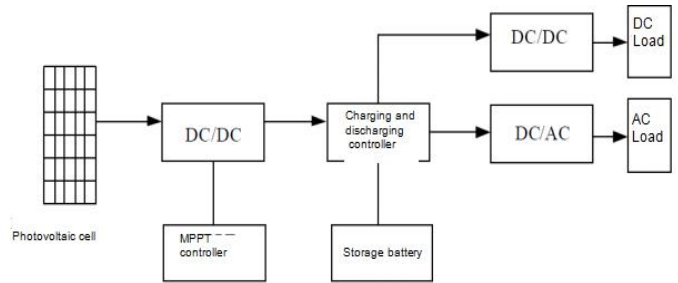


Figure 3 Structure graphic of photovoltaic power system with MPPT function

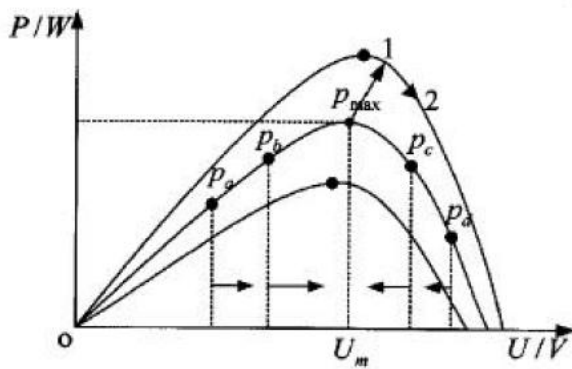
4. common disturbance observation method realizing MPPT

Interfere with the observation method is one of the MPPT method in use is often. Its principle is every time increase or decrease the pv array output voltage, and observation after its output power changes of direction, to determine the next step of control signals. This control algorithm generally adopts the power feedback method, through the two sensors of pv array output voltage and current sampling respectively, and calculate the power output. Although the method is simple, the method and easy hardware implementation, but the response speed is slow, is only applicable to the occasion of the sunshine intensity change slowly. And steady state conditions, this algorithm can lead to near the maximum power point of pv array of actual working point in small oscillation, thus will cause a certain amount of power loss; With the classic observation algorithm is briefly as follows: Photovoltaic system controller in each control cycle with small step length change of pv array output, change the step length is a certain direction can be increased also can be reduced and controlled object can be a pv array output voltage or current, a process known as "interference".

Then, through comparing the interference period before and after the output power of pv array, if $\Delta P > 0$, reference voltage adjustment in the right direction, can continue according to the direction of the original "interference"; When a given reference electric reduce hours, if the output power is reduced, the working point located in the left side of the P_{max} , to increase the reference voltage, if the output power increases, the working point the right side of the seat P_{max} and need to continue to reduce the reference voltage.

When a given reference electric reduce hours, if the output power is reduced, the working point located in the left side of the P_{max} , to increase the reference voltage, if the output power increases, the working point the right side of the seat P_{max} and need to continue to reduce the reference voltage. In this way, the actual working point of pv arrays can be gradually close to the maximum power point, finally in the near a small range of reciprocating reached steady state. If "interference" with larger step length, and the tracking algorithm can achieve rapid tracking speed, but after reaching steady state accuracy is relatively poor, small step length is just the opposite. A good compromise is the controller can according to the pv array current working point to choose the appropriate step length, for example, when has been near the maximum power point tracking with small step length.

Figure 4 Query sketch map of disturbance observation method



A given reference voltage change process is actually a process of power optimization. Due to constantly adjust the reference voltage in the process of optimization, as a result, the working point of pv arrays is always near the maximum power point of oscillation, no Method on the maximum power point to stable work, which also caused a certain amount of power loss. At the same time, when the sunlight intensity Change quickly, and the reference voltage adjustment direction errors may occur. In 4, for example: Assumes that the system is in steady state, pv array voltage fluctuations, at about P_{max} when suddenly sunshine intensity increases, the pv array output power increase, at this time if the location of the reference voltage deviation to 1, then the system will think at this point the direction of the reference voltage adjustment and power is the direction of change, and continue to make working point move to position 2 reference voltage, lead to obtain further away from the maximum power point.

