An Improved Incremental Conductance MPPT Method for the Photovoltaic Generation

Thusitha Wellawatta and Sung-Jin Choi

School of Electrical Engineering, University of Ulsan, KOREA

Abstract

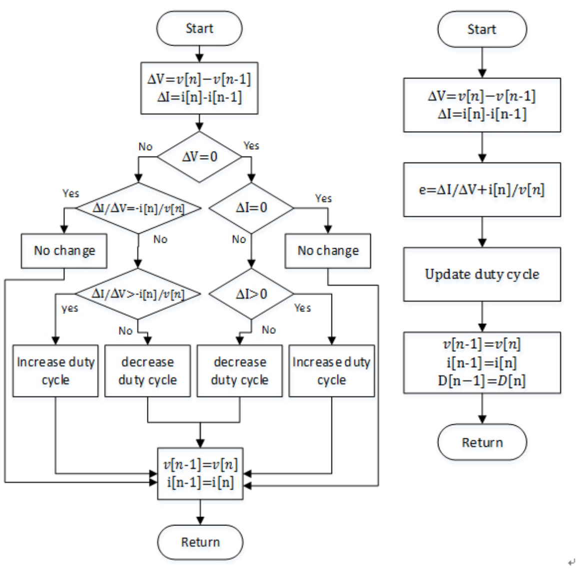
Maximum power point tracking (MPPT) techniques play a big role in improving the efficiency of photovoltaic (PV) system. Among various schemes, the incremental conductance (INC) method is mostly discussed in literature because of its fast response to the rapid irradiation changes and high tracking accuracy. However, the existing INC algorithm has trade-offs between fast dynamic response and steady state stability. This study proposes a novel INC method to meet high efficiency and fast tracking performance at the same time.

1. Introduction

As a green energy production method, photovoltaic (PV) generation systems do an important role. To maximize the efficiency of solar energy utilization, the maximum power point tracking (MPPT) concept is essential thus different kind of MPPT techniques can be found in the literature [1]. The INC method is taken into discuss in this study because of its fast response and stability in constant irradiation.

Mainly, two kinds of INC approach are mainly discussed in the literature. In decision-based approach, the voltage and current reading are used to calculate the sign of a given deterministic equation to procced the next state. In error-based approach, the error is directly calculated to update the next duty cycle [2]. Nowadays, because of its fast dynamics, numerous variable step variants have been studied in decision-based methods. However, they increase algorithm complexity too much.

In this study, a simple digital control technique has been applied to error-based method and its feasibility has been discussed.



(a) Decision-based approach (b) Error-based approach

Fig. 1 Flow Charts of INC algorithms

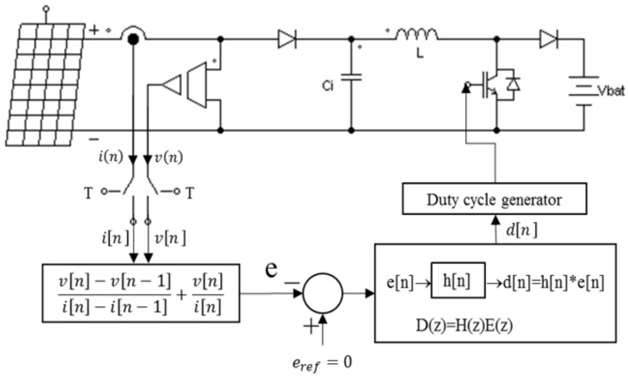


Fig.2 Proposed INC method

2. Algorithm overview

2.1 Error function and Efficiency of INC method

The basic formation of INC function can be realized as

$$\frac{dP}{dV} = I \cdot \frac{dV}{dV} + V \cdot \frac{dI}{dV} \tag{1}$$

On the MPP, differentiation of power is zero and the error function of the MPP can be taken as (3),

$$\therefore 0 = I + V \cdot \frac{dI}{dV} = \frac{I}{V} + \frac{dI}{dV} \tag{2}$$

$$e = \frac{I}{V} + \frac{dI}{dV} \tag{3}$$

2.2 Existing INC method

The existing MPPT algorithm is shown in Fig. 1 (a). Whole the algorithm function according to the polarity of error. The update of duty cycle is done by additional calculation related to fixed step size. Although this has many complex functionalities, considerable rising time and oscillation around MPP exist.

2.3 Proposed method

A new duty update equation is proposed in this study. In the error-based method, the error function is directly used to determine the duty cycle by a digital filter block as shown in Fig.1 (b) and Fig.2. Any kind of digital filter such as PI, PID, IIR, and FIR can be used to generate duty information from the error quantity. Absent of complex algorithm reduces the controller cost and meet the two different aspect of performance: speed and accuracy.

3. Performance analysis

PSIM simulation schematic of proposed method and PV module parameter is shown in Fig. 3 and Table. 1 respectively. According to the simulation results, efficiency of conventional method and proposed method are shown in Table 2 and Fig.4. This results reflect that the MPPT system needs very simple algorithm. In this paper, we adopted a simple PI controller as a digital filter.

