Alternative Arrangements of PV Panels for Enhancement of Panel Efficiency

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ABSTRACT

The alternative arrangements of photovoltaic (PV) panels with the concept of light reflector arrangements are becoming more popular in recent years due to the limitations of the usual solar power generation. The concept of this light reflection technique mitigates the incessant power generation limitation of the usual solar power generation. The light- reflecting materials are arranged so that more photon energy will be generated and imposed on the solar panel offering enhanced power generation from the solar panel. This emphasizes that the design configuration of solar panels using the light reflection scheme supports enhanced PV cell efficiency compared to other maximum power point tracking techniques (MPPT). However, the design configurations of the solar panels using various light-reflecting materials are offering incessant power generation: limited enhanced PV panel efficiency is obvious due to its light reflection coefficient magnitude. Hence, comprehensive research work is necessary to nullify the limited panel efficiency compared to the other MPPT techniques. The concept of instantaneous light reflection scheme consists of profuse effect on any cell-contained object due to its instantaneous source actions. Hence, the authors tried to verify the PV cell efficiency using instantaneous light source arrangements at various light reflection materials. Therefore, this paper shows the various experimental works carried out on PV panel design configurations using the light reflection technique. Also, other alternative PV panel design configurations are suggested for further improvements.

Keyword: *Photovoltaic panel, light reflector, light source*

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1. INTRODUCTION

The application of electrical power has increased abundantly in recent years due to digitalization, industrialization etc. modifications. To full fill these enhanced power application requirements, alternative power sources i.e., eco-friendly power sources are needed [1] [2]. There are various eco-friendly power sources such as solar, tidal, biomass etc. available to full fill these enhanced power demand requirements. Among all these eco- friendly renewable sources, solar energy source is the vivid power source significantly supports the maximum power generation compared to other power sources. However, power generation is limited due to its intermittent presence in the atmosphere. Hence, design engineers are developing maximum power extraction techniques elsewhere in the world. Although all these MPPT techniques [3-6] are developed, it is also limited to fulfilling the continuous power generation requirement. In recent times, the concept of light reflection technique [7] was developed on PV panels which is observed from Fig-1 to nullify this intermittent power generation problem and support to meet the power demand requirement significantly. Even though it meets continuous power generation requirement, this novel technique is also limited to meeting the maximum power demand requirement. Hence, comprehensive research work is necessary to alleviate this maximum power requirement.

Fig-1: Schematic View of Solar panel with Light Reflector Arrangement

Fig-1 demonstrates the solar PV panel design arrangement with sun light reflectors and offers the enhanced panel efficiency: limited to achieve this enhanced PV panel efficiency continuously especially night hours [9] [10]. Hence, the alternative design modification of light illumination energy was replaced with sunlight energy is shown in Fig-2 and tested for continuous power generation.

Fig-2: PV panel design with the light source

It is clear from Fig-2 that PV panels are arranged with light source and light reflectors. This experimental configuration may extend with various light reflector arrangements carried out by various researchers elsewhere in the world. The application of light source is also limited to these indoor type of design configurations due to concentrated heat generation on the PV panel and may lead to damage of the panels. Not only the damage of the PV panels, but it is also important to switch the minimum power consuming light source application. Hence, minimum power consuming light sources such as LED type light sources are recommendable. Also, it is clear from Fig-2 that the design configuration of PV panels with continuous light source reflector arrangements may not support the maximum power generation from the PV cells and alternate design modifications are essential. In this context, authors attempt to modify the above Fig-2 design configuration with instantaneous light source arrangement with various light reflecting material considerations. All the experimental works [11-16] are carried in indoor box containing set up and tested with two light reflecting material arrangements. From the experimental findings, other alternative design modifications are also suggested.

2. METHODOLOGY

To achieve incessant power generation from the PV cells, continuous and multiple light reflections are essential. These continuous and multiple light reflections are obtained using the concept of light reflection scheme which is already elucidated by our ancient engineers. The light reflection concept consists of two categories i.e., regular type light reflections and irregular type light reflections given in Fig-3. Regular type light reflections are obtained for flat and plane reflector bodies and vice versa for irregular light reflections [16-19]. Among these two types of light reflections, multiple number of light reflections are offered from irregular type of body arrangements compared to the regular body arrangements. Hence, the irregular type of light reflection arrangements is recommended for this proposed PV panel design configuration. Also, the selection of suitable light reflecting material is essential to achieve the maximum number of multiple reflections. There are multiple numbers of reflecting materials consisting of its own light reflecting coefficients given in Table-1.

