Rahul Rana, 2022, 10:1
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

A Review of Performance Analysis of MPPT Connected Solar Photovoltaic System

M.Tech. Scholar Rahul Rana, Guide Abhishek Dubey, Head Dr. Shweta Chourasia
Department of Electrical & Electronics
Bhopal Institute Technology of science
Bhopal,MP,India

Abstract- For electric power generation, solar technology is the preferred trend. Solar photovoltaic systems connected to the grid are a cost-effective way to generate electricity on a large scale. Such large power systems operate effectively on the grid. A 150KW grid connected solar photovoltaic system was designed and modelled in this study, and the results were compared to real-time data. Renew System Cells is the model used for real-time data. It's a Silicon Polycrystalline Module. We looked at the design and annual performance of a grid connected solar photovoltaic power plant in this paper. We also looked into how the output power of the SPV system degraded.

Keywords- maximum PV power; solar energy; MPPT.

I. INTRODUCTION

Solar energy is an area of electric power generation that is rapidly expanding. It is completely eco-friendly as this method of generating electric power relies solely on the photovoltaic effect, which produces no emissions. In the last decade, renewable energy technologies (solar and wind energy) have rapidly replaced conventional energy technologies.

Renewable energy is directly linked to our economic development of the country [1] and pollution-free climate, while non-conventional energy sources have their own set of limitations, including being limited, expensive, polluting, and contributing to global warming. Solar energy is the basis of our analysis. Solar photovoltaic (PV) modules are having 80% cost reduction than conventional energy sources. This data has been analyzed by International Renewable Energy Agency in 2009 [2].

The cost of generation of electricity form solar energy has reduced to one third in last decade and is constantly reducing. The motive of our study is to design solar photovoltaic system and to compare its performance with real time SPV system. For this purpose, real time data of 150KW power plant installed on the roof top of new girl's hostel of the Integral University. The material used in the module is poly-crystalline silicon.

It is a 320 watt module containing 72 cells. To generate 150KW, 460 modules are connected in series and parallel with 3 inverters of 50 KVA each. This model is designed and simulated on MATLAB/Simulink with the help of standard module parameters.

The main objectives to install 150 KWp are to supply non-stop electricity in the campus with pollution free environment. It is also the biggest source to provide real-time data for study. This study is done at Integral University, Lucknow, capital of Uttar Pradesh in India. According to map the standard latitude and longitude coordinates are 26°50'21.41"N, 80°55'23.27"E.

The Ministry of New& Renewable Energy has targeted solar power i.e., ground mounted 10000 MWp and has achieved 24582 MWp as on 31 December 2018. Roof top solar generation target was 10000 MWp, however, the achievement was reported 1443 MWp [3], with a 15otilt to position the module w.r.t. ground.

In this paper we have designed the model using MATLAB and the simulation result of the model is compared with the real time 150 KW solar power plant at the roof top.

II. CONSTRUCTION AND WORKING OPERATION OF SOLAR CELL

The solar cell diode is not the same as a p-n junction diode. On top of a thick layer of n-type semiconductor, a thin layer of p-type semiconductor is fabricated. As shown, light can pass through a thin electrode on top of a p-type semiconductor and reach the p-type semiconductor.inFig.1.

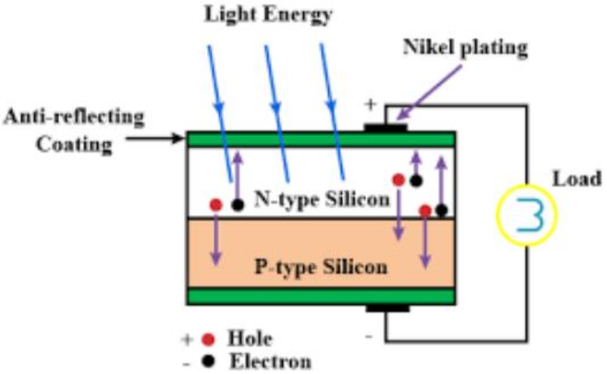

Fig 1. Cross-sectional view of solar cell diode.

A pn junction diode is a basic solar cell. When the sun's rays strike the solar cell's pn junction, photons enter the junction and the thin p layer supplies enough energy to the pn junction to generate an electron hole pair. The n region is heavily doped and thin, allowing light to easily pass through. Because the p region is lightly doped, the p side contains the majority of the depletion region.

