Energy Enhancement of aged photovoltaic Array under Hotspot Conditions: A comparison of Different Interconnection Topologies

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***Abstract*— Aged photovoltaic panels commonly have hotspots, which can result in large power losses. In this study, hotspot creation in solar panels is investigated and the reasons for it are identified and outlines many methods for preventing the establishment of pre-hotspots and investigates the findings of experimental research. The power output, voltage, current, irradiance, and loss percentage for five configurations of solar array designs have been investigated in this work using a 4×4 array consisting of 16 PV modules that are 4 years old. Experimentally it can be possible to recover the output power by changing interconnections such as SP, TCT, LD, BL, and HC. The output demonstrates that the loss of SP, TCT, LD, BL, and HC was 8.81%, 4.06%, 0.06%, 5.37%, and 3.13% respectively. 4.286% is the average loss percentage for all five configurations. The recoverable power of the TCT, LD, BL, and HC concerning SP was 5.21%, 9.73%, 3.77%, and 6.24% respectively. The findings demonstrate the LD configuration has the lowest percentage of power loss, and the maximum loss has been obtained by the SP configuration.**

Keywords—Solar module, hotspot, aging conditions, loss mitigation, interconnection topologies, recoverable energy

I. INTRODUCTION

Solar energy is one potential renewable energy source that could reduce reliance on fossil fuels. Photovoltaic (PV) systems have evolved into a cost-effective and environmentally beneficial method of producing renewable energy. However, a PV system might overheat due to aging, cracks, and hotspots [1]. It has been found in Islamabad that 20% of flaws caused by the environment on a 1 MW photovoltaic system diminish the power production by 306.08 MWh per year [2]. In the work [3], the performance of PV array has been investigated in outdoor conditions in India for the silicon cell, heterojunction cell, and multi-crystalline silicon cell. For these three modules, the average deterioration rates (Isc, Voc, and PMP) are determined to be 1.24, 0.14, and 1.50 percent per year respectively. The hotspot is one of many degradation factors that can mostly affect the characteristics and efficiency of PV modules. Hotspots are responsible for almost half of the entire defects in PV systems [4]. Open eyes can detect hotspots but it will take longer lime For example, the current hotspot identification methods take up to 210 days for a 30 MW plant generating from 126000 panels containing a large number of cells [5]. Thermal imaging can be used to reduce the time. The cell efficiency falls to a very low level, less than 3%, and then gradually declines as the temperature continues to rise rapidly over 700C. [6]. The relation between hotspot temperature and solar PV cell efficiency is illustrated in the following Figure 1.

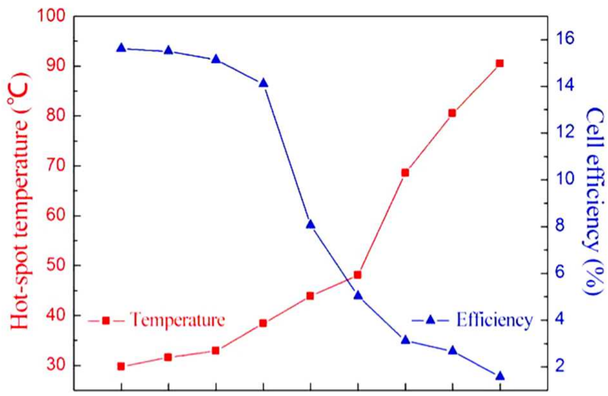

Fig. 1. Relation between hotspot temperature and PV cell efficiency [7]

Hotspots can be caused by growing series resistance and a low current flowing through the solar cells. For microcracks, there was initially little power loss. Additionally, a hotspot with a high rate of power loss can be partially produced by this microcrack [8]. The thermal and visible light images are presented in Fig. 3. The module illustrates the hotspot and the corresponding level of temperature range from lower to higher. With temperatures of thirty-two degrees Celsius for a good part of a module and 38.2.0°C for a worm location which are are noted in the research work [9]. The fundamental source of hotspots is a change in the solar and ambient temperatures that affect the PV modules. They might also come about as a result of the cells being darker [10]. Bird droppings, accumulated leaves, and dust can all cause cells to become less active and hinder the flow of current created by nearby cells, which can result in this shade. The solar module becomes hotter due to this shading effect and can cause hotspots which is very alarming for the lifetime reduction of solar modules and can cause significant degradation over time [11]. Another study