TEST Engineering & Management

July – August 2020
ISSN: 0193-4120 Page No. 426 - 429

Experimentally Diagnosing the Effect of Colour and Shade on PV Panel in Gwalior Region

Sampurna Panda, Manoj Gupta
Poornima University, Jaipur
Sampurnapanda1412@gmail.com, manojg@poornima.edu.in

Cs Malvi
Madhav Institute of Technology &Science, Gwalior
csmalvi@gmail.com

Article Info
Volume 83
Page Number: 426 - 429
Publication Issue:
July - August 2020

Article History
***Article Received**: 06 June 2020*
***Revised**: 29 June 2020*
***Accepted**: 14 July 2020*
***Publication**: 25 July 2020*

Abstract
The goal of this experimentation is to consider the impacts of various color spectrum, shade and the combination of both. An experimental investigation has done to analyze the various effects of color shades and card board shade. This also determined the sensitivity of the PV Panel towards different color spectrum. This experiment has been carried out on shade free terrace of ITM University, Gwalior. The measured parameters have been used to calculate power and efficiency. For better demonstration, analysis has been done by plotting graphs. The outcome shows that PV panel is affected mostly by visible lights compared to infra-red lights and shadow can be a destructing factor in PV panel efficiency.

Index Terms— *color filter, shading, efficiency, Photovoltaics*

I. Introduction

Sun light based energy is developing as impressive, potent, decent, enduring, and clean energy. Solar PV energy is used in residential, industrial and utility levels over the world [1]. Increasing high acknowledgement in India is because of its high sun energy capacity. India is blessed with 300 clear sunny days and around 4-7 kWh/m^2 energy per day [2]. A part of this energy is satisfactory to lessen energy deficiency raised in past few years. From the most recent two decades, rooftop mounted solar powered PV framework establishment quickly increases. Till the end of 2019, around 2141 MW power is produced from a housetop PV framework [3]. According to report of IEEFA, India has set a target of 40 GW electricity generation through solar roof-top framework by 2022 [4].

PV cell utilize semiconductor materials for conversion of solar energy to electricity. This conversion efficiency depends on light intensity, temperature and few other weather conditions [5]. Due to various environmental factors like shade, dust, bird drop and high temperature, the efficiency of the PV panel decreases [6]. The power generated by PV panel decreases due to shading effect as there is voltage drop across its terminal [7,8].

The model to calculate the BIPV electricity production considering shadow effect was developed by Masa-Bote and Caamaño-Martín [9]. The effect of shading on the output power was also studied by Topić et al. They had considered the effect of shading factor in the developed mathematical model and calculated the optimal shading row number [10]. Considering the partial shading or mismatch, Bai et al. simulated the output characteristics of a PV system [11]. Renaudineau et al. proposed the maximum power point tracking algorithm and used this to solve the shadow problems in PV systems [12]. The performance of the single stage 3-phase power generation system was evaluated by Ghoddami and Yazdani and the results were verified by using PSCAD/EMTDC simulating software [13].

Presence of shading plays an important role in addition with ecological conditions in deciding the performance of PV system. Under this circumstances PV system can be divided into two types depending on the radiation as Homogenous PV systems and non-homogenous PV systems. In homogenous, all the PV units receive equal amount of irradiance and in non-homogenous PV units work on different irradiance levels. The output power curve for homogenous system follows the ideal PV characteristics of a PV system and results in a single peak whereas the output power curve for non-homogenous PV system have multiple numbers of peaks resulting in power loss. In Homogenous PV system the peak present in output power curve is known as Maximum Power Point (MPP) [14]. In non-homogenous PV system, numbers of local peaks are produced; in which one is true maximum power point, known as Global Maximum power point (GMPP). Cause of incomplete concealing of PV module may be any environmental factors like bird drop, intermittent clouds, adjacent PV modules or new infrastructure, any other obstacle which is merely predictable. This portion of the PV module remained concealed while other parts remain enlightened [15]. The objective of this investigation is to research the impact of color shades on proficiency of Photovoltaics panel. It is likewise proposed that if the shade of the sunlight changes, the output parameters will be affected.

