Review on Analysis of the Shadow Effect on the Power Output Characteristics of Solar Cell, Solar Panel and Small-scale Solar System

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Abstract - The analysis of shadow plays a vital role during installation of the photovoltaic system, as it affects technical as well as economical performance of the system. Till date researchers have studied and analysed the factors that affect shadow such as latitude of the installing location, nearby buildings, effect due to trees and passing of clouds etc. A detailed review of papers dealing with types of shadows such as uniform and non-uniform, affecting photovoltaic cell, panel and system efficiency has been done. Many researches to studied different methods to overcome shadow effects on power output parameters, also analysis of power output characteristics between short circuit current (Isc) verses open circuit voltage(Voc) and Output power verses open circuit voltage. In this paper the attempt has been made to study and review the recent shadowing effect on performance characteristics like power output, fill factor and efficiency of solar cell, solar panel and solar system.

Keywords— Photovoltaic System, Power output parameters, Shadowing effects, Power output Characteristics

I. INTRODUCTION

Energy demand in the globe is increasing day by day. This demand cannot be met only by the conventional sources. As a result, several alternative energy sources are being explored. Solar energy is one such promising source which has great potential to meet the growing need. Photo Voltaic (PV) technology is commonly used to generate electricity using sun's energy [4]. Photovoltaic systems are becoming popular both in the residential and industrial sector. However, the output current of a solar system depends on the incident irradiation level. If within a solar array the irradiation level is not homogenous, this can lead to a fault called shadowing effect [1].

The fill factor of a Photovoltaic panel is a most important performance indicator. Although physically unrealizable, an ideal PV panel technology would produce a perfectly rectangular I-V curve in which the maximum power point coincided with (I*sc*, V*oc*). A solar cell produces about 0.5 V only and by connecting in series inside the panel, a more useful voltage can be achieved. Most solar panels are rated at 12V although higher voltage panels are also available. The problem gets more complex, when the array receives non-uniform shading [8].

II. SHADOW EFFECTS OF SOLAR CELL, SOLAR PANEL, SOLAR SYSTEM

A. Classification of Shadow effect

There are two types of shadowing phenomena like the uniform (partial) and non-uniform (non-partial) in PV system, and they can be divided into the following categories after longtime surveys and observation on one large ground-based grid-connected PV system [13].

1. shading phenomenon in front row
2. shading phenomenon in surrounding plant and guano
3. shading phenomenon nearby power distribution room and wire poles.

B. Shadow effect on solar cell

Chikate (2015) have studied on the influences of temperature irradiance variations on the different solar cell parameters. The efficiency of solar module was directly related with the solar parameters. So, solar parameter changes and affects the efficiency of solar cell [5]. Sai et al (2015) have studied of variation of different electrical properties with irradiance becomes necessary to estimate the conversion efficiency of solar cell. A numerical model is developed to study the effects of solar irradiation under the non-uniform conditions [9]. Ekpenyong et al (2013)

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have explained a detailed analysis of different shadow effect on solar cell and solar panel. The investigated efficiency and robustness enhancement methods of the photovoltaic system under partial shading [12]. Ghitals (2006) have experimentally investigated shadowing location and percentage on the solar cell surface and observed the behavior of the solar cell characteristics with an edge and central shadowing the edges of the solar cell with the total covering the area and vice versa in case of current density. They identify that central and edge shading occurs negative effect on the solar cell efficiency [19].

C. Shadow effect on solar panel

Veerapen (2016) have analyzed shadowing effect on a panel parameter used bypass diode are used across every 10 cells in the solar panel and explained that when irradiance level is changed, percentage increase in maximum power point(MPP) is almost equal to percentage increase in incident irradiance level on the solar panel. [1]

Graphs of power against Voltage under shadowing effect with and without bypass diode.

