A Novel Partial Shading Detection Algorithm Utilizing Power Level Monitoring

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Abstract

Maximum power point tracking (MPPT) under partial shading condition (PSC) is a challenging process in the PV array system. The shaded PV panel makes different peak patterns on the P-V curve and misguides the MPPT algorithm. Various kinds of global MPP (GMPP) detecting algorithms are used to overcome this issue. Generally, too frequent execution of GMPP tracking algorithm reduces the achievable power of PV panel due to time spent on the scanning process. Thus, partial shading detection algorithm is essential for efficient utilization of solar energy source. While conventional method only detects fast shading patterns, the proposed algorithm always shows superb performance regardless of the speed of partial shading patterns.

1. Introduction

Photovoltaic (PV) generation is going to be of immense importance due to its free energy with zero environmental pollution. To maximize the efficiency of the PV array utilization, maximum power point tracking (MPPT) algorithm is essential. Moreover, in the real environment, insolation shadows on the PV array are unavoidable. According to the PV characteristic, partially shading of PV array makes a considerable energy loss in entire system [1.]

The MPPT algorithm always attempts to locate the operating point in the power peak in the characteristics curve. In the partial shading condition (PSC), multiple peaks can occur on the power vs voltage curve. Thus, obtainable output power may not be maximized without correct selection of that peak. In this case, global MPPT (GMPPT) algorithm is needed and it selects the highest peak among various local MPPs and gives the new reference to the MPPT algorithm.

However, the GMPPT sometimes causes to reduction of the system efficiency because it needs repeated scanning interval of local MPPs which hinders the optimal operation of PV panel. [2]. Hence, PSC detection is essential to avoid such an unnecessary GMPPT and improve the system performance. In this study, a simple PSC detection algorithm has been proposed and its practicability has been deliberated.

2. Algorithm overview

2.1 Basic concept

According to observations in Fig.1, if a single panel shading level of two panel array is increased up to 50% (α = 0.5) of $P_{mpp,array}$, two peak points are having same power (two peaks are equal in 470W/m^2 shading). The most right hand peak point of $V_{mpp,array}$ (RP) is only affected by shading of insolation [2]. When the MPPT operates at RP, both of non-shaded and shaded panels contribute to the total power and array current is determined by the shaded panel. When the MPPT operates at left hand side peak (LP), the non-shaded panel is delivered the power along (shaded panel is cutoff due to activation of bypass diode) and the array current is determined by the non-shaded panel. The α is dependent on number of panels in the array.

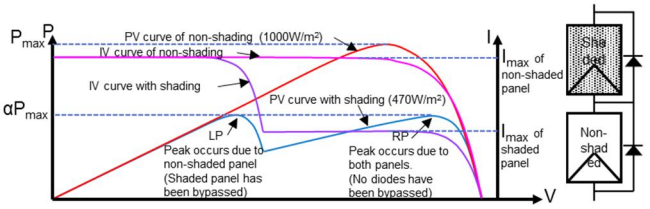
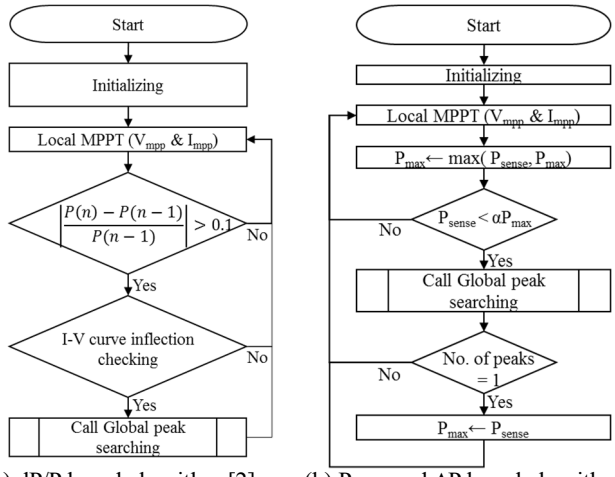


Fig. 1 PV curves under PSC with array configuration



(a) dP/P based algorithm [2] (b) Proposed ΔP based algorithm

Fig. 2 Flow Charts of PSC detection algorithms

2.2 Conventional PSC method

Conventional PSC detection algorithm shown in Fig. 2 (a) monitors the power difference of consecutive two samples [2]. In a sudden change of insolation, dP/P can be considerably higher and if it becomes greater than 0.1, the algorithm triggers GMPP subroutine. The problems of this method are that PSC detection could have failed in smoother change of insolation and unnecessary detection in slight shading condition (In 100% to 50% shading, RP is the highest peak and GMPPT is no needed to decide it).

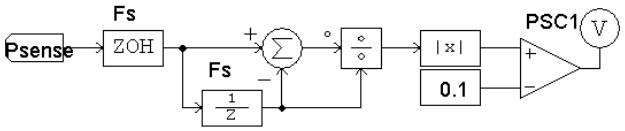
2.3 Proposed method

The basic concept is directly followed in proposed

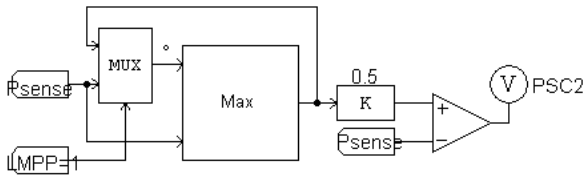
method. As shown in Fig.2 (b), the proposed algorithm tracks the maximum power information (P_{mpp}) and the instantaneous power is compared with αP_{mpp}, continuously. If it gets lower than αP_{mpp}, GMPPT subroutine is triggered and GMPPT

