Efficient Feasibility Checking Algorithm of Photovoltaic Array Reconfiguration

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***Abstract*—Power generation efficiency of photovoltaic (PV) systems is significantly affected buy partial shading and PV cell damage. Partial shading or PV cell damage induces mismatched power generation among PV panels. Conducted bypass diodes under mismatch conditions result in loss of efficiency in power generation. Mismatched PV array can be recovered by re-configuring electrical connections among PV panels in it. In this paper, a feasibility check problem of PV panel reconfiguration is introduced. This problem identifies whether a connection among PV panels can be configured from a given PV module level solution. Proposed algorithm evaluated by comparison with the exhaustive search through random shading distributed PV array. The experimental results demonstrate that proposed algorithm can identify feasible configurations more than 49,000 times faster than the exhaustive search with around 0.5% errors.**

***Index Terms*—PV reconfiguration, partial-shading, mismatch, feasibility, heuristic**

I. Introduction

In recent years, the use of green and renewable energy sources has been increased with the aim to reduce fossil fuel depletion and environment pollution. Photovoltaic (PV) energy is one of the most promising emerging technologies. PV market growth by improvements of converting unlimited solar energy into electrical energy as well as the cost reductions of PV panels.

The use of PV systems for power generation brings many challenges. Due to the nature of PV cell, which is the basic component of PV array. PV system easily suffers from various forms of system faults, which include physical damage, temperature in-homogeneity, or partial shading. Unlike cell damage or other system faults, partial shading sources from cloud, dust or snow are very hard to prevent and predict. Thus, when PV cell could not uniformly generate power when they experience different irradiance or been damaged. This unbalanced working scenario will lead whole system mismatch. Mismatch condition might accelerate heating or aging of PV cells and furthermore hinder operation of maximum power point tracking (MPPT) algorithm, especially when the PV array output P-V curve becomes non-convex [1].

For several series connected PV cells, shaded or damaged cell causing normal cells to produce higher voltages that may reverse bias of "bad" cells. When a large number of series connected cells cause a huge reverse bias across shaded cells, leading to large dissipation of energy in the "bad" cells. This huge energy dissipation occurring in a small area might get overheating or burning of PV cells, or "hot-spots". To protect PV cells from "hot-spots", bypass diode is used to circumvent concentrated energy dissipation. However, the operation of bypass diode will cause several stop delivering power and generate multiple local maximum power points [2] or the total PV module current are limited by the one of worst "bad" cell. In both situation, available energy is lost. Furthermore, strand bypass diode can not complete eliminate hot-spotting [3].

In order to improve PV system power generation efficiency and protect PV cells from damage, an efficient and effectively PV system manage method is worth to investigate. The key to improve power generation efficiency is to maintain maximum output power. Thus, different maximum power point tracking (MPPT) algorithms have been proposed in this regard. In different MPPT algorithms, P&O [4]–[7]and hill climbing [8]–[10] methods received many attention due to its low complexity and implement cost. Hill climbing and P&O methods are different ways to implement the same fundamental method. Using the approximate linear relationship between V_{OC},I_{SC} and V_{MPP}, I_{MPP}, fractional voltage-based and current-based MPPT are popular due to their linear dependency of PV panel characteristic and irradiance level [11]–[15]. However, under abnormal working condition such as partial shading, it is very hard for conventional MPPT algorithms to find global maximum power point. Meanwhile, without any PV module level improvement, it is impossible to protect PV panel against hot-spotting [16], [17].

Another attractive direction to improve PV system efficiency under different working condition is the reconfiguration of PV arrays. This concept was first proposed by Salameh et $al.$ [18] in 1990. Then in 2002, Sherif and Boutros et $al.$ proposed a reconfigurable scheme for PV arrays that using transistors as switch network to improve performance [19]. Nguyen et $al.$ proposed a method that divide PV array into two parts as the "fixed" part which is static connected PV modules and "adaptive" part that can be attached to "fixed" part with different configurations [20].

In this type of "fixed" - "adaptive" architecture, the mathematical formulation is not clear. Moreover, if the partial shading part is large enough to cover "adaptive" part, this scheme become ineffective.

II. Conclusion

The conclusion goes here.

Appendix A
Proof of the First Zonklar Equation

Appendix one text goes here.

Appendix B

Appendix two text goes here.

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TEMP

It is well known that mismatch due to partial shading, soiling, or ageing causes significant losses in the energy yield of photovoltaic (PV) systems [1,2]. Furthermore, mismatches may hinder operation of maximum power point (MPP) tracking algorithms, especially if the power versus output voltage characteristic becomes nonconvex [3]. It has also been shown that, even with commonly used bypass diodes, mismatched cells may become reverse-biased and dissipate power, producing an undesired cell temperature rise or hot spot [4,5]. This may lead to accelerated ageing and reduced reliability of the PV system

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