The wavelength affects penetration, and the absorption coefficient rises as the wavelength decreases. In the depletion region, electron hole pairs (EHPs) are formed. Electrons move to the n region and holes to the p region due to the built-in potential and electric field. This happened once [4].

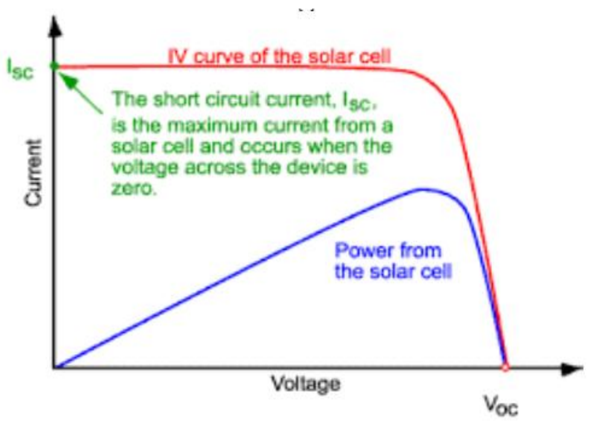

Fig 2. I-V and P-V characteristic of solar cell.

I-V and P-V characteristics shown in Fig. 2 [5]. During night, when there is no sun light, the solar cells are inactive. It simply behaves as p-n junction diode and remains connected to the external load, producing reverse saturation current or also called the dark current [6].

III. FABRICATION OF CRYSTALLINE SILICON PHOTO VOLTAIC CELL

Metallurgical-grade is silicon with a purity of 98 percent or higher that is used in the metallurgical industry. Because MSG with a purity level of 98 percent is insufficient for use in the fabrication industry, it is further processed to achieve extremely pure electronic-grade silicon. Solar cells and liquid crystal displays are made from slightly purer upgraded metallurgical-grade silicon.

High purity silicon metal is classified into three grades: metallurgical grade (1N-2N), high purity and special grade (3N-4N), and solar grade (5N+), where N refers to a figure of 9's with a decimal part for 99 percent purity. As a result, 5N = 99.999 percent. Through the carbo-thermal reduction process, metallurgical grade silicon (MGS) is produced from silica with a purity level of 2N-3N. The MGS is then passed on to the next stage.

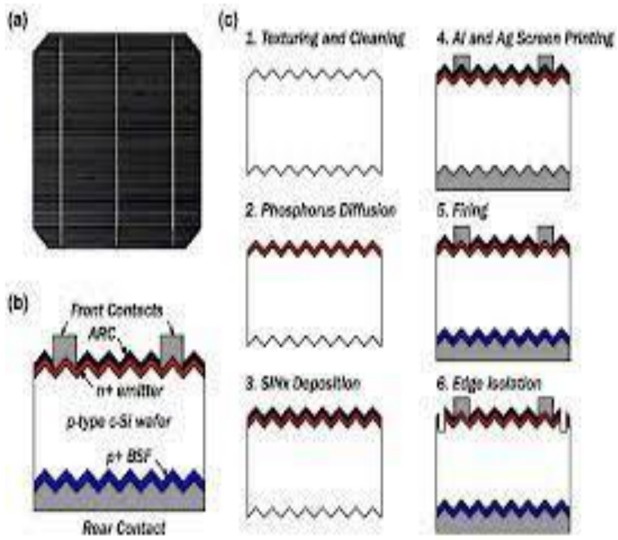

Fig 3. Fabrication of Crystalline Silicon Photo Voltaic Cell.

The polycrystalline material is further produced into mono crystalline and polycrystalline silicon as shown in Fig. 3 (a) and (b). Mono-crystalline silicon is produced by czochralski (CZ) method and multi-crystalline Si through solidification (brick casting) method. Mono-crystalline silicon is sliced into wafers but multi-crystalline Si is melted into a brick, diced and then sliced.

Wafers may be square or hexagonal in shape. The efficiency of multi-crystalline silicon is less than mono-crystalline silicon by1.5%to 2%but the fabrication cost of poly-crystalline is less than mono-crystalline silicon.