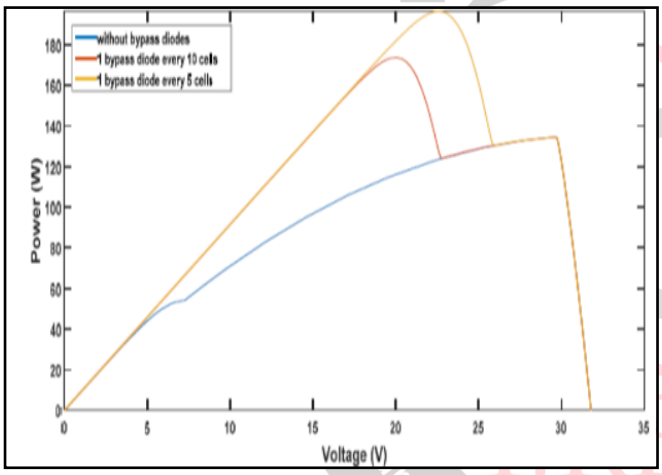

Figure.1. Output power against voltage for 1 panel with shadowing effect. The irradiance level of 1 cell is set at 0.5 kW.m^2 and the irradiance of the other cells is set at 1 kW.m^2. Temperature is kept constant at 250C [1].

Torres et al (2016) analyzed the effects of partial shading of solar cell strings and temperature on the performance of various PV modules [2]. Boukebbous et al (2015) studied the behavior of the photovoltaic panels in a uniform and non-uniform illumination conditions on the module surface. The Photovoltaic panels were simulated under MATLAB or Simulink environment toward discussing and compare the external power output characteristics in the different studied situations [4]. Sathyanarayana et al (2015) systematically studied the effect of shading on the power output, fill factor and Efficiency of the solar panel. The direct correlation is found between Solar cell, solar irradiation under uniform shading condition and observed non-uniform shading

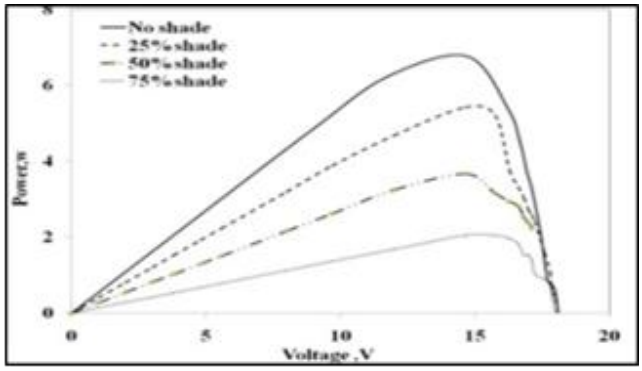

Figure.2. P-V Characteristics of the module under uniform shading [8].

condition yielded a variety of performance behavior comparison between both shading condition should be avoided for better performance of solar panels [8].

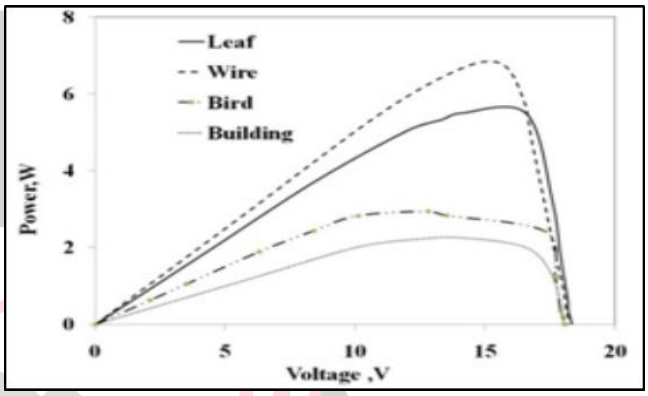

Figure.3. P-V characteristics of the module under non-uniform shading [8].

Pandit *et al* (2014) have studied experimentally to provides the effect of shading on the photovoltaic panel and to enhance the power of series and parallel connection of solar panel under shading condition to used bypass diode. They evacuated the higher power of photovoltaic panel under the shading condition 1 solar cell of 1 solar cell, 2 solar cell, 4 solar cell, 9 solar cell and full covered panel, these all panel or cells. Results indicated that the power improves approximately between 20-30% of solar system under shading condition [11]. Sarkar *et al* (2014) have analyzed the shading on the solar panel which is caused by steady clouds. They used image processing techniques to get the diode to bypass area on the photovoltaic panel to increase the efficiency of a solar panel by a significant amount [10]. Silvestre *et al* (2009) presented application examples of the simulation methodology, showing its potential on the design of bypass diodes configuration to include in a PV module and also on the study of PV generators working in partial shading conditions [16].

