Photovoltaic System Reconfiguration strategy for mismatch condition

1st Dafang Zhao
dept. name of organization (of Aff.)
name of organization (of Aff.)

2nd Given Name Surname
dept. name of organization (of Aff.)
name of organization (of Aff.)

3rd Given Name Surname
dept. name of organization (of Aff.)
name of organization (of Aff.)

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I. Introduction

As the world of fossil energy constantly exhausted and the increasingly serious environmental pollution, the research and utilization of renewable energy and green energy have become maintain necessary means of survival and development of the human. Photovoltaic (PV) energy received significant attention since it has unlimited energy and easy to be scaled up. Thanks to extensive technology and research on photovoltaic energy generation, large scale photovoltaic energy generation system have been deployed into many practical application. But due to PV arrays are senstive to shading and PV cell's fault or aging. That means when interconnection of PV cells or modules do no have identical properties or experience different conditions from one another. PV arrays are in mismatch condition. In order to avoid mismatch condition damage PV cells, we proposed an algorithm that can re-configurate photovoltaic arrays to minimize mismatch loss.

In this paper, we using non-uniform irradiance levels to represent mismatch condition and analyzes the efficiency of a PV system under different shaded working condition is presented. When photovoltaic arrays operating in non-uniform irradiance levels may present multiple local maximum power points (MPPs) [1], which been generated by turning on bypass diodes. By changing electrical connection among the panels to prevent activate bypass diodes is a recent appealing solution [2].

The main difficulty facing the reconfiguration problem is that some or even all panels can be subjected to partial shading, so there may be more than one MPP for each panel. Reconfiguration strategy need also consider to group PV modules which provided high power separately [3] [4].

This procedure enables to detect panel's operating conditions, in more than two-strings, receiving different irradiance levels. The reconfiguration algorithm will analyzes panels' working conditions and reorganizes panels into different strings by different irradiance levels. However, in sparse of mismatching conditions, distribution of panels among different irradiance levels are not significant. For that, by increasing number of strings in the PV array and using exhaustive search can be a solution [3].Another approach to optimize photovoltaic arrays is using genetic algorithm [5]. However, computing cost is too significant, and this algorithm can't detect best configuration precisely.

II. Assumption of a PV array

In this paper, we using following definitions of PV arrays, modules, strings and panels. A PV array formed by several parallel connected PV strings, and string is several series connected PV panels. For a PV panel, formed by two or three PV modules connected in series with bypass diodes. An equivalent connection as showed in Fig. 1.

Fig. 1. Definition of PV array and internal components.

The algorithm we proposed based on following assumptions.

- The current versus voltage (*I-V*) curve of each panel calculated by algorithm presented in [6]. This algorithm will analyzes panel's *I-V* curve sample and coordinate to maximum or minimum power point in *P-V* curve.

- All the panels in PV array have same number (*N*) of modules. For particular module, using (V_{mppn}, I_{mppn}) to identify MPP voltage and current by index *n*. Those parameter can be directly estimated by the prosess provided in [7].

Furthermore, it is also assumed that for each string it has same number of panels in PV array. Means every string in PV array have same length. String's length are identical based on when they connected in parallel, a string has more panels may cause current back flow into other strings which have less panels [8].

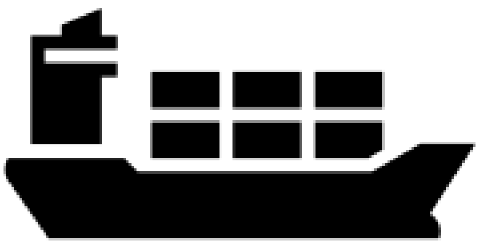

Fig. 2. Flowchart of reconfiguration algorithm.

III. Reconfiguration Algorithm

The general steps of reconfiguration algorithm are presented in Fig.2. The first step is determine each PV module's V_{mpp} and I_{mpp} by using algorithm provided in [7] [9], and calculate MPP current and voltage candidates of PV array. Afterward, determine real number of working modules Q_{MN} per string by applying method in [10]. Next, find MPP candidates by multiplying current candidates and voltage candidates which determine by Q_{MN}. Due to $V_{mpp}s$ and $I_{mpp}s$ can indicate shadowing distribution among PV array. Then grouping panels into different shadow levels. Then grouping panels by different irradiance levels.

After this procedures is conducted for PV array, all panels will be sorted into many groups that from un-shadowed to fully shadowed group. However, if just simply grouping panels by shadow conditions it may cause electrical connection overhead or unable calculate optimal configuration. To further reconfigure PV system into a better configuration, the algorithm will proceed as follow:

- Sorting group by different irradiance levels, select panels from first group into a PV string which working on high current level.
- If selected panels' working modules (Q^{*}_{MN}) less than Q_{MN} , select panels from next irradiance level group.
- If selected panels' Q^{*}_{MN} more than Q_{MN}, re-select panels to adjust Q^{*}_{MN} equal to Q_{MN} if it is possible.

When there are more than two panels connected in series, for a string MPPs is not straightforward. The MPP current and voltage candidates can be evaluated though a procedure presented in [10]

References

[1] Koutroulis, Eftichios, and Frede Blaabjerg. "A new technique for tracking the global maximum power point of PV arrays operating under partial-shading conditions." IEEE Journal of Photovoltaics 2.2 (2012): 184-190.

[2] La Manna, Damiano, et al. "Reconfigurable electrical interconnection strategies for photovoltaic arrays: A review." Renewable and Sustainable Energy Reviews 33 (2014): 412-426.

[3] Storey, Jonathan, Peter R. Wilson, and Darren Bagnall. "The optimized-string dynamic photovoltaic array." IEEE Transactions on Power Electronics 29.4 (2014): 1768-1776.

[4] Storey, Jonathan P., Peter R. Wilson, and Darren Bagnall. "Improved optimization strategy for irradiance equalization in dynamic photovoltaic arrays." IEEE transactions on power electronics 28.6 (2013): 2946-2956.

[5] P. Carotenuto, A. D. Cioppa, A. Marcelli, and G. Spagnuolo, An evolutionary approach to the dynamical reconfiguration of photovoltaic fields, Neurocomputing, vol. 170, pp. 393405, 2015.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7] Orozco-Gutierrez, M. L., et al. "Fast estimation of MPPs in mismatched PV arrays based on lossless model." Clean Electrical Power (ICCEP), 2015 International Conference on. IEEE, 2015.

[8] Spagnuolo, Giovanni, et al. "Control of photovoltaic arrays: Dynamical reconfiguration for fighting mismatched conditions and meeting load requests." IEEE Industrial Electronics Magazine 9.1 (2015): 62-76.

[9] Carotenuto, Pietro Luigi, et al. "Online recording a PV module fingerprint." IEEE Journal of Photovoltaics 4.2 (2014): 659-668.

[10] Orozco-Gutierrez, M. L., et al. "Optimized configuration of mismatched photovoltaic arrays." IEEE J. Photovolt 6.5 (2016): 1210-1220.