PERFORMANCE ANALYSIS OF THE PV MODULE MITIGATION METHOD AFFECTED BY HOTSPOT CONDITION

Mohd Munif Rosli[1], Mohd Shawal Jadin[2], Mahfuzah Mustafa[2], Norizam Sulaiman[2], Mohd Shafie Bakar[2]

[1]*College of Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang*
[2]*Faculty of Electrical & Electronics Engineering Technology, Universiti Malaysia Pahang, 26600 Pekan, Pahang*
**mohdshawal@ump.edu.my*

Keywords: MITIGATION METHOD, FUZZY LOGIC CONTROLLER (FLC), PARTIAL SHADING, BYPASS DIODE, PV MODULE

Abstract

This paper presents the study analyses numerous mismatch mitigation techniques for the PV modules when affected by partial shading and hotspot condition. This evaluation serves as a guide for selecting appropriate techniques based on the associated needs and applications. Three types of mismatch mitigation techniques for PV modules were discussed. Benchmarking results show that power electronic-based (DC-DC Boost Converter) techniques are used to get the most power out of the system and to lessen the mismatch effect, but these techniques are a little more complicated to use and cost a lot and less effective in term of the waveform for current and voltage. A Fuzzy Logic Controller with DC-DC Boost Converter implementation was proposed as a solution to this problem. It was discovered that FLC with DC-DC Boost Converter retrieves more power than the other methods when the shading conditions are the same. Additionally, it is more dominant in terms of the waveform, where the performance of this method is 97.50%, which is an increase of 3.75% from the performance performed by the MPPT DC-DC Boost Converter. It also demonstrated that the MPPT based on FLC is robust, fast, and simple to implement.

1 Introduction

Photovoltaic (PV) systems have already proven to be a viable option in the energy sector. The rate of expansion of solar installations has remained consistent and continues to expand [1]. However, there are some severe concerns with the usage of solar energy, and PV reliability analysis has become crucial in understanding the main causes of PV deterioration, failure, and mismatch circumstances. Cloud movement, continual shade, and dust particles all contribute to partial shading circumstances. This worry is regarded as a significant contributor to solar module output power production performance, as well as generating an uneven increase in cell temperature, resulting in a phenomenon known as PV hotspots [2]. Hotspots are a problem in PV panels where an unmatched cell rapidly heats up and lowers the output power performance of the PV panel. PV hotspots occur when a cell or group of cells operate in reverse bias, wasting energy rather than supplying it and so functioning at abnormally high temperatures, as illustrated in Fig. 1. Due to the high temperature generated by hotspots, the cell encapsulation can be damaged, resulting in a second breakdown, both of which cause permanent damage to the PV panel [3].

It should be noted that the hot-spotting phenomenon is caused by more than only partial shadowing, mismatching circumstances, and age. However, because PV modules are susceptible to microcracks, snail trail pollution, internal corrosion, and delamination, these problems significantly enhance the likelihood of the presence of hotspots. Adopting a conventional bypass diode circuit is common practice for mitigating this phenomenon, but this method does not guarantee a reduction in the temperature of hot-spotted solar cells. [4].

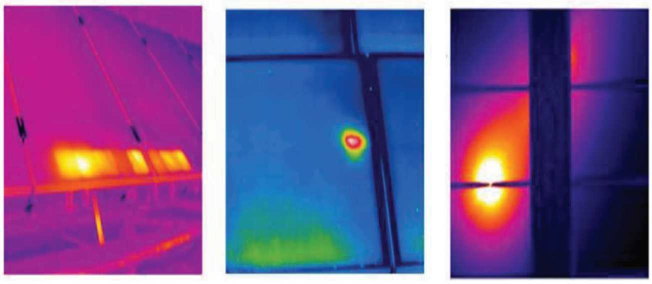

Fig. 1 Presence of Hotspots on PV Module

Therefore, this research will examine the numerous techniques presented to overcome the conventional approach to establish the most effective mitigation techniques [4]. Many factors contribute to the reduced output power of PV modules, but mismatch effects and shadows are perhaps the most important. The cells in a PV module that is partially shaded can have mismatches, which can lower power, mismatch loss, and hotspots if this occurs for a long time, it can lead to physical damage to the module. To reduce the effect of mismatching, bypass diodes are commonly used in practice that why most manufacturers include one or more bypass diodes on commercial PV panels to avoid shadowing problems. A bypass diode is linked antiparallel to a series of solar cells. As