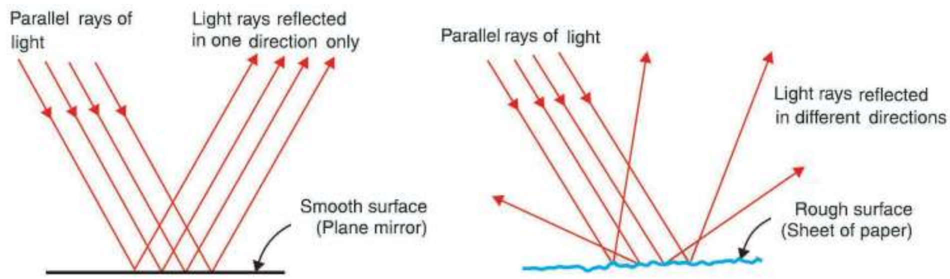

Fig -3: Light reflection classification

The magnitude of solar power of a given solar panel depends on the type of reflector material selected for operation and the reflection coefficient of various reflecting materials is projected in Table-1.

Table-1: VARIOUS SURFACES REFLECTION COEFFICIENTS

Material	Reflection Coefficient
Polished (highly) silver	0.92
Glass mirrors	0.70 to 0.85
White paper	0.82
green paper	0.18
Black paper	0.05
Dark Blue suit	0.03
Dark blue(overcoat)	0.02
grey suit (light)	0.11
Grey suit	0.07
Concrete	0.08 to 0.15

Therefore, among all these reflecting materials, aluminum foil and mirror material are selected to achieve the maximum number of light reflections.

3. EXPERIMENTAL STUDIES

To study the proposed light reflection-based PV cell power generation, various experimental case studies are carried out with two i.e., aluminum reflecting material and mirror as reflecting material.

3.1 Case Study 1: Top Solar Panel Measurement without Light Reflector

To investigate the accuracy and efficiency comparison of the proposed light reflection technique methodology, PV panel power measurements are observed under usual dry weather conditions. To conduct experimental studies following PV panel specifications are considered throughout the experiments and observed from Fig-4.

Maximum Power Output : 1.5 W
Open Circuit Voltage : 6.0 V

Short Circuit Current : 250 A

Fig-4: Solar panel Specifications

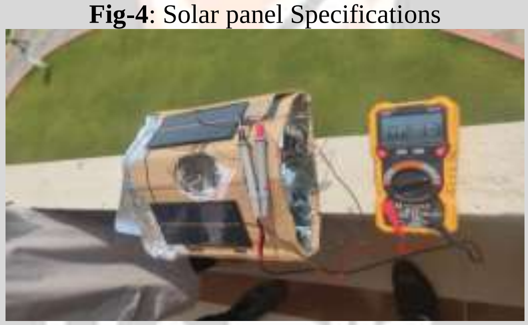

Fig-5: Top Solar panel Measurement without Light Reflector

The measurements are noted at afternoon 12.00 PM to 1.00 PM dry weather conditions on plane ground surface observed from Fig-5 are 6.0 volts and 0.213 Amp respectively. Generally, the sun luminous intensity at dry climatic atmospheric conditions was recorded at 1 lakh luminous lux. This sun luminous intensity was vast compared to the market available light bulb luminous intensity.

3.2 Case Study 2: Bottom Solar Panel Measurement with Aluminum Light Reflecting Material

The Bottom Solar Panel Measurement with Aluminum Light Reflecting Arrangement are measured. The sunlight (photon energy) will fall on the PV panel with the help of Aluminum light reflecting material. The panel absorbs the photon energy and gives efficient output power.

Hence, the experimental set up uses the Aluminum Foil as the light reflecting material and the arrangement of panels and aluminum sheet shown in Fig-6. The measurements are noted at afternoon 12.00 PM to 1.00 PM dry weather conditions on plane ground surface observed from figure 6 are 1.4 V and 0.044 amp respectively are shown in Fig-7.

