TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol.12, No.2, February 2014, pp. 899 ~ 904
DOI: http://dx.doi.org/10.11591/telkomnika.v12i2.4172

Research on Single-Variable Current Perturbation Tracking Method for Maximal Power Tracking Control Method of the Solar Power Generation System

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Abstract

In this paper, the traditional grid-connected PV perturbation method of disturbance near the maximum power point about the problems of shock, introduced a method based on single variable current control thought, established grid-connected PV maximum power tracking control system mathematical model, a novel single-variable current perturbation tracking method was put out, as long as the detected output current of the solar panel power generation system can achieve a stable variable maximum power tracking, through simulation and experimental study to verify the correctness of the model and the effectiveness of control methods.

***Keywords**: solar power generation, single-variable current perturbation tracking method, maximal power tracking*

1. Introduction

In grid-connected PV systems, solar panels output current and output voltage has a nonlinear relationship characteristics, output power curve with the amount of sunlight, the solar panel surface temperature changes, a different time and place, the load requirements of each state output power curve there is a maximum power point, the maximum power point of photovoltaic panels output connection is the best working curve. [1-3] Therefore, in order to improve the efficiency of photovoltaic panels, should try to control the output power of solar panels always work at the maximum power curve, allowing the system to obtain maximum energy. Current widespread use of maximum power point tracking control method has a voltage feedback method, power feedback method, perturbation and observation method, incremental conductance method, linear approximation method, the actual measurement method. [4-7] These types of conventional solar power system maximum power point tracking control method requires the simultaneous detection of solar photovoltaic panels Vpv the output voltage and output current Ipv [8-9]. This paper presents a method based on single variable current maximum power point tracking control method you can simply detect the output current of the solar photovoltaic panels which a variable can be realized Ipv solar panel's maximum power output, greatly simplifying the process of maximum power point tracking control. The method discriminant by continuously adjusting the duty cycle to achieve maximum power point tracking purposes, but also on the duty cycle for the defined boundaries, such a combination of coarse and fine speed control mode can be tracking speed, reduce environmental power loss caused by changes greatly improved the traditional perturbation method of disturbance at the maximum power point about concussion problem.

2. Single Variable Current Method the Basic Idea

The equivalent circuit of solar photovoltaic panels 1, the output current of the solar photovoltaic panels Ipv as [10-12]:

Received July 18, 2013; Revised August 24, 2013; Accepted September 19, 2013

$$I_{pv} = n_p I_{ph} - n_p I_{rs}\left[\exp\left(\frac{q}{kTA}\cdot\frac{V_{pv}+I_{pv}R_s}{n_s}\right)-1\right]-\frac{V_{pv}+I_{pv}R_s}{R_{sh}} \quad (1)$$

Output power Ppv is:

$$\begin{aligned} P_{pv} &= V_{pv}I_{pv} \\ &= n_p V_{pv} I_{ph} - n_p V_{pv} I_{rs}\left[\exp\left(\frac{q}{kTA}\cdot\frac{V_{pv}+I_{pv}R_s}{n_s}\right)-1\right]-V_{pv}\cdot\frac{V_{pv}+I_{pv}R_s}{R_{sh}} \\ &= P_{pv}(V_{pv}I_{pv}) \end{aligned} \quad (2)$$

In order to introduce proposed method based on univariate current maximum power point tracking control thought, in the solar panel and DC / DC boost power converter connected between a voltage regulator [13], voltage regulator circuit shown in Figure 1, the regulator the output voltage Vo is:

