International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105

JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 5, Issue 1 - January 2016 - Pages 108-111

TESTING OF PV MODULE PERFORMANCE UNDER DIFFERENT CONDITIONS

S. Parthasarathy[1], K.Srinivasan[2],
[1]Research Scholar, Maharishi University of Information Technology, Lucknow, E-mail: spsarathy_au@yahoo.co.in
[2]Professor, Tagore Engineering College, Chennai-India-600 127,E-mail: omsrivas@yahoo.co.in

ABSTRACT- The irradiance effect on several PV modules is examined by the changing a tilt angle and comparing different meteorological situations of sky clearness (clouds) on the modules mounted outdoor and exposed to Sun. Also, the influence of temperature and dust on the performance of a PV panel is under research using measurement methods described in the paper. The measured current and voltage data at the clean surface of the PV module correspond to the declared data of the PV module manufacturer, and in the case of fouling of the module surface with dust, a power drop of 7.39% was measured.

Keywords: dust effect; irradiance; PV generation; solar panel testing; temperature effect

INTRODUCTION

The amount of energy produced in the PV module is directly affected by the solar irradiance, which means that in cloudy weather the PV module produces less energy and does not produce electricity at night. The performance of the PV module is most influenced by the collector tilt angle, which is defined concerning the horizontal position. The optimal tilt angle of a fixed PV module depends on local climatic conditions such as geographical location and season [1]. The total irradiated solar energy is affected by the duration of solar hours and the average monthly cloudiness [2]. The effect of irradiance and temperature on the performance of a PV panel was investigated by Zuhal ER et al. [3] and Aoun et al. [4]. Damasen Ikwaba Paul [5] analysed the electrical performance of three PV modules with cells connected in different configurations to address the nonuniform illumination effect. Ramabadran and Badrilal [6] investigated the harmful effects of partial shading of series and parallel connected PV modules and compare their performance. It is clear that the nature of dust particles, such as particle size distribution, and chemical composition also influence the result.

PV panels must guarantee cost-effectiveness for investors. It is a fact that the light spectrum changes when sunlight passes through the atmosphere. To enable an accurate comparison of the characteristics of solar cells tested at different times and in different places, the standardized spectrum and power density (irradiation) for radiation outside the Earth's atmosphere and on the Earth's surface is defined (ISO 9845-1: 1992, IEC EN 60904-3: 1989-02). Air Mass 0 means that light has not passed through the atmosphere. This irradiance on the border of the atmosphere is 1367 W/m2 and is declared as solar constant.

2 MATERIAL AND METHODS

2.1 Description of the Experimental Test

The photovoltaic module is created by connecting photovoltaic cells, where the cells can be connected in series, which increases the voltage or in parallel in a submodule, which increases the output current. The modules produce DC, usually 12 V or 24 V, but there are versions of 6 V and 18 V. During the operation of the PV module, degradations of properties may occur, the causes of which can be very different, for example:

- Degradation or safety issues caused by the failure of cell interconnects, solder bonds, or the bypass diodes that protect in case of shading
- Early degradation in the short-circuit current related to light-induced degradation
- Changes in transmittance associated with changes in anti-reflection coatings, encapsulation discolouration, and delamination
- Corrosion of cells and ribbons (often associated with delamination in the field)
- Junction-box failures, including non-functioning bypass diodes, etc.

In this paper, the aim is to examine the characteristics in different operating conditions and compare them with the nominal values given by the module manufacturer. Each manufacturer of PV modules takes samples from the production line and tests them following appropriate procedures to ensure the quality of their products. However, it is also interesting to do tests

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Volume 5, Issue 1 - January 2016 - Pages 108-111

of PV modules that can be bought on the free market. For this purpose, appropriate PV modules were procured and the values of voltage, current, and power were measured and compared with the values stated by the manufacturer.

