
Wang Yu-xin*,1,2, Zhang Feng-ge¹, LI Lin-lin²
¹School of Electrical Engineering, Shenyang University of Technology, Shenyang, China
²Institute of Technology, Shenyang Open University, china
No.111, Shenliao West Road, Economic&Technological Development Zone
Shenyang 110870, P.R. China
*Corresponding author, e-mail: sytvu_wyx@163.com

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

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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]:

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\[ I_{pv} = n_p I_{in} - n_s I_s \left[ \exp \left( \frac{q}{kTA} \frac{V_{pv} + I_{pv} R_s}{n_s} \right) - 1 \right] \frac{V_{pv} + I_{pv} R_s}{R_{in}} \]  

(1)

Output power \( P_{pv} \) is:

\[ P_{pv} = V_{pv} I_{pv} \]
\[ = n_p V_{in} I_{in} - n_s V_s I_s \left[ \exp \left( \frac{q}{kTA} \frac{V_{pv} + I_{pv} R_s}{n_s} \right) - 1 \right] V_{pv} \frac{V_{pv} + I_{pv} R_s}{R_{in}} \]
\[ = P_{pv}(V_{pv} I_{pv}) \]  

(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 \( V_o \) is:

\[ V_o = \frac{t_{on}}{T} V_{pv} = d_p V_{pv} \]  

(3)

Figure 1. Circuit Structure of Voltage Stabilizer

Figure 2. \( P_{pv-d_{pv}} \) curve and \( P_{Buck-d_{pv}} \) Curve of Solar Power Generation System

Then, the output power of photovoltaic panels can also be written as \( P_{pv} \):

\[ P_{pv} = V_{pv} I_{pv} = V_{pv} \frac{I_{pv}}{d_{pv}} \]  

(4)

Regulator output power \( P_{Buck} \) as:

\[ \frac{I_{on}}{d_{pv}} = P_{Buck}(I_{pv}) \]  

(5)

By Equation (4) and (5) respectively, can be \( P_{pv-d_{pv}} \) curves and \( P_{Buck-d_{pv}} \) curve shown in Figure 2. As can be seen, the output power of solar photovoltaic panels \( P_{pv} \) maximum power point and the regulator output power \( P_{Buck} \) 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 \( P_{Buck} \) corresponding duty than \( d_{pv-m} \), controlled duty cycle of the switching power supply \( d_{pv-m} \), thus achieving maximum power point tracking \( P_{pv} \) purpose, which is to use a single variable current method \( (I_{pv}) \) to achieve maximum power tracking control of the basic idea.

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 dpv](image)

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 isIpv (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_max, 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](image)
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 \( \Delta dpv1 = 0.02, \Delta dpv2 = 0.005 \), then the ambient temperature is 25 °C, an amount of sunlight and 1000W/m² 800W/m² the VI characteristic curve, respectively as shown in Figure 5 and Figure 6.

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 °C, the amount of sunlight is 1000W/m² different theoretical calculations and the corresponding disturbance comparison of results.

Figure 7 compares the results can be seen, when the ambient temperature is 25°C, the amount of sunlight is 1000W/m², the disturbance of \( \Delta dpv1 = 0.01, \Delta dpv2 = 0.005, \Delta dpv1 = 0.02, \Delta dpv2 = 0.005, \Delta dpv1 = 0.03, \Delta dpv2 = 0.005 \) are relatively close to the theoretical calculated value. Discussed further under an ambient temperature of 25°C, when the amount of
sunlight is 800W/m², different theoretical calculations and comparison of the results corresponding disturbance shown in Figure 8.

Comparison of Figure 9 can be seen, when the ambient temperature is 25°C, sunshine amount of 800W/m², the disturbance of $\Delta dpv_1 = 0.02$, $\Delta dpv_2 = 0.005$ corresponds with the theoretical calculated values are very close, either fine or coarse tone, have a high degree of accuracy. When the disturbance is $\Delta dpv_1 = 0.03$, $\Delta dpv_2 = 0.005$, slightly coarse time will deviate from the theoretical calculated values and disturbance of $\Delta dpv_1 = 0.05$, $\Delta dpv_2 = 0.01$ and $\Delta dpv_1 = 0.08$, $\Delta dpv_2 = 0.02$ 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 $\Delta dpv_1 = 0.02$, $\Delta dpv_2 = 0.005$ 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.

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