$$V_o = \frac{t_{on}}{T}V_{pv} = d_{pv}V_{pv} \quad (3)$$

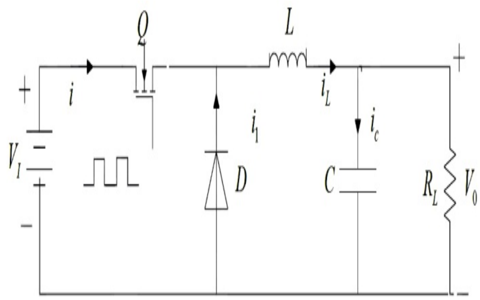

Figure 1. Circuit Structure of Voltage Stabilizer

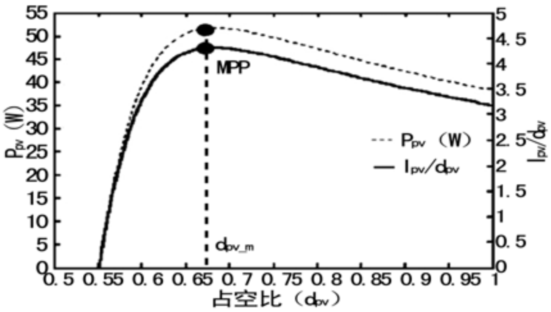

Figure 2. P_{pv}-d_{pv} curve and $_{PBuck}$-d_{pv} Curve of Solar Power Generation System

Then, the output power of photovoltaic panels can also be written as Ppv:

$$P_{pv} = V_{pv}I_{pv} = V_o\frac{I_{pv}}{d_{pv}} \quad (4)$$

Regulator output power PBuck as:

$$P_{Buck} = \frac{I_{pv}}{d_{pv}} = P_{Buck}(I_{pv}) \quad (5)$$

By Equation (4) and (5) respectively, can be Ppv-dpv curves and PBuck-dpv curve shown in Figure 2. As can be seen, the output power of solar photovoltaic panels Ppv maximum power point and the regulator output power PBuck maximum power point corresponds to the duty cycle of the same, so, this article will be based on the formula (5) to obtain the maximum power point PBuck corresponding duty than dpv_m, controlled duty cycle of the switching power supply dpv_m, thus achieving maximum power point tracking Ppv purpose, which is to use a single variable current method (Ipv) to achieve maximum power tracking control of the basic idea.

3. Single-variable Current Perturbation Tracking Method

First, the boundaries of the duty cycle to limit the scope dpv, assuming dpv_min (minimum boundary value) <dpv <dpv_max (maximum boundary value), shown in Figure 3. Duty dpv boundary defining the purpose of reducing the number of comparisons, speed tracking speed, when the duty ratio dpv outside the boundary defined, i.e. dpv <dpv_min or dpv> dpv_max, then the need to compare the output power should be first duty dpv adjusted to within the limits.

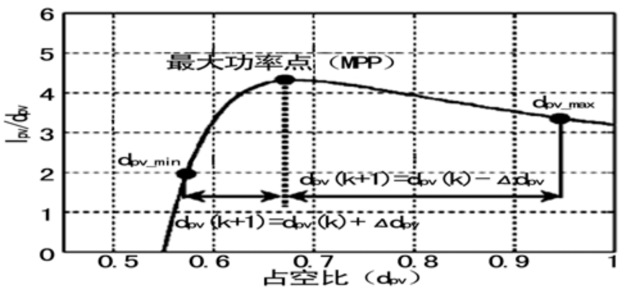

Figure 3. Boundary Range Limit of Duty Cycle d_{pv}

The initial value of the duty cycle is set to its minimum boundary value dpv_0 dpv_min, gradually increase the duty cycle dpv, and ensure dpv a limited boundaries [dpv_min, dpv_max] inside, at some point, the output current of the solar photovoltaic panels is Ipv (k), an output of the regulator PBuck (k), changing the duty cycle at the next time dpv, the output current and output power PBuck Ipv were changed, then the output current of the solar photovoltaic panels denoted Ipv (k +1), the output power of the regulator is denoted PBuck (k +1), by comparing before and after the disturbance, the output power PBuck (k) and PBuck (k +1) between the duty dpv (k) and dpv (k +1) to determine the magnitude relationship between the duty cycle of the next time adjustment direction dpv. It can be divided into three cases.

