Experimental Analysis of Performance Degradation of Photovoltaic Solar Panel for Central Indian Weather Condition

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Abstract- **The extensive growth has seen in PV manufacturing industry and installed capacity of solar power plants in the last few years. Hence, the investors seek reassurance of their investments by the long-term performance of PV power plants. The main goal of this work is to study of the PV module degradation under the open circuit and close circuit condition in central India region. For the analysis the two methods i.e. IV curve and visual inspection has been carried out. The experimental analysis has been carried out to asses the degradation of solar panel performance. There is significant decrement in solar panel in terms of maximum power, short circuit current, voltage, efficiency and fill factor has been observed and demonstrated.**

Index Terms- Photovoltaics, Solar panel degradation, IV curve, Visual inspection, fill factor, module temperature.

I. INTRODUCTION

All the renewable energy sources start totally from the sun. The sun's beams that achieve the external climate are subjected to ingestion, reflection, and transmission forms through the environment before achieving the world's surface. Then again, contingent upon the world's surface geography, as clarified by Neuwirth (1980), the sunlight based radiation demonstrates distinctive appearances. The rise of enthusiasm for sun oriented energy usage has occurred since 1970, basically because of the then increasing expense of energy from ordinary sources. Sun oriented radiation is the world's most bottomless and lasting energy source. The measure of sun based energy gotten by the surface of the earth every moment is more noteworthy than the energy use by the whole populace in one year. For the present, sun based energy, being accessible all over the place, is appealing for remain solitary frameworks especially in the rustic parts of creating countries.

1.2 Photovoltaic solar energy (solar electricity)

1.2.1 Introduction to photovoltaic solar energy

The energy of solar radiation is directly applied in mostly two procedures:

i) Direct conversion into electricity that takes place in semiconductor devices called solar cells

ii) Accumulation of heat in solar collectors.

1.3 Photovoltaic applications and market

The change effectiveness of sun powered cells utilized in space applications is the underlying productivity estimated before the sun based cells are propelled into the space. This change effectiveness is likewise alluded to as the start of-life productivity. The present business PV frameworks in earthbound applications convert sunlight into electricity with effectiveness running from 7% to 17%. They are exceedingly solid and most makers give something like 20 years ensure on module execution. If there should be an occurrence of the thin-film sunlight based cells the best change productivity that has been accomplished in research facility is demonstrated together with the transformation effectiveness that is common for business sun oriented cells.

II-LITERATURE REVIEW

Information on long haul execution and debasement of field-matured sun based photovoltaic modules is broadly perceived as vital for proceeded innovative enhancement and market certainty. It is likewise vital

that such research should cover different topographical areas of the globe.

The impact of ultrasound on current {voltage attributes of crystalline silicon sun powered offer was researched tentatively. The transverse and longitudinal acoustic waves were utilized over a temperature scope of 290(340 K). It was discovered that the ultrasound stacking prompts the reversible reduction in the photograph produced current, open {circuit voltage, ll factor, transporter lifetime, and shunt opposition and in addition the expansion in the ideality factor. The test results were depicted by utilizing the models of coupled deformity level recombination, Read {Hall recombination, and dislocation} initiated impedance. The commitment of the boron-oxygen related deformities, press boron sets, and oxide accelerates to both the bearer recombination and imperfection communication was talked about. The tentatively watched wonders are related with the expansion out there between coupled deformities and in addition the augmentation of the bearer catch coefficient of complex point imperfections and disengagements. (O.Ya. Olikh: 2018)

David A. Quansah and Muyiwa S. Adaramol; 2018 presents an investigation on twenty-nine (29) crystalline silicon modules sent in lattice associated, battery-charging and water-pumping applications. The modules, introduced at six unique areas in Ghana were matured somewhere in the range of 6 and 32 years. Pinnacle control (Pmax) misfortunes ran from 0.8%/year e 6.5%/year. The Pmax misfortunes were overwhelmed by misfortunes in fill factor (FF) and short out current (Isc). Outwardly perceptible imperfections are likewise detailed.

III-RESEARCH METHODOLOGY

Pioneers have three fundamental difficulties to achieve: Energy Security, Social Equity, and Environmental Impact Mitigation. PV (Photovoltaic) boards present a genuine answer for these difficulties. A photovoltaic framework does not have moving components as conventional power age units, it likewise does not work at high temperature. Be that as it may, debasement of PV boards and blames jumping out at these boards present a significant issue in diminishing their proficiency and unwavering quality. To evaluating the deficiencies following system can be received.

