Modified PV Panel Design Configurations for Enhancement of Panel Efficiency

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***Abstract*—This research work discusses the application of concept of the light reflection methodology to generate cost-effective extreme power generation under optimum photo voltaic (PV) panel space constraints. Multiple light reflector materials are arranged so that multiple input solar light intensities are initiated on the solar PV panel along with direct solar light intensity. Because of the multiple input light intensity reflections on the PV panel, substantial load current generation ensues, which was a key drawback of commercial PV panels. Also, this key action of multiple light input reflections on the PV panels enables the replacement of the application of large size of PV panels for adequate load current generation. This in turn offers enhanced panel efficiency in optimal space constraints results in the socio-economic benefit operation. Mirrors and aluminum foil are utilized as light reflecting materials due to their effective reflective coefficients. Therefore, multiple experimental investigations are carried out on minimum size of PV panels to verify the effective light reflection methodology and presented in this work. From the experimental investigations, a panel efficiency of 143.44% was noticed in optimal space constraints, which was the astonishing performance obtained using the concept of light reflection methodology**

Keywords— Photovoltaic panel, light reflector, light source, Instantaneous light, Solar tower.

I. INTRODUCTION

The application of electrical power energy becomes increased abundantly in recent years due to digitalization, industrialization etc. modifications. The electrical power utility applications are expanded vastly in recent years due to multiple sophisticated inventions. While, the key climatical changes in surrounding atmosphere advise to switch on the application of the non-vulnerable energy dependent power generation. There are multiple non-vulnerable energy sources such as bio gas, hydal, wind, solar etc., offers socio-economical sustainable energy generation [1] [2] [3] [4].

The photovoltaic based sustainable energy is vivid environment friendly energy sources offers auxiliary power source to the grid connected power system. The major problem associated with this solar photo voltaic (PV) sustainable energy generation is its erratic nature of power generation [5] [6]. Also, this solar photo voltaic (PV) sustainable energy generation was limited to meet the estimated load current need per minimum panel dimensions. However, larger PV panels are necessary to accommodate substantial load current requirements. Larger PV panels renders cost expensive and demand a larger installation space. Although, multiple extreme power extraction schemes (MPPT) are established to conquer this substantial load current demand, but failed to compensate the power demand with minimum cost expenditure in optimal space constraints [7-12]. Meanwhile, few researchers have initiated the concept of light reflection to achieve the extreme power generation under limited light source conditions shown in figure 1 [13] [14] [15]. However, the concept of light reflection scheme observed the efficient scheme compared to other MPPT scheme available elsewhere in the world [16], limited to achieve the opto-economical extreme power generation. Therefore, further research in this light reflection methodology may enables the opto-economical extreme power generation with enhanced panel efficiency. As a part of

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this, authors are attracted towards this light reflection concept and multiple experimental investigations are carried out presented in below sections

Figure 1. PV panel under sunlight reflection

II. CONCEPT OF LIGHT REFLECTION TECHNIQUE

Solar PV cells are the type of p-n junction semiconductor devices works on the principle of photo voltaic effect i.e., incident solar light energy converts in to electricity. Usually, sun light is a mixture of various light intensity rays consists various energy levels. Typically, minimum of 3 eV of photon energy is required to activate the electron in depletion region of the p-n semiconductor device. From sun light intensity, ultra violet light rays only consist this sufficient energy and which are limited in our atmosphere [14]. Therefore, the finest possible way to improve the efficiency of the commercial PV cells is increasing the input light energy. But it is practically impossible to increase the input sun light intensities. Although, it is impossible to increase the sun light intensity, but it is possible design the PV panels with the consideration of arrangements light reflecting materials at appropriate position may offer the multiple sun light reflection along with the usual solar light incidence. Usually, light reflections may be classified in to two types: regular reflections and irregular reflections shown in figure 2 [15] [16]. The present work considered regular type of light reflections due to plane surface nature pf light reflecting materials. In the study, mirrors are arranged at suitable reflecting angles on the top side of the solar PV panels and aluminum foil was employed at bottom side of the PV panels to obtain the power generation at optimal panels space constraints and was described in following sections. However, the application of light reflections using mirrors arrangement was limited due to generation of concentrated heat on the cells, but may be nullified using proper reflecting angle suggestion.

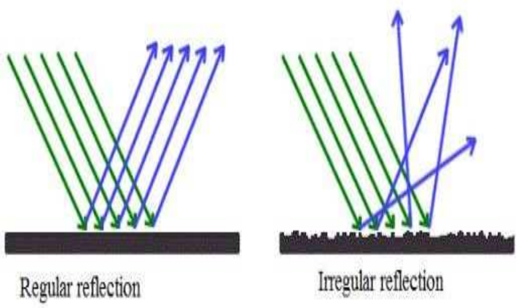

Figure 2. Regular and Irregular surface based light reflections

III. EXPERIMENTAL RESULTS

To evaluate the innovative light source reflection methodology, various experimental investigations are carried out using multiple PV panels. There are four similar small size PV panels rated with 6 volts and 250 mA shown in figure 3 designed on the card board. Also, the design arrangement of four PV panels on card board is shown in figure 4 and figure 5 evidences two panels are arranged at top side and other two are exact back side of the of the card to obtain the effective panels operation with optimal space consideration.