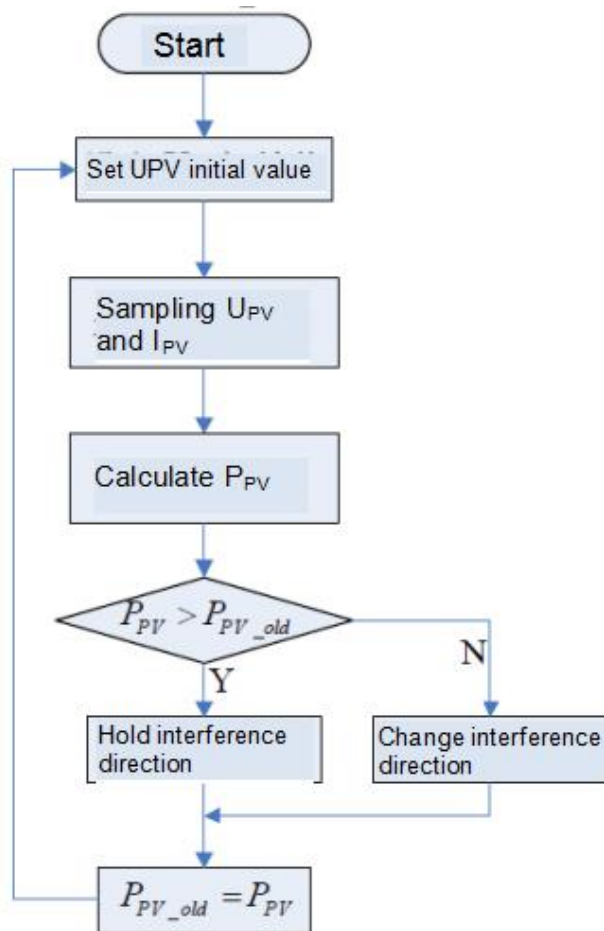


Figure 5 Control flow chart of disturbance observation method
Summarize the merits of the disturbance observation method is as follows

- 1) modular control circuit;
- 2) tracking method is simple, easy implementation;
- 3) on the sensor accuracy is not high.

Disadvantages:

- 1) near the maximum power point of pv array oscillation operation, result in a certain power loss;
- 2) tracking step set can't juggle tracking precision and response speed;
- 3) wrong would happen in certain situations.

5. Basic introduction of adaptive control technology

Adaptive control theory is proposed in the control engineering. In the process of complex control, control of purpose is that the state of the controlled object or trajectory meets the demands of reservation, clearer in some parameters or model. System, we can according to the reference model or performance parameters to control, but as the modern industry, more and more people need to control the process, and these objects is unknown or poorly understood, In this case, the traditional control theory can not work, but the adaptive control theory but it can be very ideal To solve these problems. Although adaptive theory starts late, but in the process of control has showed its unique superiority, has been used on various occasions, has achieved ideal result.

6. MPPT method based on adaptive control idea

The study of pv array maximum power point tracking algorithm a lot, especially for the disturbance observation method, many in the literature are improved algorithm is proposed. In ordinary disturbance observation method, existing set of tracking step can't juggle tracking precision and response speed. In duty ratio disturbance observation method, the step adjustment still exist when duty ratio D grew up in a small problem: Step size is too small, the tracking time stretched and affect the system dynamic response; This problem by adding a step automatically online regulator is resolved, this scheme can guarantee system, and the dynamic and steady performance.

Among them: $A(k)$ for the adjustment of the interfering voltage V step length, between 0 and 1;

When the temperature of the external environmental factors such as photovoltaic array, a sudden large sunshine intensity change, ordinary concept of interference

Examine method still think cause of output power change is due to the output voltage (or current) to increase or decrease

An adjustment of step length, thus may make controller from maximum power point. By formula (1) can solve the mixed

Xiao points. When $dP/a(k)$ is small, according to the change of output power P is mainly due to the duty ratio D step tone

The whole cause, at this point a $(k-1)$ is a (k) should not be a big change. And when $dP/a(k)$ is larger, said

The change of the rate of P is mainly due to the photovoltaic array surface temperature, sunshine intensity and so on caused by external factors. At this point if large drift of maximum power point, step length $(k-1)$, a able to fast track to a new maximum power point.

