IOP Conf. Series: Materials Science and Engineering **394** (2018) 042108 doi:10.1088/1757-899X/394/4/042108

Research on PV Systems Application Based on MPPT Control Strategy Using P&O Method

Wenping Bu*, Zhilin Ding and Shuling Feng

College of Artificial Intelligence, Nanchang Institute of Science and Technology, Jiangxi Nanchang 330108, China

*Corresponding author e-mail: gold_my_fency@163.com

Abstract. This paper presents the structure of photovoltaic inverter, there are many types of processing during photovoltaic power generation., the article describes three control categories of PV system based on MPPT(Maximum Power Point Tracking), then mathematical model of photovoltaic cell is analyzed, and several methods of sampling maximum power point by MPPT control strategy is compared. The maximum power point is designed by the P&O (perturbation and observation) method, and the feasibility of the result is verified based on MATLAB simulation.

1. Introduction

Photovoltaic power generation system is to transmit the power from PV array to grid by means of inverter, in the process of grid connection, AC current and grid voltage synchronization as well as low harmonics are required. Power transmission from inverter to grid depends on the grid-connected control strategy of the photovoltaic array MPPT (Maxium Power Point Tracking) control strategy and grid-connected inverter under the condition of system structure determination. A general approach for maximum power point of PV array can be achieved by MPPT control method on the side of PV array, therefore, how to transmit the maximum power point power to grid throgh grid-connected inverter in time is the point to be resolved. Performance of inverter can be improved under study of inverter transmission approach using MPPT control strategy. The result in paper [1] is based on the simulation analysis, which presents comparison of the maximum power between centralized and distributed photovoltaic array system under MPPT control, showing that output power acquisition of the centralized MPPT strategy is not the real maximum power. The paper suggests that the maximum output potential of the photovoltaic array can be achieved by using the distributed MPPT strategy. In addition, the paper does not make a specific analysis of the difficulty of two situations. In paper [2], a passive power controller is designed by means of inverter EL power model, making up for the power loss caused by the network side filter, which can achieve maximum power transmission while solving the harmonic problem. In this paper, the P&O (disturbance and observation) method is used to track the maximum power point in sampling MPPT control, meanwhile, the peak power can be better collected, and the rationality of the theory is verified by simulation.

2. Photovoltaic system structure and MPPT control topology

2.1. Photovoltaic system structure

The operation of solar photovoltaic power system mainly includes PV array, inverter unit, LCL filter unit and grid-connection unit, the diagram of three-phase photovoltaic grid-connected inverter system is shown in Figure 1.

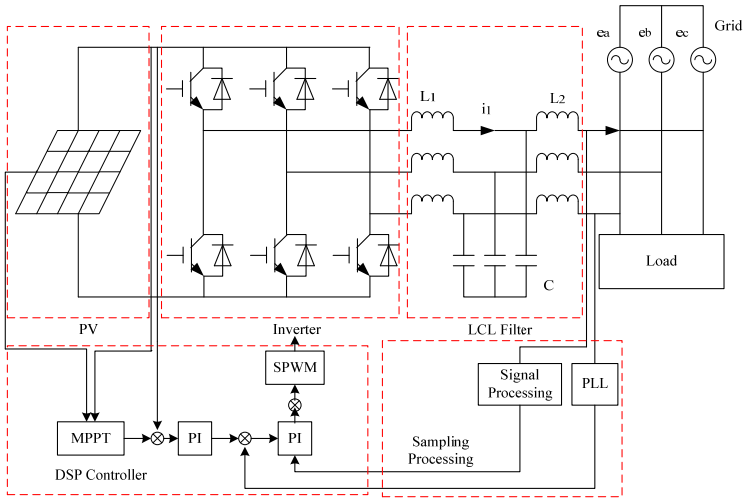
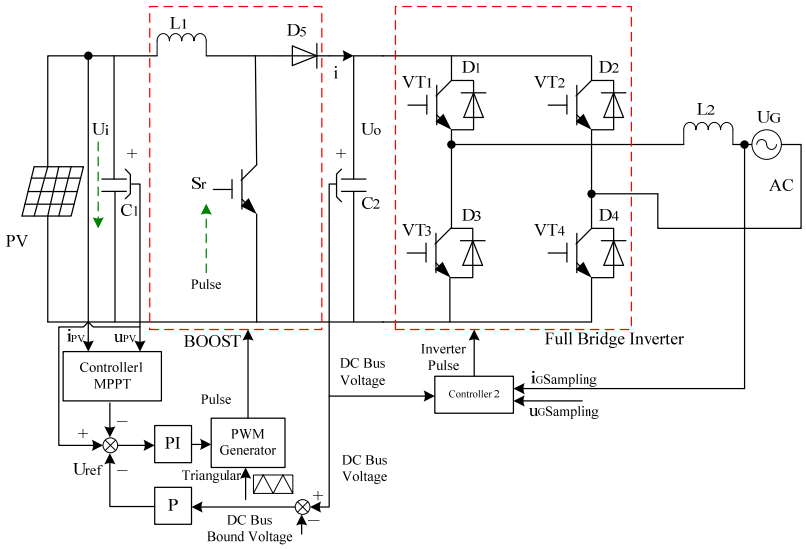


