iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** IX **Month of publication:** September 2021

DOI: https://doi.org/10.22214/ijraset.2021.38176

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue IX Sep 2021- Available at www.ijraset.com

Performance Analysis of 3kW Residential Grid-Connected Photovoltaic System with Microinverter Topology using System Advisor Model

Shubham Tiwari[1], Dr. Ruchi Pandey[2], Mr. Anand Goswami[3]
[1]*Scholar, M Tech Energy Technology, GGITS Jabalpur, India*
[2]*Professor & H.O.D Electrical and Electronics Engineering, GGITS Jabalpur, India*
[3] *Asst. Professor Electrical and Electronics Engineering, GGITS Jabalpur, India*

Abstract: ***Grid connected rooftop PV systems are the most common form of solar energy utilization that helps home owners to reduce carbon footprint and save money in utility bills. This project focuses on the design and modelling of a 3KW residential PV system connected to a 240V single phase grid. The purpose of this study was to conduct an independent experiment on a photovoltaic system with microinverters, to determine their performance characteristics in shaded and unshaded conditions.***
The systems have fixed tilt angle and fixed azimuth angle. In order to analyse the performance of the systems, the Energy Yield, Performance Ratio, Capacity factor and Annual Energy have been used. This allowed to obtain reliable metrics even with different Irradiance values and different Peak Powers. In the conventional central inverters, several strings of PV modules are combined in order to achieve the power required from the inverter to operate. Strings are connected in parallel and then these strings are led to the inverter after running several meters of DC cables. These cables are often very thick and as a result are very expensive while at the same time, they add losses to the overall system. On the other hand, AC cables are much less expensive and they have fewer losses. A residential system was designed in SAM using specific weather data. The simulation results supported the fact that micro inverters perform well in both shaded and non-shaded conditions. A significant advantage of Micro Inverters is the avoidance of shading losses and mismatch among different PV technologies which consists a great challenge on PV installations. The String Inverter system produced an annual energy of 4763 kWh in the first year with no shading and 4286 kWh in the first year with shading losses.
Keywords: Inverters, Photovoltaic cells, Photovoltaic systems, Solar energy, Solar panels.

I. INTRODUCTION

The use of module level power electronic devices (MLPE) has been proposed to mitigate electrical and thermal mismatch losses in the field by tracking the maximum power point of individual modules. In general, MLPE devices consist of two main categories: micro inverters and power optimizers. In this paper micro inverters and boost power optimizers are considered.[1].
The key challenges of partial shading PV models are therefore to generate accurate yield predictions under heterogeneous irradiance conditions with reduced simulation time. In this paper a model is presented that considers cell shading fractions determined by a 3D model and applies an irradiance model to determine the effective irradiance on a partially shaded cell. Moreover, the model takes into consideration the system architecture and associated power electronics efficiency losses.[2]
Partial shading is considered as the major challenge faced by the roof-top PV system that aims to reduce the power output of the system. All the modules in a string connected in series carries the same current. Partially shaded modules which generate less photon current forcefully carry the current equivalent to the non-shaded modules. Shaded modules, once reverse biased behave as loads and deplete the power from non-shaded modules. The absence of suitable protection for the system can lead to the hot-spot formation and in the worst scenario will cause permanent damage [3].
Integration of PV Systems to existing buildings poses another problem of inevitable partial shading due to neighbouring structures for different seasons. In standard PV systems this shading reduces the total power production to a larger extent than anticipated, leading to higher capital costs as more modules are required. This makes the PV systems less appealing to customers. Hence, the study of partial shading is very important. Also, to make PV systems reliable for all conditions their characteristics under different partial shading conditions needs to be understood.
In the last few years, effects of partial shading on PV system have been thoroughly studied [4], [5]. Since field trial of physical PV modules for partial shading study is expensive, slow and highly dependent on the ongoing atmospheric conditions, it is impractical to examine the effects of partial shading using physical PV modules.

©IJRASET: All Rights are Reserved

Also, it is hard to continue the similar shading type with a greater shaded units and completely unshaded cells for the entire experiment. Hence, it is easier to perform the experiment using a simulation model. In a majority of the studies, partial shading effects which reduce the power output of the PV system have been examined [6], [7].

In this paper, we consider a 3kW system and perform a simulation of the microinverter-based system.

Eight identical panels were used in both of the systems.