In theory, can always find the P_{max} of maximum power point of pv arrays, in P_{max} place, theoretically, $|dP| = 0$ the discriminant is true, but the actual operation process, almost can not find this established discriminant point, so the interference of traditional method of observation can result in system working point near the maximum

power point of pv array oscillation operation, result in a certain power loss, so e parameters are introduced, and to determine $|dP|$ when $|dP| < e$, systems that find the maximum power point, the size of the e can according to different precision requirement. And the interference of traditional method of observation, when find system P_{max} of maximum power point, not to disturbance, but stop the disturbance. Do this, because if to disturbance, the system always can't work on the maximum power point, resulting in the output of the system is not stable, and reduce the system efficiency. Because in the daylight, in a short period of time of pv array output change is very small, so it is not necessary to have been disturbed. Stop after disturbance, the working state of the monitoring system at any time, and make the right judgment, according to the variation of different processes is shown in figure 6.

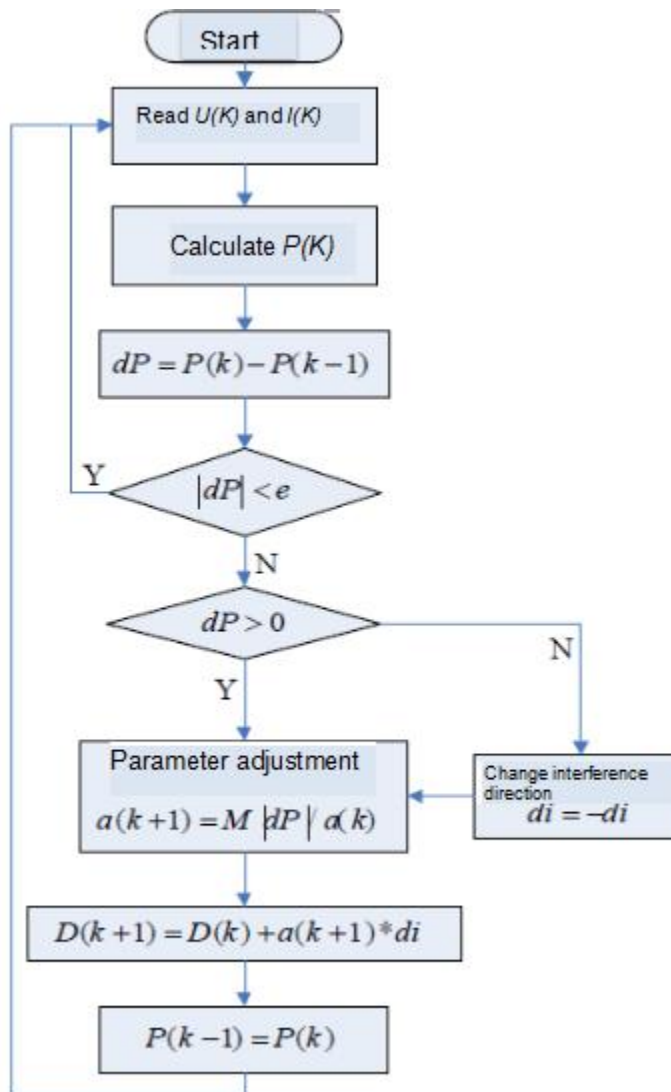


Figure 6 Flow chart of improved adaptive disturbance observation method

7. Conclusion

The proposed optimization method compared with traditional disturbance observation method, keep the idea of disturbance observation method, and by constantly disturbed to find system of maximum power point, but the difference is that the size of the disturbance amplitude varies according to the system of the working point, embodies the idea of adaptive, both to increase the rapidity of the system, and improve the accuracy and stability of the system.

References

1. Changgui Wang, New energy and renewable energy status quo and outlook of solar energy photovoltaic industry development BBS proceedings, 2003, 9: 4-17
2. Lu-guang Yan, Renewable energy power generation technology development in China. China's new energy, 2005, 9: 15-20
3. Zhengming Zhao, Jianzheng Liu, Xiaoying Sun et al. solar photovoltaic power generation and application of Beijing, science press, 2005, 1 – 8.
4. Dejia Zhou, Zhengming Zhao, Libo Wu, et al. Based on the simulation model of the paper analyses the characteristics of the pv array of tsinghua university (natural science edition) cutflower production potentials 2007.
5. Shi-jie Yu, Huire He, Photovoltaic pump system of CVT and TMPPT control comparison, the solar energy journal. 1998,4,394 – 398.
6. Li-qiang Yuan, Which has the function of MPPT photovoltaic pump system controller of the study, master degree theses of master of [], Beijing, tsinghua university, 2001.
7. Meng Ni, Leung M K, Sumathy K, New progress in the study of solar cells, renewable energy, 2004, 2: 9-11.