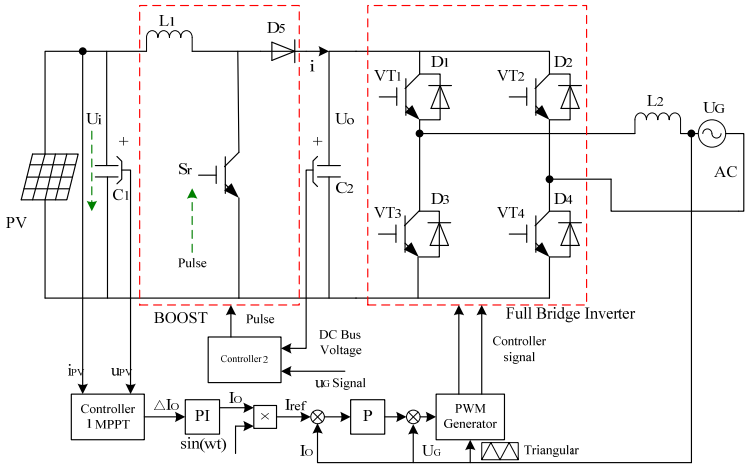
Figure 1. Structure diagram of photovoltaic grid-connected inverter system.

2.2. MPPT control topology in photovoltaic system

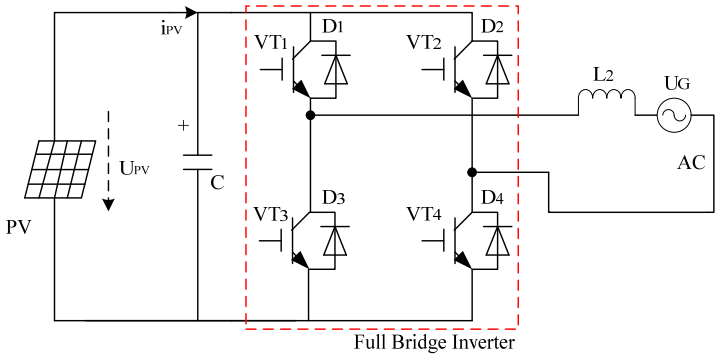
Grid-connected PV inverters can be divided into two-stage grid-connected inverter and single-stage grid-connected inverter according to topology and position of MPPT tracking realization, as shown in Figure 2.



(a) Structure diagram of preceding-stage DC/AC grid-connected inverter based on MPPT



(b) Structure diagram of post-stage DC/AC grid-connected inverter based on MPPT



(c) Structure diagram of Single-stage photovoltaic power system

Figure 2. MPPT control topology diagram

3. Photovoltaic cell model and MPPT control curve

As shown in Figure 3, I_L is the output current produced by photovoltaic panels under the effect of photovoltaic effect. The size of output current is related to the light intensity, temperature, and the properties of battery. VD is a diode in parallel with a current source equivalent to a photovoltaic panel, and I_L is called diffusion current that flows through the equivalent diode, and the R_S is a series resistance consisting of the internal resistance of the battery and the electrode resistance, which is usually small.