A microinverter connected to a single PV module has become a trend for residential grid-connected PV systems, replacing a single inverter connected to a string of series-connected PV modules for many reasons including:

1) Improved energy harvest
2) Improved system efficiency
3) Lower installation costs
4) Plug-N-play operation and
5) Enhanced flexibility and modularity [8, 9, 10]

A. Other Benefits Include

1) Maximum power per panel: The most significant advantage of microinverters is that they are designed to determine each system's optimal voltage and generate maximum peak power.
2) Shade Tolerant: Since each Solar Panel is producing independent of other panels, the performance of a Solar Panel doesn't affect its neighbouring Solar Panel. So, a shaded Solar Panel won't necessarily drop the performance of other solar panels as they work independently. This is not the case with String Inverters.
3) No Air-cooling: These are very small inverters that can fit in the back of a solar panel. Because of its size, one doesn't need to have separate cooling as central inverters. So, less loss in the form of heat.
4) Minimum Maintenance loss: A defective solar panel or an inverter doesn't affect the generation of the solar output from other panels, while a defective Solar String or Central Inverter will bring the performance of the entire array to a halt.
5) Smaller Cable Size: Since output is converted from DC to AC (230V) at the back of the panel, the cable required to carry the current can be of lower diameter.
6) Easily Expandable: Due to its modularity, a solar system can be easily expandable from single panel to multiple panels independent of each other.
7) Suitable for Residential Buildings: Due to its modularity and its size, it's very suitable for residential buildings where each panel can be differently oriented or have different shading pattern during the day.

At first glance, the string inverter appears to have a lower per-watt capital cost when just the inverter is considered. However, the inverter represents only about 15% of the entire PV system cost whereas the installation labour and balance of system (BOS) cost account for 40%, depending on the system configuration and inverter technology. These factors have made it difficult to perform a comparative cost study.

An alternating-current photovoltaic module (ACPV) is created when the microinverter is directly attached to a single PV module [19]. The result is a PV module that produces AC power without any extra electronic components. The implication, however, that since the power electronics is indelibly integrated with the PV module, the microinverter must have a lifetime that matches the PV module - namely 25 years. Hence, most of the microinverter manufacturers are now providing a standard 25-year warranty [11, 12, 13].

©IJRASET: All Rights are Reserved

II. METHODOLOGY

1) For this project we will concentrate on the PV system design and analysis. This chapter will focus on a step-by-step approach on how to model residential PV systems using SAM. We take into consideration all the various factors and constraints that need to be considered for an efficient design.

2) System Advisor Model (SAM) is a modelling tool developed by NREL and is funded by the US Department of Energy [22]. SAM is a free software and can be used for technical and economic modelling of sustainable systems such as photovoltaic, wind, and geo-thermal. SAM is a very user-friendly software that has been designed for students, researchers, and professionals. SAM can be used for a feasibility study. With a huge database of PV system components and the manufacturer's pricing and datasheet we can model an actual system and then by entering location specific weather files and utility electricity rates we can run simulations and analyse technical and economic feasibility study before starting any installation work.

A. Simulation Parameters

In SAM we can specify the DC system size by either specifying the desired array size and letting SAM automatically calculate the string configuration to best match the required array size, or we can specifically input specific modules and inverters. This could be entered in the system sizing module. All the sizing parameters in SAM are based on the manufacturer's specification sheet as per standard test conditions. The variations in output for actual can only be understood once we run the simulation after selecting specific weather data for specific locations.

1) The PV Module Selection for 3kW Micro Inverter is LG NeON® R Solar Panel 370W High Efficiency LG NeON® R Solar Panel with 60 Cells (6 x 10), Module Efficiency 21.4% Monocrystalline/N-type Cell

2) The Inverter selection for 3kW Micro Inverter is Enphase IQ 7+ Micro™ IQ7plus-DS-EN-US 240V
The String Configuration for 3kW Micro Inverter is 1S 8P

3) The Tilt for 3kW Micro Inverter and 3kW is fixed 23.15 deg and 180 deg azimuth