I. Effect of Color and Shade

Numbers of examinations have been performed to check the variations in I-V, P-V characteristics of the Photovoltaic system. All the experiments have been conducted on a shadow free terrace at Gwalior in a clear sky day having 39°C as maximum temperature. The aim was to take measurements of output voltage and current of the PV panel with a note to temperature.

$$Power\ Output = V_{OC} \times I_{SC} \times FF \quad (1)$$

Here V_{oc} ,Isc and FF are designated as open circuit voltage, short circuit current and fill factor respectively.

$$Efficiency\ of\ solar\ panel = \left(\frac{V_{OC} \times I_{SC} \times FF}{P_{in}}\right) \times 100 \quad (2)$$

Here *input power is designated by Pin.*

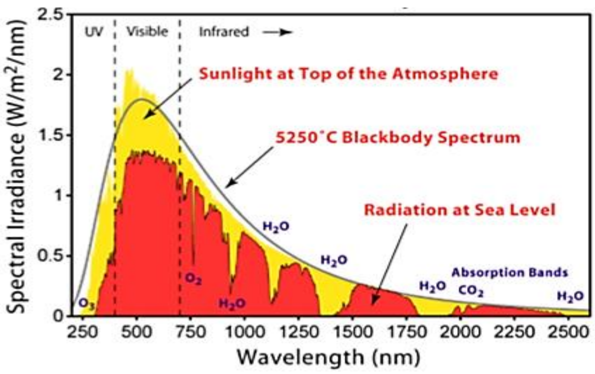

Fig1. Solar radiation spectrum [5]

Here an experiment has been made to access the impact of shades of light on Photovoltaic Panel. A contextual investigation has been done to tentatively make sure the impact of numerous color spectrum of light on the PV module. Research outcome shows that red color has significant effect on the PV panel performance. Sun radiates electromagnetic waves as light. White illumination from the Sun incorporates all shades of the noticeable range and ranges in frequency from around 400 nanometers (nm) to about 780nm. Daylight is alternate shading; it has a greater amount of the high-vitality violet finish. Red photons have the least intensity and blue photons bear the highest intensity while the Green is in the middle of the two. The vitality of the photons is controlled by their recurrence given by $E=hf$, where E is the vitality of the photon, f is its recurrence in Hz, and h is Planck's steady ($6.663 \times 10^{-34}\ Js$). It is turning out to be progressively evident that frequency of light impact the exhibition of photovoltaic modules [5].

II. Experimental Set Up

The experimental set up consists of a PV panel of 150Wp of polycrystalline type mounted on an iron stand. The data logger of Everon Company has been used for logging data like voltage, temperature and current. The PV panel is covered with different colored filters (red, green, blue, violet) so that when sunlight strikes the panel radiation of all colors get absorbed except the own color. By changing the different colored filters, output parameters like voltage and current have recorded.

TABLE I. DATA SHEET OF THE PV PANEL

Brand	Ajit Solar
Power Max P_{mpp}	150 W
Maximum System Voltage	1000 V
V_{mpp}	18.8 V
V_{oc}	22.6 V
I_{mpp}	8.35 A
I_{sc}	8.95 A
Fuse Rating	15 A

In this paper readings with different colour filters have been taken. To check the effect of shade artificial shade has created by card board paper. Then measurements have been taken by using both color filter and shade to study their combine effect.

TEST Engineering & Management

July – August 2020
ISSN: 0193-4120 Page No. 426 - 429

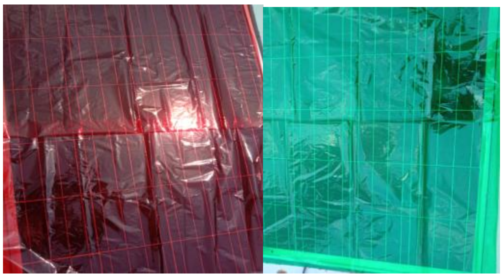

Fig 2. Red and Green color filters covered on the panel

Fig 3, yellow and violet color filters wrapped on the panel

An Apogee self-monitored Pyranometer and RTD cable have been used for irradiation and Panel temperature measurements respectively.

Fig3. Apogee S110 and RTD cable

In Fig. 3, a panel is 25% shadowed by using card boards. And similarly 50% and 75% shadowed and measurements of voltage and current have taken.