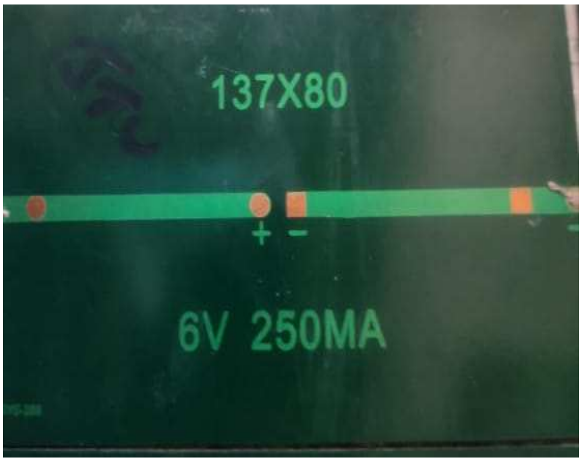

Figure 3. PV panel ratings.

Figure 4. PV panel design arrangement outside.

Figure 5. PV panel design arrangement inside.

A plane aluminum foil reflecting material was arranged inside the card board with suitable size of hole at the center of the top of the card board to access the sun light intensity for inside PV panels.

A. CASE STUDY 1: Without mirrors and with Aluminum foil at inside of the card board

The design arrangements consist two PV panels are at top of the card board and two panels are at exact back side of the top panels with consideration of aluminum foil as reflecting material for inside PV panels. For this design configuration, experimental measurements are carried out under direct sun exposure shown in figure 6 and figure 7.

Figure 6. Top PV panel measurement


Figure 7. Inside PV panel measurement

The experimental measurements are recorded at 6.0 V and 0.213 A per panel for top PV panel. While, inside PV panels measured at 3.8 V and 0.044 A. This exemplifies that, aluminum light reflecting material works efficiently to generate significant amount of power in optimum space constraints i.e., inside panel was designed at back side of the top panel only.

B. CASE STUDY 2: With mirrors and with Aluminum foil at inside of the card board

The experimental investigations are extended to consider the application of mirrors for top of the PV panels. First, one mirror was arranged for multiple tilt angle positions from 10° to 80° to conquer the maximum current drawn from the panel. Mirror tilt angles at 30° and 45° approximately conquers the maximum current generation. Also, the measurements are continued for two mirror design arrangement at same tilt angles and top PV panels are recorded at 6.54 V and 294 mA which was more than the rating of the employed PV panels shown in figure 8.

Figure 8. Top PV panel measurement under two mirror design arrangement


Figure 9. Top PV panel measurement under two mirror design arrangement

It is obvious from the experimental measurements; the proposed concept of light reflection methodology offers intense effect on extreme power generation compared to other MPPT techniques proposed elsewhere in the world. Similarly, enhanced current flow was recorded at 110 mA from 44 mA for inside PV panels design arrangement with another two mirror reflecting material arrangements including aluminum reflecting material shown in figure 9. This in turn suggests that, comprehensive research work for inside PV panel arrangements may anticipates extreme power generation capability. Furthermore, the experimental measurements are extended to test the accuracy of the measurements using the different load connections. There are two standard domestic use motors rated 2.4 Watt to 15 W are connected to validate the measurements which is observed from figure 10.

Figure 10. PV panel measurement with two motor load connection

All these measurements are continued for long time period entails the larger power generation through the load and further improvement in current flow at 0.329 A which was observed in figure 11.

Figure 11. Improved current rating

Therefore, from the various experimental measurements, panel efficiencies are estimated and observed from table 1.

From the comparison table listed in table 1, it is evident that, amazing panel efficiency i.e., 128.18 %was achieved for the application of two light reflecting mirror material arrangements. It is also obvious from comparison table that the power generation using smaller size of PV panels may generate larger panel size power requirement: suggests to avoids the larger PV panel dimensions. This authenticates that, proposed light reflection methodology offers cost effective operation with optimal space constraints.

Table 1. Comparison of the PV panel efficiencies for various panel design configurations.

Item/ Description		Panel power rating = 1.5 W			Efficiency (%)
		Voltage (V)	Current (A)	Output Power (W)	
Without Mirrors and with Aluminum foil	Top panels	6.0	0.213	1.278	85.2
	Inside panels	1.7	0.044	0.0748	4.986
With two Mirrors and with Aluminum foil	Top panels	6.54	0.329	**2.1516**	**143.44**
	Inside panels	4.3	0.093	0.399	26.6

IV. CONCLUSION

Solar is a key sustainable energy source which offers non-vulnerable and clean electrical energy generation. The major shortcomings of solar sustainable energy generation are its erratic power generation and limited load current generation per panel design. Light reflection technology is one of the efficient approaches that provides the significant support to achieve the enhanced PV panel efficiency with adequate load current generation. As a part of this, multiple experimental investigations are carried out using four small size of similar PV panels and compared their performance efficiencies. From the comparison it is evident that enhanced efficiency of 143.44 % was accomplished for top arranged PV panels using the two light reflecting material arrangements (mirrors). While, bottom arranged inside panels are achieved 26.66 % of panel efficiency for the same sun light exposure condition. Therefore, the concept of proposed light reflection technology restricts to use larger size of solar panels and enables to effective application of minimum size of PV panel offers economical operation for enhanced load power generation. Furthermore, the application of minimal size of PV panel design configurations ensures optimal space constraint operation for greater power demand applications. Additionally, the solar power generation using bottom PV panel design arrangement may be considered as auxiliary power source to the associated equipment's in the power system. Moreover, further comprehensive research work on bottom PV panel design configurations may raise the significant panel efficiency

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