4) The Shading for 3kW Micro Inverter is described below

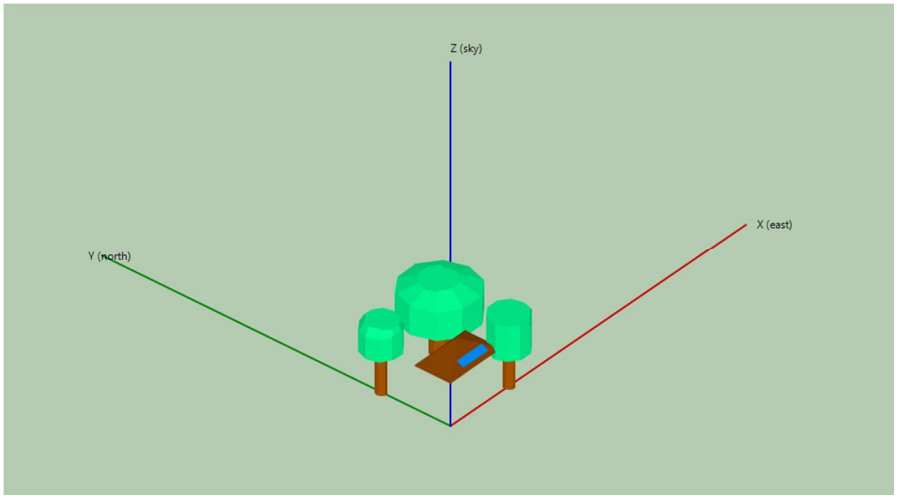


Figure 1 3D View of the solar array with tree shading

Constant sky diffusion shading loss is calculated to be 10.083

III.CONCLUSIONS

To understand the technical analysis SAM is capable of, this project includes a simulation of a 3kW residential rooftop PV system in the city of Jabalpur, Madhya Pradesh, India. Specific weather data were used in this simulation.

Using all the input data and the weather files selected SAM runs a detailed simulation which helps system designers to conduct detailed feasibility study. This project focused on residential rooftop PV systems. A 3kW grid connected PV system was designed and modelled in SAM. The working and design of different system components were presented. The comparison of micro inverter and string inverter was performed. A residential system was designed in SAM using specific weather data. The simulation results supported the fact that micro inverters perform well in both shaded and non-shaded conditions.

©IJRASET: All Rights are Reserved

1) The Micro Inverter system produced an annual energy of 4916 kWh in the first year with no shading and 4332 kWh in the first year with shading losses.

Micro Inverter without Shading

Performance Metrics For Micro Inverter without Shading

Metric	Value
Annual energy (year 1)	4,916 kWh
Capacity factor (year 1)	18.9%
Energy yield (year 1)	1,659 kWh/kW
Performance ratio (year 1)	0.76

Monthly Energy Production of Micro Inverter without Shading

Micro Inverter with Shading

Performance Metrics for Micro Inverter with Shading

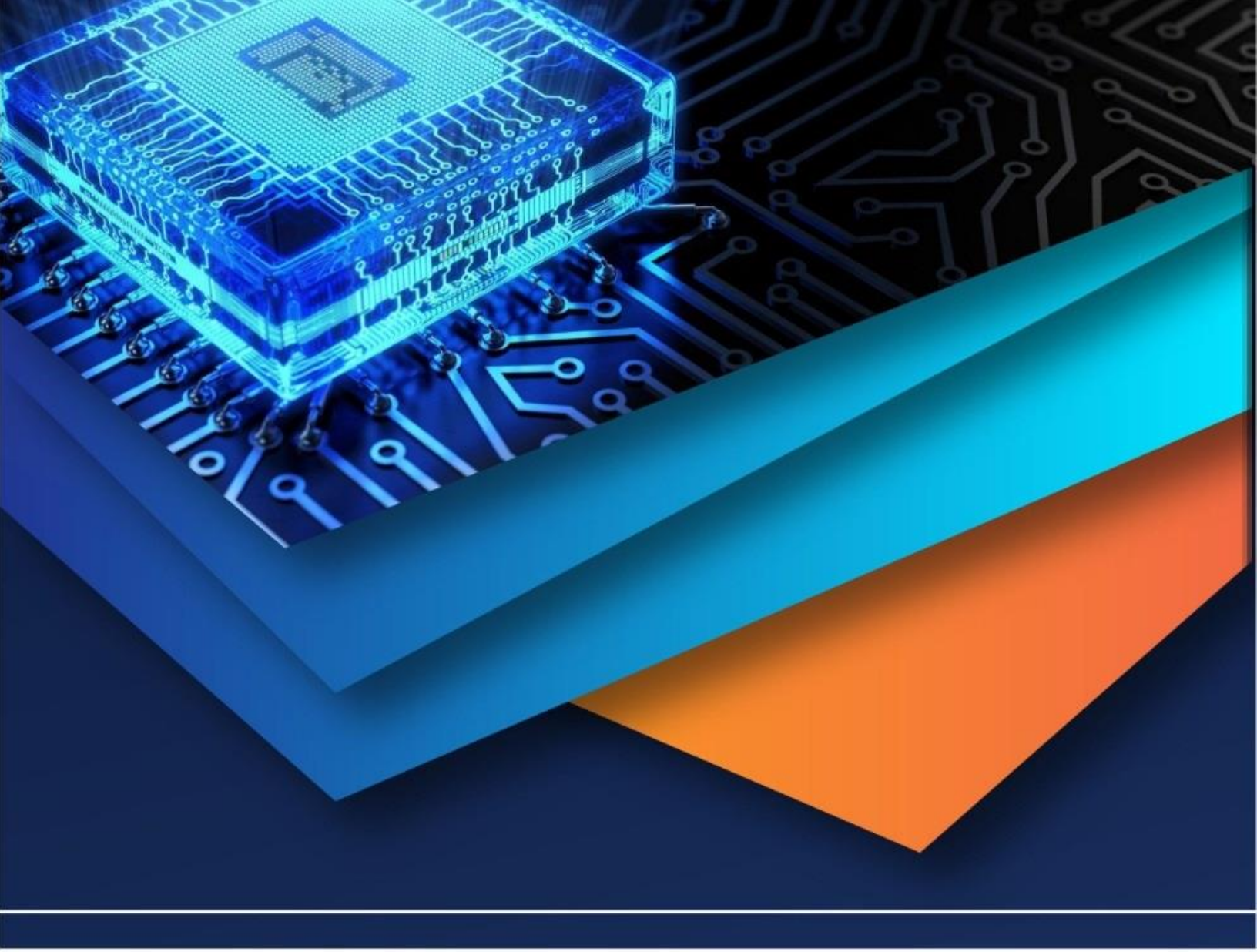
Metric	Value
Annual energy (year 1)	4,332 kWh
Capacity factor (year 1)	16.7%
Energy yield (year 1)	1,462 kWh/kW
Performance ratio (year 1)	0.67