The photo voltaic cell is made from crystalline silicon fabricating on a thin layer of the wafer with phosphorous–doped N-type layer on the boron-doped P-type layer. Due to low cost, a multi-crystalline silicon photovoltaic module is more preferred than mono-crystalline. Due to multi-grain crystallization orientations and grain boundaries, it is difficult to passivity. The crystallization defects and contamination reduce conversion efficiency. Cross sectional view of crystalline silicon solar cell isshowninFig.3c.

III. DESIGNING AND MODELING OF THE SOLAR PHOTO VOLTAIC SYSTEM

In MATLAB/SIMULINK, the model is created. Model Renew Sys DESERV 3M6 72 Cells-320 Watt, manufactured by Renew Sys, was chosen for the development of this model. It's a silicon module with multiple crystals. It's a grid-connected photovoltaic generation system with a capacity of 150 KW, installed on the roof of our university building.

The 150KW Renew Sys DESERV 3M6 power generation system is made up of 460 modules and three 50KVA inverters. Simulink is used to create a mathematical model of the solar photovoltaic system. The internal architecture of a 150 KW solar photovoltaic power generation system is depicted in Fig. 4. Is shown in Fig.5.

The equation used to model the SPV system are mentioned while modeling the sy

$$I = I_{ph}.N_p - I_{d1} - I_{sh} \quad \text{(i)}$$

$$I = I_{ph} - I_o\left(e^{(\frac{V_d}{\propto V_t})} - 1\right) - \left[\frac{(V+I\,R_{sh})}{R_{sh}}\right] \quad \text{(ii)}$$

The total current at the load is equal to the sum of photon current multiplied by the number of parallel cells, current across the diode, and current across the shunt resistance, as shown in equation I.

The PV array is divided into two sub-systems: Vcell (voltage across the cell) and Icell (current across the cell), as shown in Fig. 6. It is made up of two models: Vc and Ic.

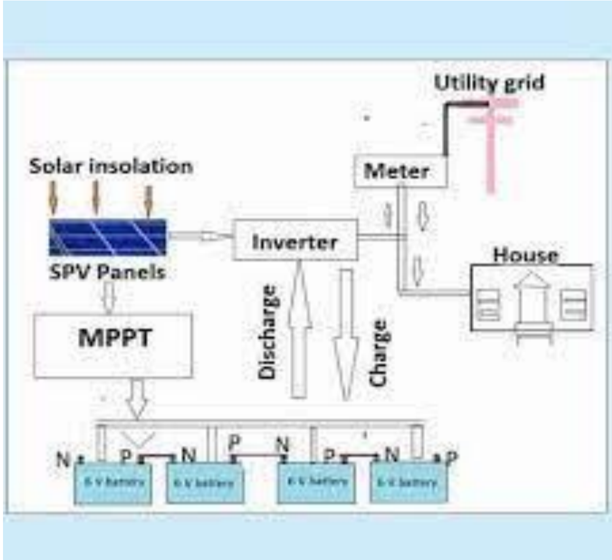

Fig 4. Designing and Modeling of the Solar Photo Voltaic System.

The internal architecture of the model Vcell to get open circuit voltage (Voc) is shown in Fig. 7. The open circuit voltage is given by

$$V_{oc} = \frac{m.k.t_{op}.N}{q} I_n\left(\frac{I_{ph}}{I_o}\right) \quad \text{(iii)}$$

$$I_{ph} = G_K[I_{sc} + K_I\left(T_{op} - T_{ref}\right)] \quad \text{(iv)}$$

$$V_{cell} = V_{oc} - I_c . R_s \quad \text{(v)}$$

Where,
ISC= Short circuit current (9.06A)
K =Boltzmann Constant
TOP=Operating value of temperature
TREF=Reference value of Temperature (25oC)
GK=Solar irradiance ratio N=No. of cells

$$G_K = \frac{G_{op}}{G_{ref}}$$

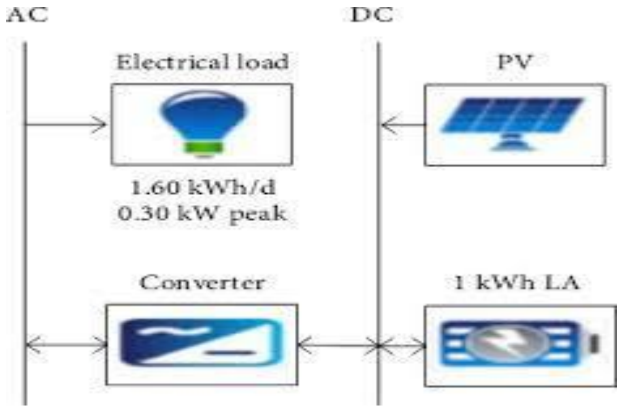

Fig.5. Internal architecture of 150 KWSPV.