Fig-6: Arrangement of Solar panels and Aluminum sheet

Fig-7: Voltage & Current Reading for Bottom PV Panel

It is clear from Fig-7, the Bottom PV panel Can generate a good power with the help of Aluminum light reflecting material.

3.3 Case Study 3: Top Solar Panel Measurement with Mirror as Light Reflector

The above case study 2 experimental work was carried out with consideration of aluminum foil sheet as light reflecting material and observed from Fig-7. The PV panel readings are measured under this experimental configuration and are 6.54 V and 0.294 Amp respectively. The panel measurements confirm that the presence of light reflecting material shows profound influence on panel power generation as compared to the above case study 1. Also, the PV panel measurements demonstrate that the proposed light reflection technique with light reflector arrangements are generating more power than the Solar panel specifications. Hence, we can say that the enhancement of PV panel efficiency is possible with the help of light reflectors.

Fig-8: Top Solar panel with light reflector arrangement and its measurements.

3.4 Case Study 4: Bottom Solar Panel Measurement with Mirrors & Aluminum Light Reflecting Material

To obtain the maximum power generation from the Bottom PV panel, authors modified above case 2 study with mirror & aluminum foil material the light effect on the PV panel is more so that the output power is increased. Hence, this methodology was adopted and tested here to verify the maximum power generation from the PV panel. The experimental measurements under this bottom solar panel measurements with mirrors and aluminum light reflecting material are 3 V and 0.093 Amp respectively.

Fig-9: Bottom Solar panel with light reflector arrangement and its measurements.

The same experimental readings are carried out for improved efficiency and are demonstrated in Table-2. Therefore, the experimental results are verified with & without Light Reflector Materials.

Table-2: Solar Panel Measurements for various experimental arrangements under consideration of with & without light reflector material arrangement

Item /Discerption	Voltage	Current	Output Power	Efficiency
Without Light Reflector Top Panel	6.0 V	0.213 A	1.278 W	85.2 %
Without Light Reflector Bottom Panel	1.7 V	0.044 A	0.074 W	4.986 %
With Light Reflectors as aluminum foil & mirrors for Top panel	6.54 V	0.294 A	1.922 W	128.184 %
With Light Reflectors as aluminum foil & mirrors for Bottom panel	3.0 V	0.093 A	0.279 W	18.6 %

3.5 Cae Study 5: Indoor Climatic Conditions with Artificial Lights

To achieve the maximum power extraction from the PV panels, authors extended the above case studies with the application of two light reflecting materials for indoor climatic conditions (during Nights). Therefore, the PV panel in a closed box which is covered with aluminum sheet with the addition of mirrors and the experimental configuration and experimental findings are observed from Fig-10. The experimental measurements of panel potential and current are recorded at 21 V and 0.47 A respectively. which is a terrible result compared to all above case study results. In addition to this, the PV panel output power was met nearly with the outdoor experimental measurements. Therefore, for easy performance analysis of the proposed instantaneous light reflection technique, the comparison of PV panel power generation using the above case studies are listed in Table-3.

Fig-10: Solar panel with aluminum & mirror light reflector arrangement and its measurements.

Table 3 authorizes that the PV panel design modifications with the instantaneous light source consideration with multiple light reflecting material applications achieves the incessant and maximum power generation.

Table-3: comparison of solar panel output power variation for indoor instantaneous light source effects and outdoor effects

Case Study	Actual Solar Panel Output Power in Watts	Proposed Case Study Solar Panel Output Power in Watts
Without Any Light Reflector Arrangement & With Continuous Light Source	10	0.0875
With Aluminum Light Reflector Arrangement & With Instantaneous Light Source	10	0.972
With combination of Aluminum, Mirror Light Reflector Arrangement & With Instantaneous Light Source	10	9.87

Furthermore, from the observation of outstanding results obtained using instantaneous light reflection technique with multiple reflecting materials, authors are also concentrated on the further novel design modifications of application of multiple PV panel arrangements with optimal space constraints.
The three-dimensional sketch of proposed novel design modification is presented in Fig-11. The authors are now extending their work on this novel design modification and expecting remarkable results.