Monthly Energy Production of Micro Inverter with Shading

REFERENCES

[1] Poshtkouhi S., Palaniappan V., Fard M., Trescases O., 'A general approach for quantifying the benefit of distributed power electronics for fine grained MPPT in photovoltaic applications using 3-D modelling' Proc IEEE on Power Electronics vol.27, No 11 page 4656-4666, 2012
[2] Hanson A.J, Deline C, A, MacAlpine S. M., Staruth J. T, Sullivan C. R., "Partial-Shading Assessment of Photovoltaic Installations via Module-Level Monitoring" IEEE J. Photovoltaics, Vol. 4 No. 6 November 2014
[3] Zhang, Q., & Li, Q. (2012, June). Temperature and reverse voltage across a partially shaded Si PV cell under hot spot test condition. In Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE (pp. 001344-001347). IEEE.
[4] Satpathy, P. R., Jena, S., Jena, B., & Sharma, R. (2017, April). Comparative study of interconnection schemes of modules in solar PV array network. In Circuit, Power and Computing Technologies (ICCPCT), 2017 International Conference on (pp.1-6). IEEE.
[5] Satpathy, P. R., Jena, S., & Sharma, R. (2017). Power Enhancement from Partially Shaded Modules of Solar PV Arrays through Various Interconnections among Modules.
[6] Bidram, A., Davoudi, A., & Balog, R. S. (2012). Control and circuiPt techniques to mitigate partial shading effects in photovoltaic arrays. IEEE Journal of Photovoltaics, 2(4), 532-546.
[7] Mäki, A., & Valkealahti, S. (2012). Power losses in long string and parallel-connected short strings of series-connected silicon based photovoltaic modules due to partial shading conditions. IEEE Transactions on Energy Conversion, 27(1), 173-183.
[8] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "A review of single-phase grid-connected inverters for photovoltaic modules," IEEE Transactions on Industry Applications, vol. 41, pp. 1292-1306, 2005.
[9] L. Quan and P. Wolfs, "A Review of the Single-Phase Photovoltaic Module Integrated Converter Topologies with Three Different DC Link Configurations," IEEE Transactions on Power Electronics, vol. 23, pp. 1320-1333, 2008.
[10] S. Harb and R. S. Balog, "Reliability of Candidate Photovoltaic Module- Integrated-Inverter (PV-MII) Topologies - A Usage Model Approach," IEEE Transactions on Power Electronics, vol. 28, pp. 3019-3027, 2013.
[11] SolarBridge Technologies Website [Online]. Available: http://solarbridgetech.com
[12] ENPHASE-Micro-Inverter [Online]
[13] PetraSolar Website [Online]. Available: http://www.petrasolar.com

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)