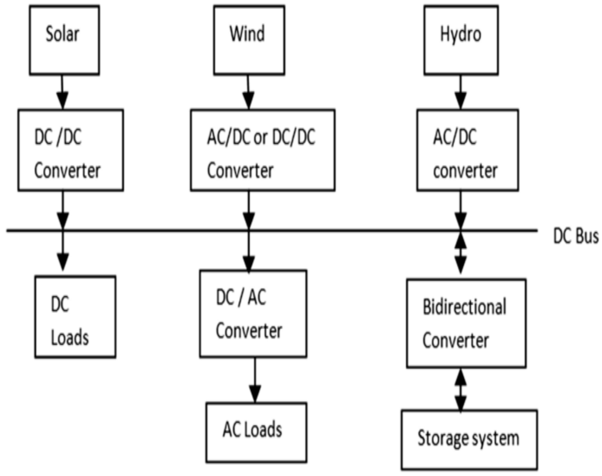

Fig 6. **Block diagram.**

The internal architecture of the model of cell current is shown in Fig. 8. In the given model we have taken alpha (α) as +0.50%/ °, beta as-0.30%/ °C and gamma as -0.40%/ °C the cell current is given as

$$I_{cell} = \frac{(T_{op} - T_{ref})Y}{G_k}$$

And

$$I_{sc} = \frac{G_{op}}{G_{ref}} + 1,$$

Where G_{OP} is the actual irradiance and G_{ref} is the nominal irradiance. The SPV system is simulated by varying the modules in series and parallel shown in the simulation Table2.

Condition 1: series (22modules) and parallel (22modules)
Condition1: series (53modules) and parallel (9modules)

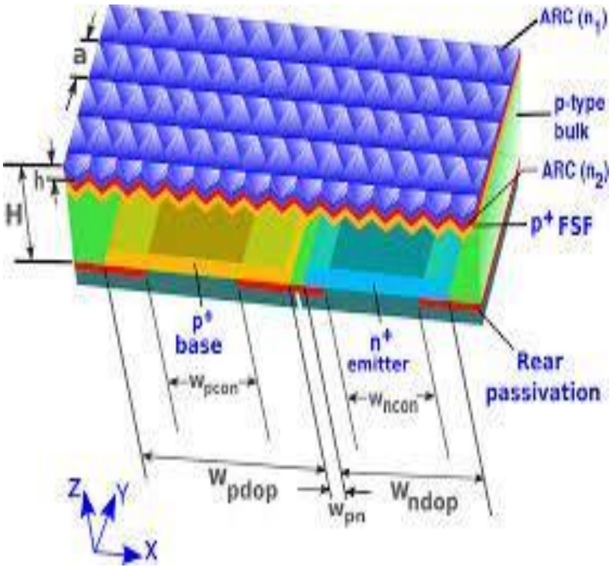

Fig 7. Internal architecture of the model Vcell to get open circuit voltage (Voc).

Condition1, 21.45 modules (Approx. 22 modules) and 21.5 modules (Approx. 22 modules) are connected in series and parallel respectively. Condition 2, 52.8 (Approx. 53 modules) modules are connected in series and 9 modules in parallel respectively. Condition 1, show 55% of 1 module in series and 50% of 1 module is parallel are partial shading. In condition 2, show 20% of a single module in series is partially shaded. Shading affects the performance of SPV system [8].