3.1 Theoretical Frame work

Basic Parameters of the Solar Cell

Some basic parameters essential for understanding the characteristics curve of the solar cell are discussed.

Overall current (I)

The overall current (I) flowing through a solar cell is given by the following equation:

$$I = I_D - I_L$$

Or

$$I = I_0 \left[\exp\left(\frac{eV}{kT}\right) - 1\right] - I_L$$

Where I_D is the diode dark current; and I_L is the light induced current I_0 leakage current.

Short circuit current (I_{SC})

The short-circuit current is the light-induced current that occurs when the load in the circuit is zero, i.e., both terminals (positive and negative) of the solar cell are connected together

Open-circuit voltage (V_{oc})

The open-circuit voltage is the voltage across the solar cell when there is no current flowing in the circuit, i.e., there is infinite resistance between the terminals of the solar cell. This can be expressed as follows:

$$V_\infty = \frac{kT}{e} In \left(\frac{I_L}{I_0} + 1\right)$$

The open-circuit voltage is the voltage of the maximum load in the circuit.

I–V characteristics

For a perfect sun-oriented cell, the arrangement opposition must be zero and the shunt obstruction must be interminable. For better execution of a sunlight-based cell, the arrangement obstruction must be kept as least as would be prudent and the shunt opposition must be as expansive as could reasonably be expected. In business sun-based cells, the shunt obstruction is vast and is ignored contrasted and the forward opposition of the diode.

The optimum load resistance R_L (P_{max}) = R_{pmax} corresponding to the maximum power delivered from the solar cell is obtained as follows:

$$P_{max} = V_{P\,max} I_{Pmax}$$

The efficiency is defined as

$\eta = P/\emptyset$

where P = V × I is the power delivered by the PV generator;ϕ= I_T × A is the solar radiation falling on the PV generator; and I_T is the solar intensity; and A is the surface area irradiated.

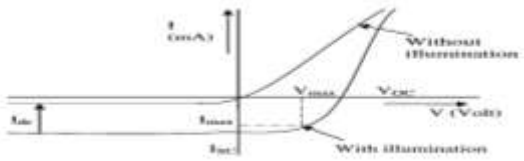

Figure 3.1 I–V characteristics of a solar cell with and without illumination *(from Tiwari and Mishra)*

Fill factor (FF)

The fill factor gives an idea of the maximum power output withdrawn from the solar cell for a given V_{oc} and I_{sc}. The value of FF under ideal conditions is unity. Deviation from the ideal value is due to defects and contact resistance. The lower the value of the FF, the less sharp will be the I–V curve . For an Si solar cell, the maximum value of FF is 0.88.

$FF = \frac{P_{max}}{V_{oc} \times I_{sc}}$

Maximum power (P_{max})

Output power from a solar cell is obtained by multiplying the output voltage and output current as given below:

$P_{out} = V_{out} \times I_{out}$

Similarly, the maximum power is obtained by multiplying V_{max} and I_{max}. This corresponds to the maximum value of product IV on the characteristics curve.

Hence,

$P_{max} = V_{max} \times I_{max}$

Solar cell efficiency (η_{ec})

The solar cell power conversion efficiency can be given as

$\eta_{ec} = \frac{P_{max}}{P_{in}}$

$\eta_{ec} = \frac{V_{max} \times I_{max}}{Incident\ solar\ radiation \times Area\ of\ solar\ cell}$

To characterize a PV array as a power source, it is very important to determine its main parameters that help in studying its performance. These main parameters are short circuit current, open circuit voltage, maximum output power, fill factor, and instantaneous efficiency. To simplify the analysis, the following assumptions are considered:

1. The shunt resistance of PV array (Rsh) is infinite, so that the current in the shunt resistance (Ish) can be neglected.
2. The short circuit current of PV array (Isc) is equal to their light generated current.
3. The series resistance of PV array (Rs) is independent of incident solar radiation and modules surface temperature.

