

Photovoltaic System Reconfiguration strategy for mismatch condition

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Abstract—This document is a model and instructions for L^AT_EX. This and the IEEEtran.cls file define the components of your paper [title, text, heads, etc.]. *CRITICAL: Do Not Use Symbols, Special Characters, Footnotes, or Math in Paper Title or Abstract.

Index Terms—component, formatting, style, styling, insert

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 sensitive to shading and PV cell's fault or aging. That means when interconnection of PV cells or modules do not 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-configure 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 process 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. 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]. For string MPP current candidates, I_{mppn} values different less than 5% are assumed to be equal. For string MPP voltage candidates, V_{mppn} can be calculated though multiply number of active modules (N_a) by average MPP voltages (V_{mpp}) with $\pm 18\%$ error [10]. 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 distribution.

After this procedures is conducted for PV array, all panels will be organized into many groups that from un-shadowed or uniform shadow to fully shadowed group. However, if just simply grouping panels by shadow distribution conditions it

may cause electrical connection overhead or unable calculate optimal configuration. To further reconfigure PV system into a better configuration, the replacement part of algorithm will proceed as follow:

- Sorting group by different shadow distribution conditions, 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.



Fig. 3. Flowchart of reconfiguration algorithm.

This algorithm will better understood by applying to shadow condition showed in Fig. 3. This PV system is composed with 9 PV panels connected into 3 strings as showed in Fig.3. Irradiance levels, I_{mpp} and V_{mpp} of each module are given in Table I

TABLE I
TABLE TYPE STYLES

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^aSample of a Table footnote.

The example refer to a three-strings PV array, each string contain with 3 panels, each one made of three identical PV modules ($N=3$). In this example, it is assumed that input range of DC-DC converter and MPPT device defined by $V_{min} = 200V$ and $V_{max} = 500V$. MPP current candidates and MPP voltage candidates are present in (1) and (2), respectively. Additional, number of real working module at MPP current

candidates are given in (3).

$$I_{mppn} = [\{0.5_{(9)}, 0.5_{(9)}, 0.5_{(9)}\}, \{0.5_{(9)}, 0.5_{(9)}, 2_{(11)}\}, \{0.5_{(9)}, 0.5_{(9)}, 3_{(4)}\}, \{0.5_{(9)}, 2_{(11)}, 2_{(11)}\}, \{0.5_{(9)}, 2_{(11)}, 3_{(4)}\}, \{0.5_{(9)}, 3_{(4)}, 3_{(4)}\}, \{2_{(11)}, 2_{(11)}, 2_{(11)}\}, \{2_{(11)}, 2_{(11)}, 3_{(4)}\}, \{2_{(11)}, 3_{(4)}, 3_{(4)}\}, \{3_{(4)}, 3_{(4)}, 3_{(4)}\}] \pm 5\% \quad (1)$$

$$V_{mppn} = [12, 4, 24.8, 37.2, 49.6, 62.0, 74.4, 86.8, 99.2, 111.6] \pm 18\% \quad (2)$$

$$Q_{Mn} = [\{8, 8, 8\}, \{8, 8, 8\}, \{4, 4, 4\}, \{7, 7, 7\}, \{4, 4, 4\}, \{2, 2, 2\}, \{5, 5, 5\}, \{4, 4, 4\}, \{2, 2, 2\}, \{1, 1, 1\}] \quad (3)$$



Fig. 4. Flowchart of reconfiguration algorithm.

Due to 5% error of MPP current candidates and 18% error of MPP voltage candidates, total error rate of MPP candidates is 23%. Though procedure of algorithm, MPP candidates with 23% are: $\{0.5, 0.5, 2\}$, $\{0.5, 2, 2\}$, $\{2, 2, 2\}$, $\{2, 2, 3\}$ and require working modules per strings are: $\{8, 8, 8\}$, $\{7, 7, 7\}$, $\{5, 5, 5\}$, $\{4, 4, 4\}$. And PV array are organized as Fig 4 Those MPP candidates are able to generate maximum output power of PV system, but the configurations of MPP candidates may meet electrical connection overhead. In order to reduce electrical connection simulation time, replacement and feasibility check will be approved.

Consider fourth MPP candidate, it require panels on string one working at 2A, panels on string two working at 2A, panels on string three working at 3A and require 4 PV modules working for each string. Firstly, selecting panels for high current string, string three. According to Table I, only panel 2, panel 7 and panel 9 are able to work at 3A. Those four panel can provide 4 PV module working at 3A and meet requirement of Q_{Mn} . Because on extra panel can provide module working on 3A, no replacement will be approved. Means no further improvement for configuration of string three. Then select panel for string two, panel 4 and panel 8 will be selected, but

this configuration is not optimized. Selected panels provide 5 modules able to work at 2A, satisfy requirement of $Q_{Mn} \geq 4$, but one module more than requirement. The process will replace panel 4 by panel 1 that provide just 4 modules working at 2A. Configuration for string two are panel 8 and pane 1. At last, select panels for string one.

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Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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An excellent style manual for science writers is [7].

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TABLE II
TABLE TYPE STYLES

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Fig. 5. Example of a figure caption.

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ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

REFERENCES

Please number citations consecutively within brackets . The sentence punctuation follows the bracket. Refer simply to the reference number, as in [3]—do not use “Ref. [3]” or “reference [3]” except at the beginning of a sentence: “Reference [3] was the first ...”

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For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

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