The first case: if PBuck (k +1)> PBuck (k), dpv (k +1)> dpv (k), described dpv_min <dpv <dpv_m, then increase the duty cycle dpv; dpv (k +1) <dpv (k), described dpv_m <dpv <dpv_max, decrease the duty cycle dpv.

Case 2: If PBuck (k +1) <PBuck (k), dpv (k +1)> dpv (k), described dpv_m <dpv <dpv_max, decrease the duty dpv; dpv (k +1) <dpv (k), described dpv_min <dpv <dpv_m, then increase the duty cycle dpv.

Case 3: If PBuck (k +1) = PBuck (k), described dpv = dpv_m, remain constant duty dpv. Repeating the above process, the regulator to increase the output power PBuck changing trends in order to achieve maximum power tracking.

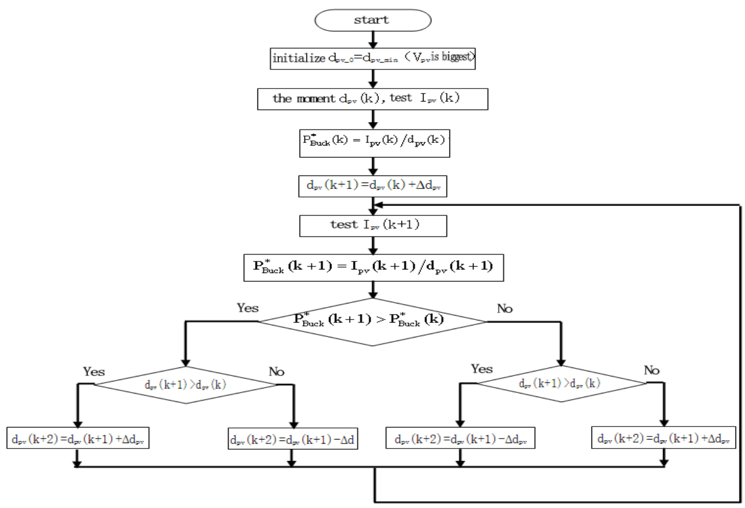

Figure 4. Control Flow Chart of Single-variable Current Perturbation Tracking Method

Thus, the single variable current perturbation tracking method is based on two discriminant (Comparative PBuck (k), PBuck (k +1) the size and dpv (k), dpv (k +1) size), by continuously adjusting the duty cycle dpv to change the output current of the solar photovoltaic panels Ipv, thereby changing the regulator output power PBuck, so PBuck to change the direction of increasing, and ultimately achieve the purpose of tracking the maximum power point, Figure 4 shows the single-variable current perturbation tracking method control flow.

4. Simulation and Experiment

According to univariate current control flow disturbance tracking method using LabView software to design, through man-machine interface for the current size of the adjustment, the result of calculation, disturbance Δdpv1 = 0.02, Δdpv2 = 0.005, then the ambient temperature is 25 ℃, an amount of sunlight and 1000W/m2 800W/m^2 the VI characteristic curve, respectively as shown in Figure 5 and Figure 6.

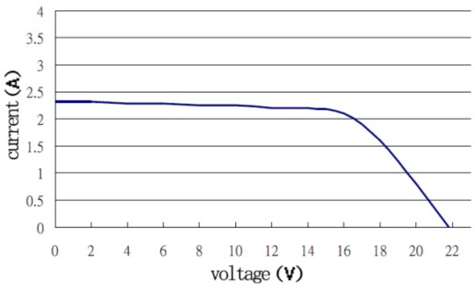

Figure 5. V-I characteristic curve as environmental temperature is 25℃, daily sunshine is 800W/m^2