Table 1 Declared parameters of photovoltaic modules

	PV module SOLE	PV module ANBES	PV module Cewaal
U (V)	18	12	6
I (A)	1.11	0.12	0.33
P (W)	20	1,5	2

Illuminance is a measure of photometric flux per unit area or visible flux density. Luminous efficacy in daylight is defined as the ratio of illuminance to global solar irradiation.

$$K_g = E(\mathrm{lx}) \,/\, G(\mathrm{W/m^2}) \quad \text{........(1)}$$

Luminous efficacy models for the clear-sky global and direct beam are mainly related to global solar radiation and solar altitude angle and in some extent of atmospheric conditions. The expression for luminous efficacy:

$$K_g = 91.2 + 0.702\gamma_S - 0.0063\gamma_S^2 \quad \text{.......(2)}$$

For measuring conditions in Chennai (season and time of day results in altitude 45°), the value Kg = 109 (lm/W) was calculated. So, the amount of irradiation on the surface can be approximately calculated using the expression:

$$G\ (\mathrm{W/m^2}) = E\ (\mathrm{lx}) \cdot 0.00917 \quad \text{.....(3)}$$

2.2 Influence of the Tilt Angle on the Performance of the PV Module

The test aims to define the influence of the tilt angle of the module on its efficiency. The SOLE module with the possibility of changing the tilt angle was used for this test. The test is performed by connecting the photovoltaic module to the circuit with the measuring module and the consumer and using a slider to set a tilt angle (0-90°). The test is conducted in the open air with measured illumination of 86,200 lumens. Applying expression (1), this illumination corresponds to irradiation of 783.6 W/m2. By changing the tilt angle of the photovoltaic module, its performance also changes. The share of direct solar radiation is dominant in the total radiation, and the maximum performance is achieved by placing the surface of the PV module perpendicular to the direction of radiation. During the test, the module achieved the best performance at the tilt angle of 30°, which is the closest to the optimal tilt angle for the area of Chennai, which is 35° (Fig. 3).

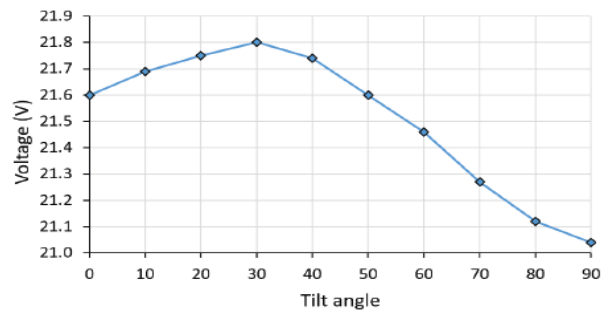

Figure 1 Voltage as a function of tilt angle

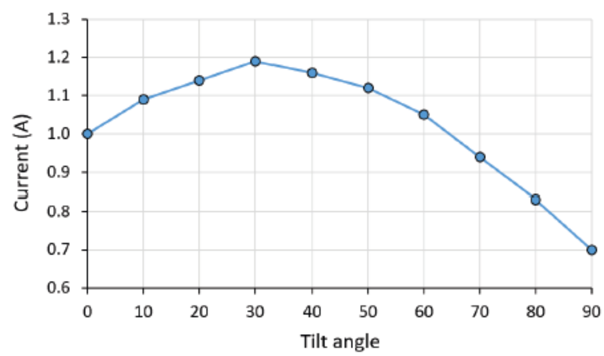

Figure 2 Current as a function of tilt angle

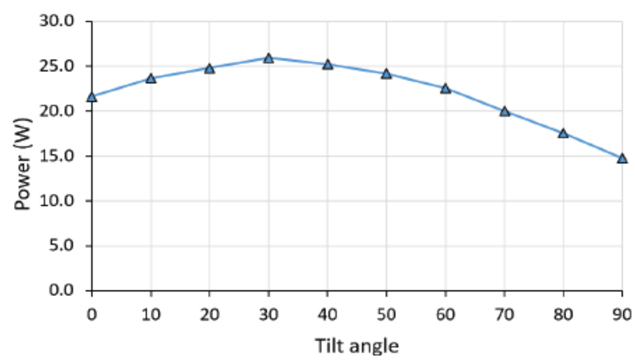

Figure 3 Power as a function of tilt angle

2.3 Influence of the PV Module Temperature Rise on the Voltage and Current

The test is performed by connecting the SOLE photovoltaic module to the circuit with the measuring module and the consumer. The temperature and voltage of the PV module are then measured every 5 minutes up to 30 minutes. The procedure was performed outdoors at a light intensity of 84,500 lx, which corresponds to irradiation of 775 W/m2.