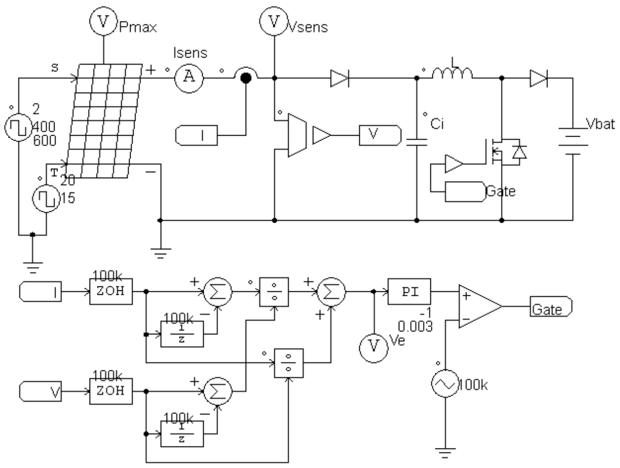


Fig. 3 PSIM simulation schematic

Table. 1 parameters of PV module and power condition circuit

Category	Parameter	Value
PV panel	Pmax	60.53W
	Voltage at Pmax	17.1V
	Current at Pmax	3.5A
	Voc	21 1V
	Isc	3.8A
	Shunt resistance	1000Ω
	Series resistance	0.008Ω
Power circuit	Ci	470uF
	L	25uH
	V_{bat}	20V

Table. 2 Compassion results

Test condition	Method	Rise time	Efficiency
25 ^{0}C	Conventional	3.4ms	96.3%
1000W/m^2 ⇒ 200 W/m^2	Proposed	2.5ms	97.1%
25 ^{0}C ⇒ 15 ^{0}C	Conventional	3.4ms	96.7%
1000W/m^2	Proposed	2.5ms	97.6%

Efficiency of PV system has been calculated by

$$\eta = \frac{\int_{T_m} P_{MPP} dt}{\int_{T_m} P_{\max} dt} \quad (4)$$

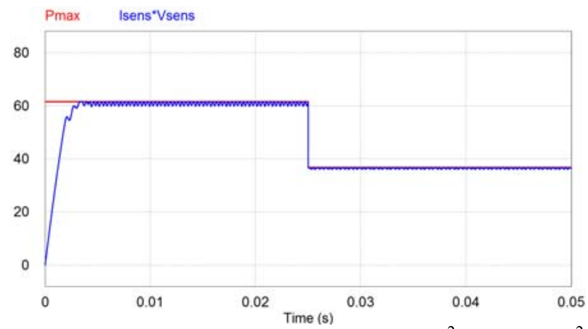
where PV panel power output indication is $P_{max,}$ P_{MPP} = i[n] v[n].

4. Conclusion

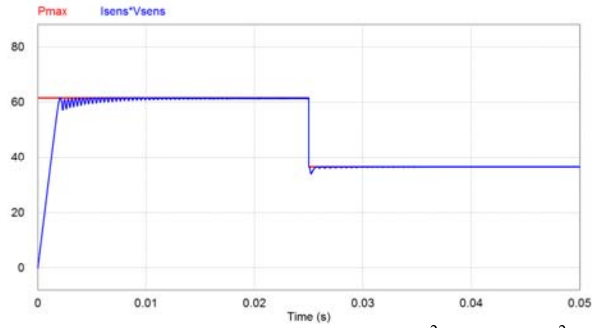
In this paper, we proposed a new error-based INC algorithm with the variable step INC algorithm. In this method, the error of the INC calculation directly fed into the PI controller and the duty cycle is determined. Performances of the new system are compared with conventional fixed step INC algorithm. According to the comparison results, the proposed one achieves fewer rising time and oscillations. Furthermore, the simple structure of algorithm reduces the cost of the controller. In the future works, we planned to try various kind of digital filter method to achieve optimum performance.

Acknowledgment

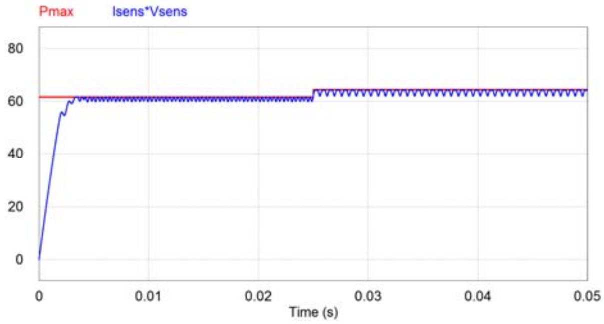
This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2014R1A1A2059772).



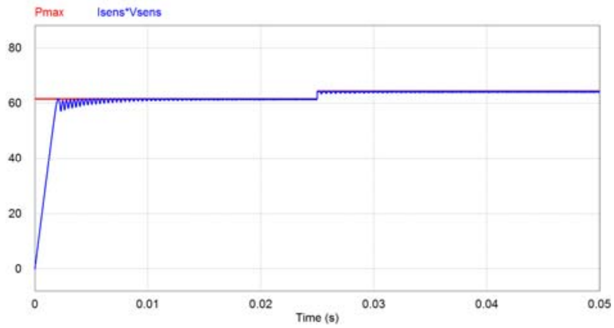
(a) Conventional INC in irradiation 1000w/m^2 → 200 w/m^2



(b) Proposed INC in irradiation 1000w/m^2 → 200 w/m^2



(c) Conventional INC in temperature 25 ^{0}C → 15 ^{0}C



(d) Proposed INC in temperature 25 ^{0}C → 15 ^{0}C

Fig. 4 Comparison of INC algorithm

Reference

[1] A. Safari and S. Mekhilef, "Simulation and hardware implementation of incremental conductance MPPT with direct control method using Cuk converter," *IEEE Transactions on Industrial Electronics*, vol. 58, no. 4, pp. 1154–1161, 2011.

[2] E.M. Ahmed and M. Shoyama, "Stability Study of Variable Step Size Incremental Conductance/Impedance MPPT for PV systems", *2011 IEEE 8th International Conference on Power Electronics and ECCE Asia (ICPE & ECCE),* May-Jun. 2011, TuB2-3, 2011.05.