Fig 4. With 25% shadow on the panel created by cardboard

III. RESULT ANALYSIS AND GRAPHS

TABLE I. Without Filter

White light of 390-780 nm

S. No	Voltage(v)	Current(A)	Power(w)	Panel Temperature (°C)	Irradiation (kw/m^2)
1	11.387	4.55	51.81	21.783	52.98
2	13.562	5.4248	73.57	44.938	151.8
3	14.923	5.962	88.97	45.59	162.65
4	16.337	6.53	106.680	46.3	171.2
5	17.085	6.834	116.758	48.21	188.8

TABLE II. With Filter

At 188.8w/m^2 and 48.21°C panel temperature

S. no	Filter	Wavelength in nm	Voltage (v)	Current (A)	Power (w)
1	Red	625-780	17	5.83	92.21
2	yellow	575-595	16.8	5.23	88
3	green	495-595	16.8	5.23	88
4	Violtet	390-455	14	5.08	71.12
5	No filter	390-780	17.085	6.834	116.758

TABLE III. With Shading(25%,50%,75%)

S. no	Shading	V (v)	I (A)	P (W)
1	25%	2.9	0.1	0.29
2	50%	1.23	0	0
3	75%	0.4	0.01	0.004

TABLE IV. With both colour and shade filter and shading

S. No.	P without anything (W)	P with filter (W)	P with shade (W)	P combine (W)
1	127.30	102.1	8.4	1.29

Out of all color filters, Red responded best. So for studying combine effect red color filter has been considered with 25% shade at irradiation level 204.8w/m^2 which was the peak of that day recording 40.2°C as maximum temperature.

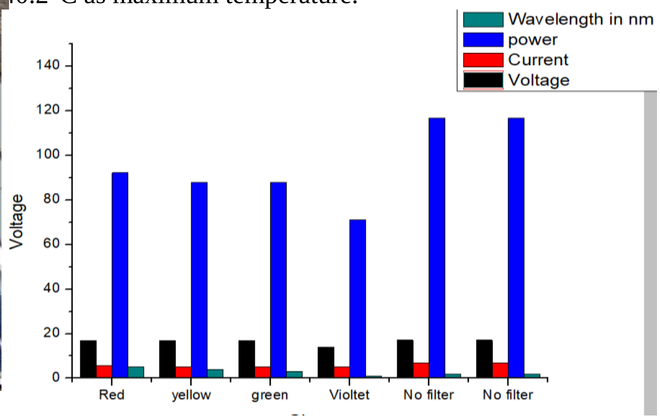

Fig 5.Voltage, current and power variation in various filters

Fig. 5 shows the variation of various output parameters of the PV panel with respect to various color filters with the no filter one. It shows the np filter panel gives the maximum output power followed by the red filter.

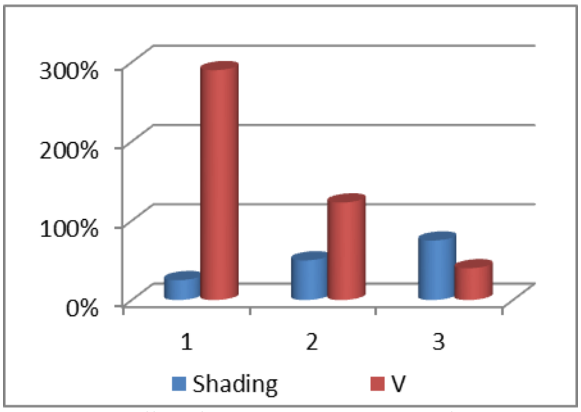

Fig 6. Effect of shadow on output voltage of Panel

Fig 6. Clearly indicated the dominance effect of shadow on theoutput voltage of the PV panel. It shows ,ore shadow results in less power.

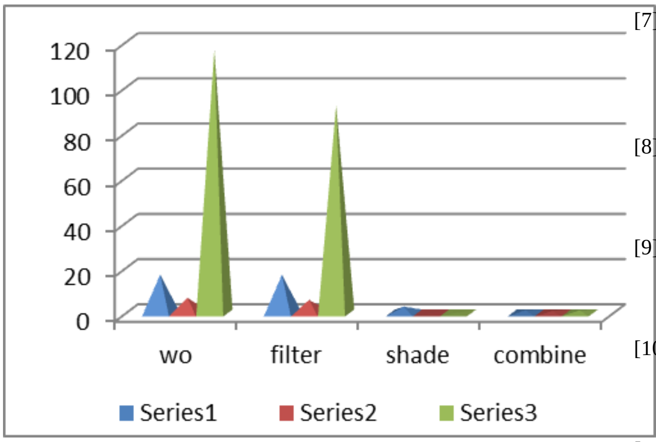

Fig 7. Output parameters for various categories

Effect of colour filter (spectrum), shade and combine effect of both of these can be seen from fig.7 which clearly describes the output parameter difference between a clear panel and a panel covered with color filter and shadow.