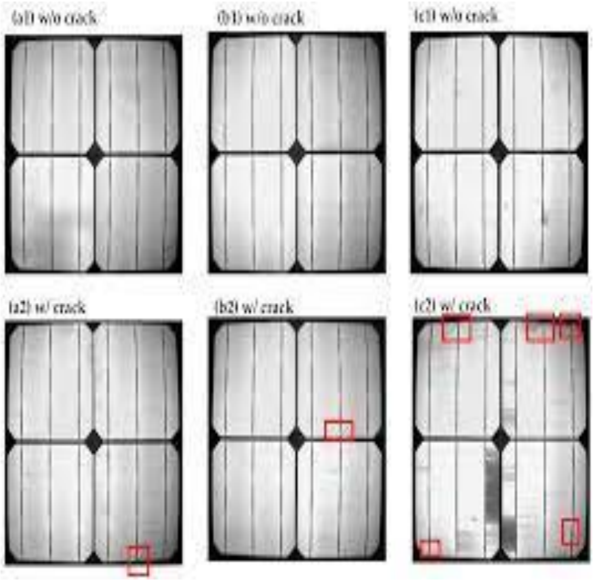

Fig 8. Internal architecture of the model of cell current.

There are many reasons of shading. Shading may occur due to feces of birds [9, stains due to water drops in a rain [3, 2], dew drops, sticky dust

accumulated on the module [10, 11] dew drops, dead leaves [12, 13], and shadow of trees [14].
Shading may also result in overheating of module causing hotspot [15]. Hotspot damages the junction of the diode hence affecting the performance of SPV system. Performance of SPV system is also affected by high temperature [14], humidity, moisture, snow fall [16], ultra violet radiation and also environmental gases [5] and exhibit characteristic degradation [17].

IV. CONCLUSIONS

We observed that power varies by varying number of modules in series and parallel. In our study we analyzed that by varying numbers of series and parallel combination, simulation value of output power remains same i.e, 150 KWp (under partial shading). In condition 1 when 21.45(22) and 21.5(22) modules are connected in series and parallel respectively and in condition 2 when 52.8 (53) modules in series and 9 modules in parallel respectively gives 150 KW output power.

This shows that in condition 1, one module in series and one module in parallel are 55 % and 50 % partially shaded where as in condition 2, shows that only one module connected in series with 20% partially shaded. Though the number of modules in series and parallel vary output power remains the same. We also observed the percentage error between theoretical power and simulated power.

It is seen that percentage error is very small and is 0.65 % and 0.75 % for condition 1 and condition 2 respectively. The degradation in output p0wer is observed as 4.6% in condition 1 and 0.33% in condition 2. From this analysis we also analyzed that in series connection output power degradation is very less compared to parallel connection. From real time data analysis, we observed that three inverters are connected to get 150 KW power at the load though different numbers of modules are connected in series and parallel.

REFERENCES

[1] Jiahe Chen, Energy Efficiency Improvements in Smart Grid Components submitted: June 22nd 2014 Reviewed: September 8th 2014 Published: by Intech Open; 2014. DOI: 10.5772/59171.

[2] Chapter 2 Traditional silicon material, cell structure and processes for silicon based solar cell, Intech Open; 2015.

[3] Pratish Rawat et al, Simulation and Performance Analysis of 100 KWp Grid Connected Roof top Solar Photovoltaic Plant Using PVSYST, International Journal of Science and Research (IJSR)ISSN(Online):2319-7064.

[4] Cheung N. U.C. Berkeley, Solar Cells Fabrication Technologies,Available:http://wwwnst.eecs.berkeley.edu/~ee143/fa10/lectures/Lec_26.pdf.

[5] Kavita Singh et al, Effect of bypass diode under partial shading in SPV module: A review, International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878.2019; 8(1).

[6] Kavita Singh et al, Effect of Bypass Diode under Partial Shading in SPV Module, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249-8958. 20419; 8(5).

[7] FanX, Zhao DJ. Availability of identified non-conventional resources of energy–Their potential Vis-À-Vis Utilization, Ministry of New and Renewable Energy, Twenty-Ninth Report Standing Committee on Energy (2011-12), India. Math. Anal. Appl. 2001; 263:749-760. Available: http://re.indiaenvironmentportal.org.in/files/file/Availability%20of%20Identified%20Nonconventional%20Resources%20of%20Energy

[8] Renewable Power Generation Costs in 2017, International Renewable Energy Agency (IREA) Abu Dhabi. Copyright © IRENA; 2018.ISBN978-92-9260-040-2, Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_2017_Power_Costs_2018

[9] Government of India, Ministry of New and Renewable Energy, Physical Progress achievement, Available: https://mnre.gov.in/physical -progress-achievements

[10] Ohajianya AC, etal, Construction of a Solar Panel Using Solar Oven for the Panel Lamination, Advances in Science and Technology. 2015; 9 (1 & 2): 6-13.