D. Shadow effect on solar System

Nagaraja et al (2016) have developed MATLAB-programmed model for the I-V and P-V characteristics of PV array under non-uniform insolation caused by both partially and completely shaded modules. Developed model and experimental results show that, under the non-uniform insolation condition, the output power of a PV array get

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reduced and output PV curve become more complex with multiple peaks [3]. Xueye et al (2015) studied the output characteristics of the photovoltaic array and was related to the topology of the array, shadow distribution, and illumination level [6]. Sun et al (2013) described shading phenomena a grid-connected Photovoltaic system in Northwest China. They analyzed through I-V curve test of photovoltaic panels it can be seen that dust influences system performance of the grid-connected photovoltaic system [13]. Gao et al (2009) have described a portable solar PV system that effectively eliminates aforementioned problems. This system is capable of simultaneously maximizing the power generated by every PV cell in the PV panel. Study results demonstrate that, under complex irradiance conditions, the power generated by the new configuration is approximately twice that of the traditional configuration [15]. Sera et al (2008) studied clearly, the different types of mechanism of uniform photovoltaic shading on a number of photovoltaic panels connected in parallel or series with and without bypass diodes. This analysis is presented in simple terms and can be useful to someone who wishes to determine the impact of some shading geometry on a PV system [17]. Nguyen et al (2007) proposed a method to accurately predict the maximum output power of the solar photovoltaic arrays under the shadow conditions by using neural network, a combined method using the multilayer perceptron's feedforward network and the back-propagation algorithm [18].

III. Discussion

From the above literature, it has been observed that,

Photovoltaic power plant system is the standalone system to produce electric power. The performance of photovoltaic system strongly depends upon operating temperature, solar irradiations, shadowing effects. Many researchers have been considered two types of shadow effect, uniform and non-uniform shadow is caused bypassed poles, clouds, building models, trees. This effect on the stabilized system to reduce output power parameter (i.e. voltage, current, fill factor, efficiency) and also affected on output power characteristics. Then power reduced by 70-80% of total power generation in just 30-40% of the shaded portion of the solar photovoltaic system. The total power system is disturbed due to shadow effect.

Many researchers have been studied to reduce the effect of shadow on a photovoltaic system. Then used to some techniques like bypass diode system and change array configuration. The bypass diode system to minimize shadow effect on the photovoltaic system. Increase power generation capacity, it is neglected portion of shaded cell and panel on the photovoltaic system and improves system power. Bypass diode system to improve 25-40 percentages of power in shadowing condition, also to maintain power factor and efficiency of the photovoltaic power plant.

Nowadays, the demand of electricity of society is increasing rapidly. The study shows that the system gives good performance under the partial and non-partial shading condition by using bypass diode, to improve 25-30% performance of the solar system under shading condition.

IV. Conclusion

This review of the paper, researchers have studied and analysed the factors that affect shadow such as latitude of the installing location, nearby buildings, the effect due to trees and passing of clouds etc. A detailed review of papers dealing with types of shadows such as uniform and non-uniform, affecting the photovoltaic cell, panel and system. Many researchers considered the 25%, 50%, 75%, 100% shaded portion in the uniform shadow effect. As extension to the shadow effect, the considered 5%, 10%, 15%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100% of shaded portion for proper analysis.

Many researchers have studied different methods to overcome shadow effects on power output parameters (i.e. current, voltage, fill factor, efficiency), also analysis of power output characteristics between short-circuit current (Isc) versus open circuit voltage(Voc) and Output power versus open circuit voltage. So, still there is opportunity to study theoretically and experimentally performance for improving output power of the photovoltaic system.

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