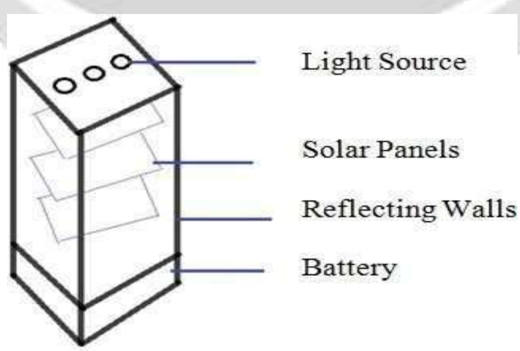

Fig-11: 3-Dimensional sketch of PV panels

4. CONCLUSION

Electrical power generation using pollution free solar PV panels is acting as significant support to existing power sources to meet the enhanced power demand requirements. The erratic problem with solar power generation is its irregular existence in nature. Hence, alternative Arrangements of PV panels are essential. In view of this, alternative novel design configurations using light reflection concept was proposed by authors and carried out various experimental studies. From the various experimental studies discussed in above sections, it is clear evident that, the application of light reflection technique with the consideration of multiple number of effective reflecting materials offering incessant and maximum pollution free power generation in an optimum space and we can also generate more power than the panel rating. In addition to this, authors have also proposed the extended novel design configuration using PV panels for enormous power generation with optimal space constraints.

5. ACKNOWLEDGEMENT

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6. REFERENCES

[1]. S. Bouguerra, M. R. Yaiche, O. Gassab, A. Sangwongwanich and F. Blaabjerg, "The Impact of PV Panel Positioning and Degradation on the PV Inverter Lifetime and Reliability," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 9, no. 3, pp. 3114-3126, June 2021, doi: 10.1109/JESTPE.2020.3006267.

[2]. J. Macaulay, C. W. Lin and Z. Zhou, "An emulated PV source based on an Indoor Solar Panel with external excitement current and voltage compensation," 2018 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), 2018, pp. 859-864, doi: 10.1109/SPEEDAM.2018.8445307.

[3]. C. Moo and G. Wu, "Maximum Power Point Tracking With Ripple Current Orientation for Photovoltaic Applications," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 2, no. 4, pp. 842-848, Dec. 2014.

[4]. M. Dhimish, "Assessing MPPT Techniques on Hot-Spotted and Partially Shaded Photovoltaic Modules: Comprehensive Review Based on Experimental Data," in IEEE Transactions on Electron Devices, vol. 66, no. 3, pp. 1132-1144, March 2019.

[5]. T. S. Kumar, M. R. Nayak, R. V. Krishna and K. P. Rao, "Enhanced Performance of Solar PV Array-Based Machine Drives Using Zeta Converter," 2020 IEEE International Conference on Advances and Developments in Electrical and Electronics Engineering (ICADEE), Coimbatore, India, 2020, pp. 1-5, doi: 10.1109/ICADEE51157.2020.9368937.

[6]. M. A. Elgendy, B. Zahawi and D. J. Atkinson, "Evaluation of perturb and observe MPPT algorithm implementation techniques," 6th IET International Conference on Power Electronics, Machines and Drives (PEMD 2012), 2012, pp. 1-6, doi: 10.1049/cp.2012.0156.

[7]. K. Amara et al., "Improved Performance of a PV Solar Panel with Adaptive Neuro Fuzzy Inference System ANFIS based MPPT," 2018 7th International Conference on Renewable Energy Research and Applications (ICRERA), 2018, pp. 1098-1101, doi: 10.1109/ICRERA.2018.8566818.

[8]. Y. Xue, S. Sun, J. Fei and H. Wu, "A new piecewise adaptive step MPPT algorithm for PV systems," 2017 12th IEEE Conference on Industrial Electronics and Applications (ICIEA), 2017, pp. 1652-1656, doi: 10.1109/ICIEA.2017.8283104.

[9]. D. Rana, G. Kumar and A. R. Gupta, "Increasing the Output Power and Efficiency of Solar Panel by Using Concentrator Photovoltaic (CPV) and Low Cost Solar Tracker," 2018 4th International Conference on Computational Intelligence & Communication Technology (CICT), 2018, pp. 1-5, doi: 10.1109/CIACT.2018.8480199.