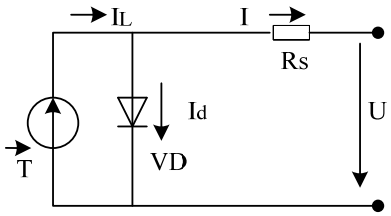


Figure 3. Equivalent circuit of photovoltaic cells

The output characteristic equation of the photovoltaic cell is as follows:

$$I = I_L - I_d = I_L - I_o\left\{\exp\left[\frac{q}{AkT}U\right]-1\right\} \quad (1)$$

Where:

I_L - short circuit current is determined by sunlight intensity, assuming 14 (A).

I_0 - the reverse saturation current of photovoltaic cells in the absence of light,

The silicon PN junction value is generally for 1 x 10-14-1 x 10-10 (A).

q - Quantity of electric charge, 1.6×10-19 (C).

A - Diode characteristic factor, when positive bias voltage is large, A=1, positive bias voltage small, A=2.

K - Boltzmann constant, 1.38×10-23 (J/K).

T - Cell element temperature.

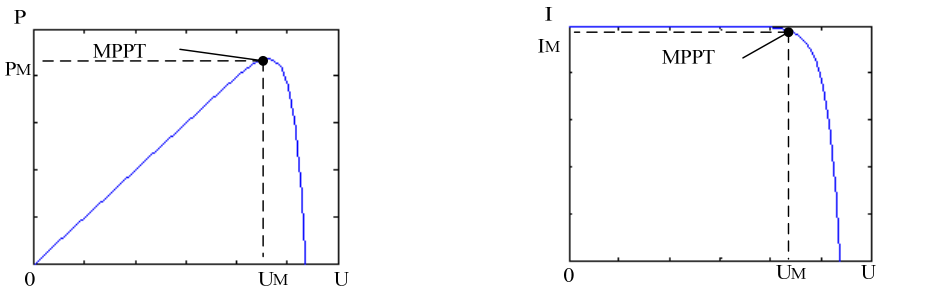
U - Output voltage of photovoltaic cells.

The mathematical equation of output power of photovoltaic cells can be obtained by formula (1) as follows:

$$P = I_L \bullet U - I_0 \bullet U \left\{ \exp\left[\frac{q}{AkT} U \right] - 1 \right\} \tag{2}$$

Formula (2) shows that the output power of photovoltaic cells has nonlinear relationship with sunshine intensity and temperature.

At present, for large power occasions, multiple solar cells are used to form photovoltaic modules in series and parallel connection.



(a) mppt maximum power characteristic (b) photovoltaic array characteristic

Figure 4. Photovoltaic array curve and MPPT maximum power characteristic curve

4. MPPT Control strategies

In the process of collecting the maximum power point of PV module, there are usually several methods.

1) Constant Voltage Tracking (Abbreviation: CVT), under the basic stability of the photovoltaic cell temperature, the maximum power point voltage on the output P-U characteristic curve of the photovoltaic cell is basically distributed on both sides of the fixed point voltage value.Therefore, the CVT control method is equivalent to controlling the output voltage of PV cells at this voltage point, at the same time the approximate operation of the voltage of battery is at the maximum power point.

2) Perturb and Observation method(Abbreviation: P&O method), the principle of the system is to determine the output power of the system during the disturbance observation of the output voltage in photovoltaic system, and control the system according to the principle of the direction of increasing the output power.

3) Incremental conductance method (Abbreviation: IncCond), the P-U characteristic curve of the photovoltaic cell can be obtained, and there is a dP/dU=0 at the maximum power point to determine whether the photovoltaic cell works at the maximum power point.

4) Admittance increment method, based on gradient variable step length, through the P-U characteristic curve of the photovoltaic cell group, it can be seen that the power characteristic curve is a single peak function in the whole voltage range, and there is dP/dU=0 at the maximum power point,

and the value is not 0 at the maximum power point. The variable step length tracking of the maximum power point is realized by adjusting the step length of the sampled data during the whole operation process.