3.3 Description of installations and locations

3.3.1 Photovoltaic test field

The photovoltaic platform shown in Figure 3.2 is used in this study. It is installed at Jabalpur in Madhya Pradesh. Jabalpur is located in India with the latitude and longitude of 23.1815° N, 79.9864° E. It presents the mixed rainy, cold and hot tropical climate characterized by three seasons: a hot season from March to June, rainy season from July to October and winter season from November to February. Jabalpur has a significant solar potential with annual average radiation of exposure rate of 5.25 kWh/m^2/d. This radiation varies from maximum value of 7.07 kWh/m^2/d in Summer season and the minimum value of 3.46 kWh/m^2/d in rainy season. The average temperature of the region is about 33.3°C. The average relative humidity varies between 6% and 71%. Platform consists of monocrystalline and polycrystalline photovoltaic modules. The two modules which have been considered for the study are on the roof top of the engineering college. One of them are not in use from the last six month i.e. open circuit while the other one is in use with inverter connection. Thus, performance parameters (I–V and P–V curves, Voc, Isc, FF and Pmax) are measured under the standard test conditions (AM1.5, 1000 W/m^2, 25 °C).

The optimum tilt angle about 30° has been considered for the panels.

Figure 3.2 Solar panel considered for the study

3.3.2 Field Measurements

To begin testing, the battery was turned off as a safety parameter. Then the panels were cleaned with water, according to the frequency of cleaning originally proposed. Water was utilized to give a more careful perusing since it expels the littlest particles from the board. Another information is additionally recorded like temperature wind speed and moistness. The accompanying advances are taken after.

With the start with impede yield terminals of the PV boards are shorted with a wire. At that point the short out current and board yield voltage are estimated.

A substantial variable resistor is then associated with the board, beginning from bring down protection from higher one so the board voltage increments from zero toward open circuit in ventures of roughly 2~3V. Voltage and current for every resistor are estimated and recorded in the table. The information recorded is utilized to draw the I-V bend. This strategy is rehashed for various tilt points.

Figure 3.3 Circuit Arrangement for Analysis

3.3.3 Data Calculation

The first step in this performance loss rate analysis was to extract and filter outdoor measured experimental datasets for each PV system. The difference between the control and baseline data was used to describe the amount of panel degradation.

IV-RESULT ANALYSIS

4.1 General

The performance of a PV module depends mainly on solar irradiance, ambient temperature, environmental factors such as wind, humidity, nonuniform irradiation due to partial shading and in particular the dust accumulation due to pollution in atmosphere.

The extensive growth has seen in PV manufacturing industry and installed capacity of solar power plants in the last few years. Hence, the investors seek reassurance of their investments by the long-term performance of PV power plants. The performance of PV modules and balance of systems are gradually reduced with time. But, the PV module manufacturers guarantee against this power loss at 80% of name plate Pmp after 25 years by assuming 0.5% efficiency loss per year.

4.2 Module Temperature

For analysis the module temperature difference, for both the panel the readings have been recorded under real climatic conditions in two different days (clear, cloudy) in order to investigate the effect of solar irradiance and temperature on the performance parameters like power, voltage, efficiency etc., the measurements of I-V and P-V characteristics were also carried out for both days (clear, cloudy) almost in the same times.

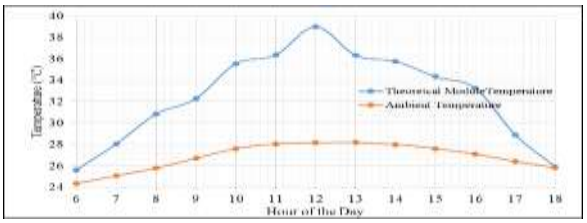

Figure 4.1 Theoretical Variation of Module Temperature

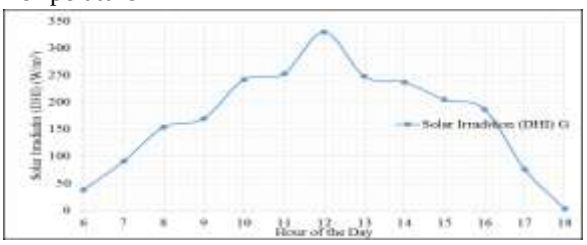

Figure 4.2 Solar Irradiation Variation on the day of reading

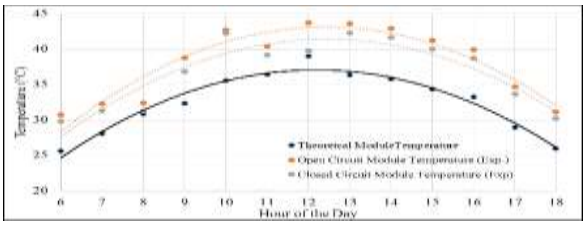

Figure 4.3 Solar module Temperature variation for both the panel on a single day reading