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Volume 5, Issue 1 - January 2016 - Pages 108-111

1.06 A. The reason is the limited accuracy of the instrument of ± 0.01 A.

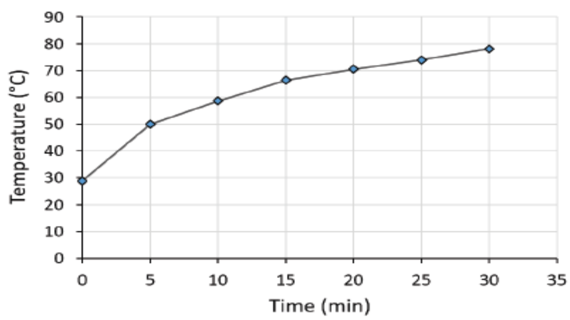

Figure 4 Temperature rise during the measurement

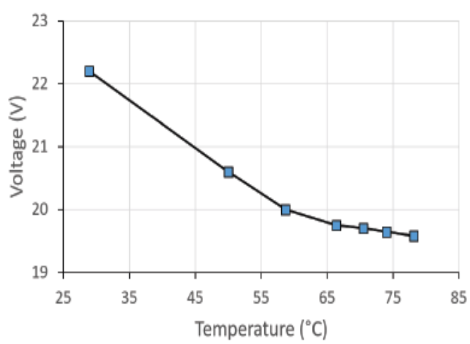

Figure 5 Influence of module temperature on the voltage

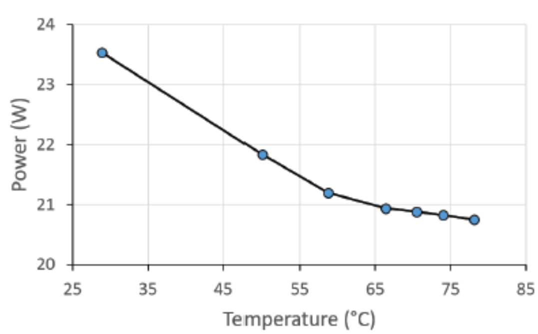

Figure 6 Influence of module temperature on the power

According to Fig. 4, it is noticeable that the voltage slowly decreases with the increasing temperature of the PV module, and the current remains unchanged. The electrical power produced from a photovoltaic panel depends on the incident solar irradiation, and the temperature of the cells. In the analysed case, when the temperature increases from 28.9 °C to 78.2 °C, the power drops by 11.8% (Fig. 5).

2.4 Examination of the Influence of Dust on the Performance of the PV Module

The test procedure is performed by connecting a photovoltaic module in a circuit with a measuring module and a resistance, then measuring current, voltage, and power under the clean surface (Fig. 6) and surface covered with a layer of dust. After that, the obtained value is compared. The procedure was performed outdoors, the panel was tilted at approximately 35° facing south. Illumination is measured by a lumino meter in the amount of 98,200 lumens. The ambient temperature was 26 °C. Calculation of the amount of irradiated energy:

$$G = 98{,}200 \cdot 0.00917 = 900 \text{ W/m}^2$$

Table 2 Measured voltage and current on the clean and fouled PV module

	Clean surface	Fouled surface
U (V)	20.90	20.50
I (A)	1.15	0.91
P (W)	20.04	18.66

According to the test results shown in Tab. 2, it is noticeable that in the case of PV modules with a layer of dust, all measured values are lower than for the case of clean module surface. In the case of the fouled surface, the current is lower 26.37%, and the voltage drop is relatively small and amounts to 1.95%. A voltage drop and current drop resulted in a power drop of 7.39%. From the obtained test data, it can be concluded that it is desirable to have a system for cleaning the surface of the PV module to avoid energy losses due to the influence of a layer of dust or other dirt on the surface of the PV module.