Table.1

Power (W)		PSC detection (1~0)		Status	
1st sample	2nd sample	Conv.	Proposed	Conv.	Proposed
250	225	1	0	Fail	Success
130	120	0	1	Fail	Success



(a) dP/P based algorithm [2]



(b) Proposed ΔP based algorithm

Fig.3 Algorithm implementation in PSIM

calculates the number of peaks and locates the GMPP. The proposed algorithm uses that peak count to distinguish global shading from partial shading. If GMPPT does not identify another peak, it reflects that insolation has reduced without PSC and the latest P_{sense} need to be stored in P_{max} to account for the global shading. A comparison of dP/P algorithm and proposed one is shown in Table 1.

3. System configuration and Simulation

The existing dP/P PSC algorithm [2] and proposed algorithm are developed in PSIM as Fig.3(a) and Fig.3(b), respectively. The overall system is configured as shown in Fig.4. Two BP MSX 120 panels are serially connected as an array. P1 and P2 are the maximum obtainable power of each panels and Pm is the summation of the two values. The current output power is calculated as the product of PV array voltage and current and is assigned to P_{sense}. The shading patterns are applied using insolation input of a PV panel and other panel has constant shading of 1000W/m^2. P&O algorithm with 0.004 ΔD is used as an MPPT algorithm.

The system is simulated both in smooth and rapid shading insolation patterns. 12 Hz saw tooth and sinusoidal wave forms are used to imitate the smoothly varying insolation and square wave form with same frequency is used for rapid changing insolation. In the first test, insolation is varied in the range of 1000W/m^2 to 300 W/m^2 and observed the detection of PSC. In the second test, insolation is varied in the range of 1000W/m^2 to 500 W/m^2. Simulation results are shown in Fig.5. According to the simulation Fig.5(a), dP/P based algorithm fails to detect smooth insolation changes. In a sharp change in insolation as shown in Fig.5. (b), conventional algorithms detect PSC and call GMPPT. However, it decides the last operated peak as the highest power peak. It causes to reduce the overall system efficiency and stability of the local MPPT algorithm. The proposed algorithm successfully functioned under this condition.

4. Conclusion

In this paper, a new PSC detection algorithm is proposed.

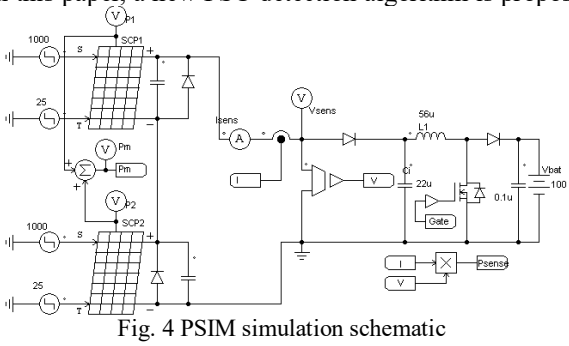
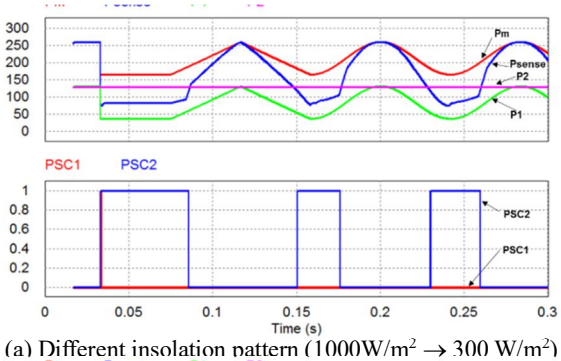
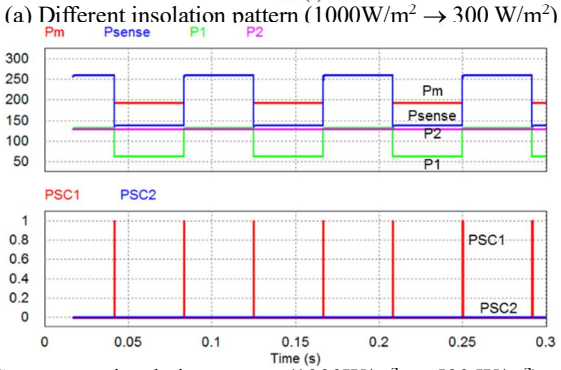


Fig. 4 PSIM simulation schematic



(a) Different insolation pattern (1000W/m^2 → 300 W/m^2)



(b) Square type insolation pattern (1000W/m^2 → 500 W/m^2)

Fig. 5 Different insolation pattern and PSC detection

To improve the efficiency of PV array under PSC, GMPPT is essential, but when the GMPPT activates, it reduces the system efficiency. Thus, the PSC detection is required to manage the activation of GMPPT. According to this study, when the current operating peak become lower than other peaks, PSC detection is needed. It is used to avoid improper GMPPT calling and distinguish the PSC from global insolation change. In subsequent work, the algorithm should be tested and improved for large scale PV array with complex shading patterns.

Acknowledgment

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government(MSIP) (No. 2017R1A2B4005488).

Reference

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[2] J. Ahmed and Z. Salam, "An Accurate Method for MPPT to Detect the Partial Shading Occurrence in PV System," *IEEE Transactions on Industrial Informatics*, DOI: 10.1109/TII.2017.2703079.