5. Proposed P&O method using in MPPT control strategy

Selecting P&O method, by means of zero order hold obtaining dP/dU data, which determines the variation tendency of dP/dU, Where achieving the maximum power point as dP/dU=0, the P&O method can judge the maximum power point as well as photovoltaic system working in a stable state. As shown in Fig. 5, the performance of PV system and load waveform is simulated under condition of the P&O method, and the corresponding results show that the proposed method can improve the dynamic performance and steady-state performance simultaneously.

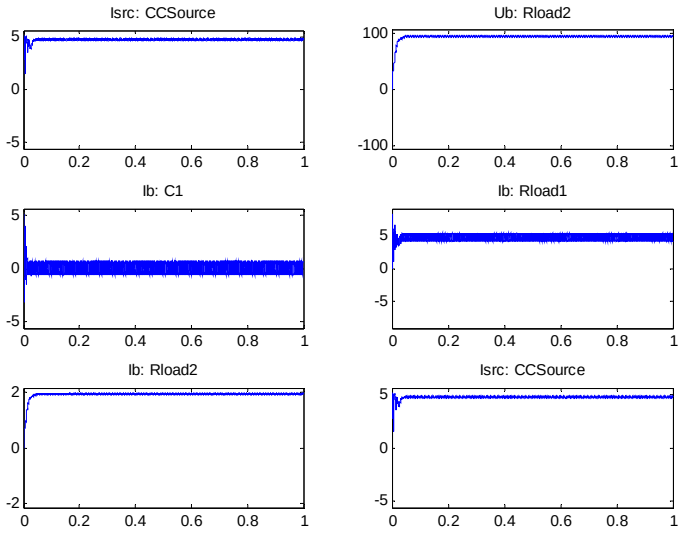


Figure 5.simulation waveform of mppt control strategy based on P&O method

6. Conclusion

This paper introduces the structure of photovoltaic power system, several sampling maximum power point methods for photovoltaic MPPT control strategies are compared. The working principle of obtaining PV maximum power point in the operating P&O method based on PV MPPT control mode is expounded, which is determined through the acquisition of dP/dU parameters, obtaining the point when parameters dP/dU=0. Finally, the feasibility of the control strategy is verified by the P&O method based on simulation.

Acknowledgments

This work was financially supported by Nanchang Institute of Science and Technology School level science and technology project'Research of photovoltaic inverter based on MPPT' in 2016 fund, Approval number: GJKJ-16-04.

References

[1] [1] Zhang Xing, Cao Renxian, Solar photovoltaic grid connected power generation and control[M], Beijing: Mechanical industry press, 2011.5.
[2] [2] SUN Hang, DU Haijiang, JI Yingxu, YANG Bo, Photovoltaic distributed MPPT mechanism analysis and simulation study [J], Power System Protection and Control, 2015, 43 (2): 48-54.
[3] [3] Wang Jiuhe, Mu Xiaobin, Zhang Baile, Zhang Zhen, Research on Maximum Power Transfer Control of Photovoltaic Grid Connected Inverters [J], TRANSACTIONS OF CHINA ELECTROTECHNICAL SOCIETY, 2014, 29 (6): 49-56.

[4] [4] LI Qiuhua, ZHOU Lin, LIU Qiang, ZHANG Feng, WU Jian, Simulative research of MPPT for photovoltaic power system [J], Electric Power Automation Equipment, 2008, 28 (7): 21-24.
[5] [5] XU Jin-song, NING Yu-lin, YANG Yong-feng, Research on power system flow calculation of PQ decomposition based on Matlab [J]. ELECTRIC DRIVE AUTOMATION, 2011, 33 (2): 10-18.
[6] [6] Qi Biaojie, Control for Inverter in Parallel Operation Based on P-Q Regulation [D], Nanjing University of Aeronautics and Astronautics, Degree of Master of Engineering, 2008.
[7] [7] XU Peng-wei, LIU Fei, LIU Bang-yin, DUAN Shan-xu, Analysis, Comparison and Improvement of Several MPPT Methods for PV System [J], Power Electronics, 2007, 5, 41 (5): 3-5.