[10]. M. Raja. Nayak and S. A. Mujeer, "New Computational Method for Study of Ionic Current Environment of HVDC Transmission Lines," 2020 IEEE International Conference on Advances and Developments in Electrical and Electronics Engineering (ICADEE), Coimbatore, India, 2020, pp. 1-5, DOI: 10.1109/ICADEE51157.2020.9368934.

[11]. A. Banerjee, K. Hoffman, X. Xu, J. Yang and S. Guha, "Back reflector texture and stability issues in high efficiency multijunction amorphous silicon alloy solar cells," Proceedings of 1994 IEEE 1st World Conference on Photovoltaic Energy Conversion - WCPEC (A Joint Conference of PVSC, PVSEC and PSEC), 1994, pp. 539-542 vol.1, doi: 10.1109/WCPEC.1994.520017.

[12]. T. S. Kumar, M. R. Nayak, R. V. Krishna and K. P. Rao, "Enhanced Performance of Solar PV Array-Based Machine Drives Using Zeta Converter," 2020 IEEE International Conference on Advances and Developments in Electrical and Electronics Engineering (ICADEE), Coimbatore, India, 2020, pp. 1-5, doi: 10.1109/ICADEE51157.2020.9368937.

[13]. F. Cappelluti, A. Musu and A. Khalili, "Study of light-trapping enhanced quantum dot solar cells based on electrical and optical numerical simulations," 2016 Compound Semiconductor Week (CSW) [Includes 28th International Conference on Indium Phosphide & Related Materials (IPRM) & 43rd International Symposium on Compound Semiconductors (ISCS), 2016, pp. 1-2, doi: 10.1109/ICIPRM.2016.7528629.

[14]. M. Raja. Nayak, G.Radhika, B.Devulal, P.Deepak Reddy, G.Suresh, "Optimization Of High Voltage Electrodes For 765 Kv Bus Post Insulators", Journal of Sustainable Energy Technologies and Assessments (ELSEVIER)- 47, Page 101529, August, 2021. ISSN: 2213-1388, https://doi.org/10.1016/j.seta.2021.101529.

[15]. K. Forghani, R. Reddy, D. Rowell and R. Tatavarti, "MOVPE growth of AlInP-InGaP Distributed Bragg Reflectors (DBR) for Monolithic Integration into Multijunction Solar Cells," 2019 IEEE 46th Photovoltaic Specialists Conference (PVSC), 2019, pp. 0227-0229, doi: 10.1109/PVSC40753.2019.8980776.

[16]. S. U. M. Reddy, N. Venkatesh, N. S. Nagendra, P. R. Prasad and M. R. Nayak, "Study On New Design Techniques for Enhancement of Solar Panel Efficiency," 2021 International Conference on Computing Sciences (ICCS), 2021, pp. 70-75, doi: 10.1109/ICCS54944.2021.00022.C.

[17]. M. Raja. Nayak, M.Saritha, S. Abdul. Mujeer, B.Devulal, T.Santhosh Kumar, "A Photovoltaic Based Multilevel Inverter Fed Induction Motor Drive", Turkish Journal of Computer and Mathematics Education, Vol.12 No.10(2021), PP. 6196-6212. April-2021. DOI: https://doi.org/10.17762/turcomat.v12i3.1647

[18]. M. Raja Nayak, T. Praveen, P. SaiTeja, K. Kshore, J. Sushma, "Electricity Generation using MAGNETOR" Journal of Advanced Research and Dynamic Control, vol 11, NO.5, pp: 173-176, November 2019.

[19]. S. A. El Naggar, M. Y. Ghannam, N. H. Rafat and F. M. Tayel, "A detailed analysis of photogenerated current enhancement in thin silicon solar cells with a diffuse back reflector," ICM'99. Proceedings. Eleventh International Conference on Microelectronics (IEEE Cat. No.99EX388), 1999, pp. 197-200, doi: 10.1109/ICM.2000.884839.intermediate reflector,"IEEE journal of photovoltaic, vol.5, no.1, pp.33- 39, 2015.