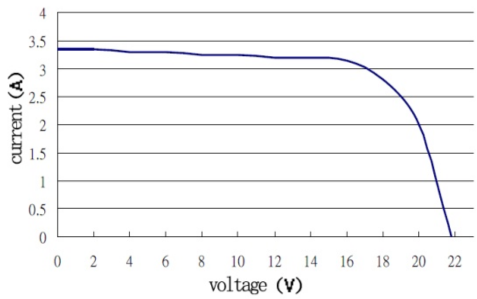

Figure 6. V-I characteristic curve as environmental temperature is 25℃, daily sunshine is 1000W/m^2

Looking for the best set of single variable current disturbance disturbance tracking method implementation is crucial, Figure 8 shows when the ambient temperature is 25 ℃, when the amount of sunlight is 1000W/m^2 different theoretical calculations and the corresponding disturbance comparison of results.

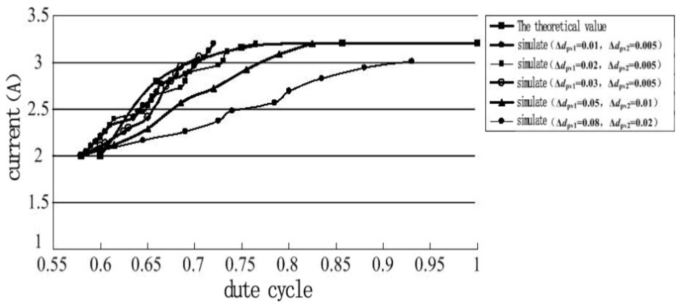

Figure 7. Theoretical Values and Comparing Result of Different Disturbance Quantities as Environmental Temperature is 25℃, Daily Sunshine is 1000W/m^2

Figure 7 compares the results can be seen, when the ambient temperature is 25℃, the amount of sunlight is 1000W/m2, the disturbance of Δdpv1 = 0.01, Δdpv2 = 0.005, Δdpv1 = 0.02, Δdpv2 = 0.005, Δdpv1 = 0.03, Δdpv2 = 0.005 are relatively close to the theoretical calculated value. Discussed further under an ambient temperature of 25℃, when the amount of sunlight is 800W/m2, different theoretical calculations and comparison of the results corresponding disturbance shown in Figure 8.

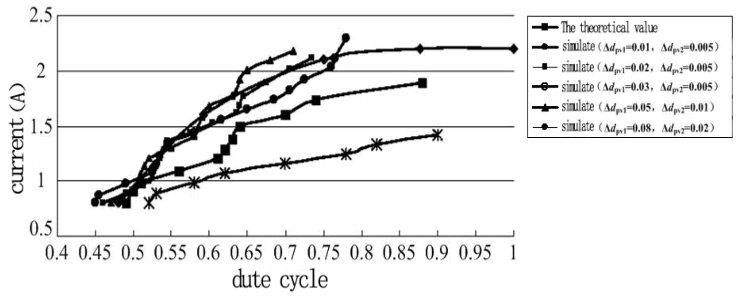

Figure 8. Theoretical Values and Comparing Result of Different Disturbance Quantities as Environmental Temperature is 25℃, Daily Sunshine is 800W/m^2

Comparison of Figure 9 can be seen, when the ambient temperature is 25℃, sunshine amount of 800W/m2, the disturbance of Δdpv1 = 0.02, Δdpv2 = 0.005 corresponds with the theoretical calculated values are very close, either fine or coarse tone, have a high degree of accuracy. When the disturbance is Δdpv1 = 0.03, Δdpv2 = 0.005, slightly coarse time will deviate from the theoretical calculated values and disturbance of Δdpv1 = 0.05, Δdpv2 = 0.01 and Δdpv1 = 0.08, Δdpv2 = 0.02 corresponding result has completely deviated from the theoretical value. Considering Figures 9 and 10 of the comparison results, the proposed single-variable current perturbation tracking method will be used for the disturbance Δdpv1 = 0.02, Δdpv2 = 0.005 for maximum power tracking control.