V. CONCLUSION

The experiment result clearly shows that colored spectrum affects the PV panel and proved that red photons have least energy. The terrible impact of shadow has been demonstrated in the form of voltage and power. Shadow can be the reason of reduction in power by 40%. This experiment promotes the importance of cleanliness and shadow free panels for unaffected performance of the PV Panel. The future work can be done in finding the reason of making the panel more responsive to red lights and ways to improve efficiency of the panel in shading conditions.

References

[1] Kannan R, Leong KC, Osman R, Ho HK, Tso CP. Life cycle assessment study of solar PV systems: An example of a 2.7 kWp distributed solar PV system in Singapore. Sol Energy 2006;80:555–63. doi:10.1016/j.solener.2005.04.008.
[2] Shukla AK, Sudhakar K, Baredar P. Simulation and performance analysis of 110 kWp grid-connected photovoltaic system for residential building in India: A comparative analysis of various PV technology. Energy Reports 2016;2:82–8. doi:10.1016/j.egyr.2016.04.001.
[3] Fuke P, Yadav AK, Anil I. Energy Performance and Economic Analysis of Different PV Technologies for Grid Connected Rooftop PV System. 2020 IEEE 9th Power India Int. Conf., IEEE; 2020, p. 1–5. doi:10.1109/PIICON49524.2020.9113060.
[4] Garg V. Vast Potential of Rooftop Solar in India. 2019.
[5] Wang D, Qi T, Liu Y, Wang Y, Fan J, Wang Y, et al. A method for evaluating both shading and power generation effects of rooftop solar PV panels for different climate zones of China. Sol Energy 2020;205:432–45. doi:10.1016/j.solener.2020.05.009.
[6] Chedid R, Tajeddine R, Chaaban F, Ghajar R. Modeling and simulation of PV arrays under varying conditions. Proc Mediterr Electrotech Conf - MELECON 2014:536–42. doi:10.1109/MELCON.2014.6820592.
[7] Ahmad RB, Mamat WMA, Mohamed Juhari MR, Daud S, Arshad NW. Web-based wireless data acquisition system using 32bit single board computer. Proc. Int. Conf. Comput. Commun. Eng. 2008, ICCCE08 Glob. Links Hum. Dev., 2008, p. 777–82. doi:10.1109/ICCCE.2008.4580711.
[8] Roy Chowdhury S, Saha H. Maximum power point tracking of partially shaded solar photovoltaic arrays. Sol. Energy Mater. Sol. Cells, vol. 94, Elsevier; 2010, p. 1441–7. doi:10.1016/j.solmat.2010.04.011.
[9] Masa-Bote D, Caamaño-Martín E. Methodology for estimating building integrated photovoltaics electricity production under shadowing conditions and case study. Renew Sustain Energy Rev 2014;31:492–500. doi:10.1016/j.rser.2013.12.019.
[10] Topić D, Knežević G, Fekete K. The mathematical model for finding an optimal PV system configuration for the given installation area providing a maximal lifetime profit. Sol Energy 2017;144:750–7. doi:10.1016/j.solener.2017.02.011.
[11] Bai J, Cao Y, Hao Y, Zhang Z, Liu S, Cao F. Characteristic output of PV systems under partial shading or mismatch conditions. Sol Energy 2015;112:41–54. doi:10.1016/j.solener.2014.09.048.
[12] Renaudineau H, Houari A, Martin JP, Pierfederici S, Meibody-Tabar F, Gerardin B. A new approach in tracking maximum power under partially shaded conditions with consideration of converter losses. Sol Energy 2011;85:2580–8. doi:10.1016/j.solener.2011.07.018.
[13] Ghoddami H, Yazdani A. A single-stage three-phase photovoltaic system with enhanced maximum power point tracking capability and increased power rating. IEEE Trans Power Deliv 2011;26:1017–29. doi:10.1109/TPWRD.2010.2055896.
[14] Haque A. Maximum Power Point Tracking (MPPT) Scheme for Solar Photovoltaic System. Energy Technol Policy 2014;1:115–22. doi:10.1080/23317000.2014.979379.
[15] Alqaisi Z, Mahmoud Y. Comprehensive Study of Partially Shaded PV Modules with Overlapping Diodes. IEEE Access 2019;7:172665–75. doi:10.1109/ACCESS.2019.2956916.
[16] Sudhakar K, Noopur J, Shivani B. Effect of Color Filter on the Performance of Solar. Int Conf Power, Energy, Control 2013:35–8.