CONCLUSION

The outdoor experiments support the understanding of parameters that influence the performance of a photovoltaic module in a real application. Measurement methods described and performed analyses in the paper enhance comprehension of the performance of the outdoor mounted PV modules. Influence of dust effect on outdoor mounted PV module surface is presented in the paper. The performed measurements show that the declared values of the PV module are achievable. Due to the increase in the module temperature, a decrease in power by 11.8% occurred, and due to the dust accumulation on the surface of the module, a decrease in the power of 6.9% was registered.

REFERENCES

[1] Aoun, N., Bouchouicha, K., & Chenni, R. (2017). Performance Evaluation of a Monocrystalline Photovoltaic Module under Different Weather and Sky Conditions. *International Journal of Renewable Energy Research*, 7(1), 292-297.

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Volume 5, Issue 1 - January 2016 - Pages 108-111

[2] Ramaprabha, R. & Mathur, B. (2009). Effect of Shading on Series and Parallel Connected Solar PV Modules. *Modern Applied Science, 3*(10), 32-41. https://doi.org/10.5539/mas.v3n10p32

[3] Jadallah, A. A., Mahmood, D. Y., & Abdulqader, Z. A. (2014). Simulation and Experimental Testing of a PV Panel at Different Operating Conditions. *IJISET - International Journal of Innovative Science, Engineering & Technology, 1*(10), 141-146.

[4] Fares, M. A., Atik, L., Bachir, G., & Aillerie, M. (2017). Photovoltaic panels characterization and experimental testing. *Energy Procedia, 119*, 945-952. https://doi.org/10.1016/j.egypro.2017.07.127

[5] Said, S. A. M. & Walwil, H. M. (2014). Fundamental studies on dust fouling effects on PV module performance, *Solar Energy, 107*, 328-337.

[6] Touati, F., Massoud, A., et al. (2013). Effects of environmental and climatic conditions on PV efficiency in Qatar. In: *International Conference on Renewable Energies and Power Quality (ICREPQ'13)*, 20-22 March 2013, Bilbao, Spain, 275-281. https://doi.org/10.24084/repqj11.275

[7] Zaihidee, F. M., Mekhilef, S., Seyedmahmoudian, M., & Horan, B. (2016). Dust as an unalterable deteriorative factor affecting PV panel's efficiency: Why and how. *Renew. Sustain. Energy Rev., 65*, 1267-1278.

[8] Kumar, E. S., Sarkar, B., et al. (2013). Soiling and dust impact on the efficiency and the maximum power point in the photovoltaic modules. *Int. J. Eng., 2*(2).

[9] Otsuka et al. (1988). Measurement of the adhesive force between particles of powdered materials and a glass substrate by means of the impact separation method III: effect of particle shape and surface asperity. *Chem. Pharm. Bull., 36*(2), 741-749. https://doi.org/10.1248/cpb.36.741

[10] Hegazy, A. A. (2001). Effect of dust accumulation on solar transmittance through glass covers of plate-type collectors. *Renew. Energy, 22*(4), 525-540. https://doi.org/10.1016/S0960-1481(00)00093-8

[11] Littlefair, P. J. (1988). Measurements of the luminous efficacy of daylight. *Lighting Research & Technology, 20* (4), 177-188. https://doi.org/10.1177/096032718802000405

[12] Kurnik, J., Jankovec, M., Brecl, K., & Topic, M. (2011). Outdoor testing of PV module temperature and performance under different mounting and operational conditions. *Solar Energy Materials and Solar Cells, 95*(1), 373 -376. https://doi.org/10.1016/j.solmat.2010.04.022