[11] Nisha Sharma, modeling, Simulation and Analysis of 100 KW grid connected PV System using MATLAB/Simulink

[12] Reza Asad pouretal. Electrical signatures of corrosion and solder bond failure in c-Si Solar Cells and Modules, IEEE J. Photo volt. 2019; 9(3). Available: https://www.globenewswire.co m/news-release/2019/02/27/1743610/0/en/PyroGenesis-Announces-Latest-PUREVAP-GEN2-Results-Provides-Update. Html

[13] Tarana Afrin Chandel et al. Modeling and simulation of photovoltaic cell using single solar cell and double solar cell model, International Journal of Innovative Technology and Exploring Engineering. Scopus Indexed and UGC Journal. ISSN: 2278-3075.209; 8(10):558-565.

[14] Tarana Afrin Chandel et al, Oxidation: A dominant source for reduced efficiency of silicon solar photo voltaic modules. Materials today Proceedings, Journal Elsevier. Available: https://www.sciencedirect.com/science/article/pii/S2214785320305782?via%3Dihub

[15] Basharat Jamil et al, Estimation of solar radiation and optimum til tangles for south-facing surfaces in Humid Sub tropical Climatic Region of India, Engineering Science and Technology, an International Journal. 2016; 19:1826–1835. Hosted be Elsevier, Available: https://doi.org/10.10 16/j.jestch.20 16.10.004

[16] Solar Electric System Design, Operation and Installation, An Overview for Builders in the U.S. Pacific North west, October 2009, © 2009 Washington State University Extension Energy Program, WSUEEP09-013

[17] GAURAV ARORA et al, International Advanced Research Journal in Science, Engineering and Technology (IARJSET), National Conference on Renewable Energy and Environment, (NCREE-2015), IMS Engineering College, Ghaziabad. 2015; 2(Special10). DOI:10.17148/IARJSET

[18] NingYi Dai, Multifunctional voltage source inverter for renewable energy integration and power quality conditioning, Hindawi Publishing Corporation, Scientific World Journal. 2014; 2014:1-10. Article ID421628. Available: http://dx.doi .org/10.1155/2014/421628

[19] K Prasada Rao. Development of A grid connected inverter for solar pv systems with energy capture improvement based on current control strategy, International Journal of Scientific and Research Publications. 2013; 3(4): SSN2250-3153.

[20] Pratish Rawat and Yashika Rawat Simulation and Performance Analysis of 100 KWp Grid Connected Rooftop Solar Photovoltaic Plant Using PVSYST, International Journal of Science and Research, ISSN: 2319-7064, pp515.

[21] Dongmin Xi*, Linjing Hu, Xiaodong Li, Power Grid and Alternating Current Distribution Research of Renewable Energy Generate Electric Power's Village System, Elsevier Energy Procedia. ICSGCE 2011, Chengdu, China. 2011; 12:328-334.

[22] Solar Energy Grid Integration Systems—SEGISǁ, Program Concept Paper October, 2007, Energy efficiency and renewable energy, U S Department of energy, Energy efficiency and renewable energy, US Department of energy; 2007.

[23] Solar Energy Grid Integration Systems: Final Report of the Florida Solar Energy Center Team, SAND 2012-1395 Unlimited Release Printed; 2012.

[24] Brain K Perera, Point of common coupling (PCC) voltage control of a grid-connected solar photo voltaic (PV) system, IECON. - 39th Annual Conference of the IEEE Industrial Electronics Society; 2013.

[25] Texas Instrument, Introduction to Photovoltaic Systems Maximum Power, Application Report, SLVA446; 2010. Leinics, Basics of MPPT Solar Charge Controller

[26] Tarana Afrin Chandel et al. Performance of Partially Shaded Solar Photo voltaic System, International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, 2019; 7(6). Networks.