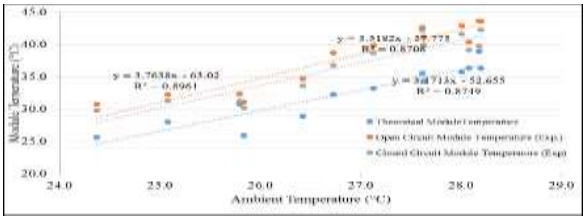

Figure 4.4 Solar module Temperature variation for both the panel with respect to Ambient Temperature

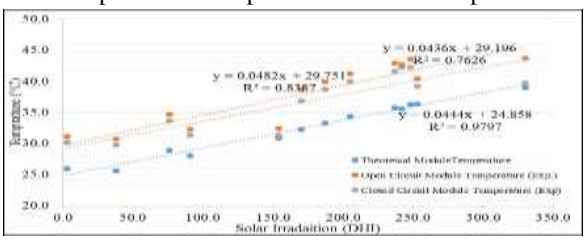

Figure 4.5 Solar Module Temperature variation for both the panel with respect to Solar Irradiation (DHI) (W/m^2)

4.3.2 Comparison for Closed Circuit Solar Panel for the duration of 150 days

For find out the degradation rat of solar panel in Jabalpur region a solar panel which was in continues use are analyzed with the help of IV characteristics, in a difference of 150 days of working.

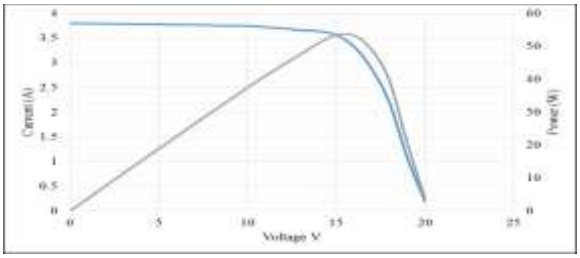

Figure 4.9 IV curve for Closed circuit Panel for single day reading in the month of April

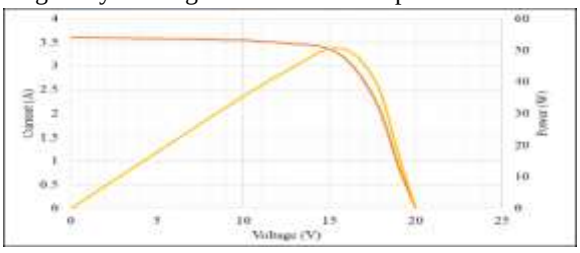

Figure 4.10 IV curve for Closed circuit Panel for single day reading in the month of September

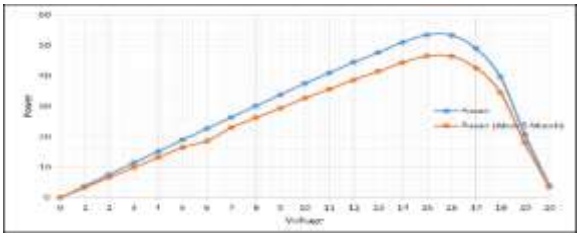

Figure 4.11 Maximum power comparison for both the day reading for closed circuit solar panel.

V-CONCLUSION AND FUTURE SCOPE

Performance and degradation assessment are important for development of PV industry and determines the potential for electricity generation of a particular area. The performance analysis done at Standard Test Condition cannot be a true representative for field exposed conditions.

There are two different analysis has been carried out. First is for comparative analysis of two solar panels one is in continuous operation and other is out of service from last 6 months. Second analysis has been carried out for solar panel degradation for the duration of 150 days.

The following observations has been made:

- It has been observed that as the ambient temperature along with solar radiation increases the theoretical value of module temperature also increases. At the noon it is maximum as the both solar radiation and ambient temperature is maximum.
- It has been observed that the open circuit module temperature was higher than the closed-circuit module temperature. The panel which was not in service was heated more than the panel which is in continuous service.
- It has been observed that at around 12 o'clock the panels most heated as ambient and solar radiation both are maximum.
- It has been observed that as the ambient temperature increases the module temperature also increases. Open circuit module temperature is more compare then the closed-circuit module temperature.

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