5. Conclusion

In the study of solar power systems typically use the maximum power point tracking control method based on the. Proposed a method based on single variable current maximum power point tracking control method, namely single-variable current perturbation tracking method, only detects the output current of solar panels can be a variable, which greatly simplifies the maximum power point tracking control process. Current method based on univariate maximum power tracking control method limits the scope of the duty cycle of the border, using a combination of coarse and fine control mode to speed up the tracking speed and reduce the music due to environmental changes caused by the power loss and improve the disturbance of the traditional perturbation method amount of the maximum power point near the shock around the issue for the future grid-connected PV system maximum power tracking propose new solutions.

Acknowledgement

This work was supported by Program for Changjiang Scholars and Innovative Research Team in University (IRT1072), Program for Liaoning BaiQianWan Talents Program (2008921038), Program for LiaoningInnovative Research Team in University (LT2011003), Program for shenyang science and technology public project in China.

References

[1] Wu Libo, Zhao Zhengming, Liu Jianzheng, et al. *Reseach on the stability of mppt strategy applied in single-stage grid-con-nected photovoltaic system.* Proceedings of the CSEE. 2006; 26(6): 73-77.
[2] Soeren baekhoej Kjaer, Pedersen John K, Frede Blaabjerg. A review of single-phase grid-connected inverters for photovoltaic moduled. *IEEE Trans on Industry Applications*. 2005; 41: 1292-1306.
[3] Yusof Y, Sayuti SH, Abdul Latuf M, et al. *Modeling and simulation of maximum power point tracker for photovoltaic system.* Proceedings of National Power and Energy Conference. Kuala Lumpur, Malaysia. 2004: 88-93.

[4] Chee Wei Tan, Green TC, Hernandez-Aramburo CA. *Animproved maximum power point tracking algorithm with currentmode control for photovoltaic application.* International Conference on Power Electronics and Drives System. Kuala Lumpur, Malaysia. 2005: 489-494.
[5] Fangrui Liu, hanxu Duan, et al. A variable step size INC MPPT method for PV systems. *IEEE ransactions on Industrial Electronics*. 2008; 55(7): 2622-2627.
[6] Mummadi Verrachary, Katsumi Uezato, Katsumi Uezato. Feed forward maximum power point tracking of PV system using fuzzy controller. *IEEE Transactions on Aerospace and Electronic System*. 2002; 38(3): 969-980.
[7] Khaehintung N, Sirisuk P. *Implementation of maximum power point tracking using fuzzy logic controller for solar-powered light-flasher applications*. The 47th IEEE Midwest symposium on Circuits and Systems. Hiroshima, Japan. 2004; 171-174.
[8] WANG Yu-xin, ZHANG Feng-ge, YIN Xiao-ju, ZHU Shi-lu. *The Research of a Derivation Calculation Method for the Maximum Power Point in Grid-connect Photovoltaic System*. AMR. 2012; (12): 588-589.
[9] WANG Yu-xin, YIN Xiao-ju. The research of intelligent fuzzy PID control in the off-grid wind-PV hybrid generating system. *Manufacturing Automation.* 2012; 34(8): 10-11.
[10] WANG Yu-xin. Research of Optimum Energy Matching on Off-grid Wind-Solar Hybrid Generating System. *Microcomputer Information.* 2012; 28(10): 48-50.
[11] WANG Yu-xin. Off-grid Wind-Solar Hybrid Power System Design Based on Maximum Energy Capture. *Microcomputer Information.* 2012; 28(11): 65-67.
[12] Aryuanto Soetedjo. Modeling of Maximum Power Point Tracking Controller for Solar Power System. *TELKOMNIKA Indonesia Journal of Electrical Engineering*. 2012; 10(3): 419-430.
[13] Zhou Tianpei, Sun Wei. MPPT Method of Wind Power Based on Improved Particle Swarm Optimization. *TELKOMNIKA Indonesia Journal of Electrical Engineering*. 2013; 11(6): 3206-3210.